Design and Development of a Governance Framework for Airports Digitization

The Case of Turnaround Coordinator

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Introduction

Airports Council International (ACI) statistics show 8.8 billion passenger traffic in the year 2018, which is 6% growth compared to the previous year. The existing rapid growth of passenger volumes has already created a pressure on airport operators to re-consider the ability of the available infrastructure and focus on terminal capacity enhancement, process improvements, new revenue models and offer world-class services to attract global passengers whilst controlling physical & cyber security, pushing them one step closer to digital transformation. (1)

For a successful digital transformation, there are some critical success factors that should be considered. In 2020 COVID-19 has accelerated the pace, as the need for social distancing and a seamless passenger journey became necessary. A roadmap for digital transformation is recommended and the challenges an airport faces, will be reported. A definition of CDO and airport ground operations will be given along with suggestions for digital transformation in many processes. Finally, some case studies will be presented regarding airports and what they have achieved during their transformation.

Digital Transformation

Digital Transformation

It all began with digitization, the move from analog to digital. Not so long ago, businesses kept records on paper. Data was analog, either handwritten or typed into documents. Then computers went mainstream, and most businesses started converting all those ink-on-paper records to digital computer files and therefore, digitization happened. Finding and sharing information became much easier, but the ways in which businesses used their new digital records largely mimicked the old analog methods. Computer operating systems were even designed around icons of file folders to feel familiar and less intimidating to new users. Digital data was more efficient for businesses, but systems and processes were still designed around analog-era ideas about how to find, share, and use information. The process of using digitized information to make established ways of working simpler and more efficient is called digitalization. It is about making the existing processes faster and better now that data is instantly accessible and not trapped in a file cabinet somewhere in a dusty archive. As digital technology evolved, people started generating ideas for using business technology in new ways, and not just to do the old things faster. This is when the idea of digital transformation began to take shape.

Digital transformation is changing the way business gets done and, in some cases, creating entirely new classes of businesses. With it, companies are taking a step back and revisiting everything they do, from internal systems to customer interactions both online and in person.

Digital transformation is the adoption of using digital technologies to create new — or modify existing — business processes, culture, and customer experiences to meet changing business and market requirements. This reimagining of business in the digital age is digital transformation. It transcends traditional roles (sales, marketing, customer service) and begins and ends with how business thinks about, and engage with, customers. It is a foundational change in how an organization delivers value to its customers. (2)

Airport Digital Transformation

Airport digital transformation involves both the implementation of new technologies and the integration of existing technologies, processes and services to deliver a better experience to all stakeholders. DT embraces achieving a seamless flow through the airport by means of integrating systems and services, including those provided by partners such as airlines, security, customs, concessions, ground handlers, etc. The technologies mostly used are cloud, mobile, block-chain technologies, big data, robotics, social media and IT. A continuous flow, by minimizing queues, will maximize passengers' time spent in retail areas. Non-aviation revenues can be increased by amending retail area attractiveness, provide commercial information through mobile apps or digital walls and use digital capabilities to perform online orders. Another important aspect refers to flow monitoring which applies predictive/preventive solutions refers to airport indoor geolocation, identity management, flow management or radio frequency identification (RFID). Customer experience is now orientated towards self-service, as it offers quite a lot of advantages not only to customers, such as being available outside of regular business hours, but also to businesses as it reduces costs. Digital transformation has impacts beyond simply the automation of existing tasks and activities: it provides new digital services, creates new business processes, and addresses the effects and implications of technological change. (3) It enables connected travel. For passengers, airports and all stakeholders, it offers a much better view of and control of the journey, minimizing disruptions and providing solutions based on data analytics. (4) The goal is to improve maintenance, handling operations, security services, eliminate delays etc.

According to Arthur D Little, the level of technology adaptation of an airport can be named as the digital maturity and airport technology adaptation can be divided into four stages, Airport 1.0, 2.0, 3.0 and 4.0. According to the above classification, the traditional airports which are with manual and analogic processes and basic IT solutions are known as Airport 1.0. In case of disruption, there is a slow recovery in the overall airport system. The next level, Airport 2.0 is known as early adaptors to the digital technology into airport operations and partial self service facilities available such as Wi-Fi technology, check-in process, bag-drop and passport check. When there is an overall optimization of airport core processes and all level of passenger services of an airport equipped to provide full self-service, it is named as Airport 3.0. In those airports, operational controls are automated whilst predictive and mobility solutions are heavily used in passenger Terminal as well as in the airside. The emerging technologies lead the airport industry towards Smart airports, where they are connected with all stakeholders. This, being the last stage of evolution, is also known as Airport 4.0. In Airport 4.0 there is also a high degree of predictability and proactivity in the airport system. (1) (5) (6)

Critical Success factors

In digital transformation, a business must change its operations and processes. This change may prove to be quite a serious risk, if not implemented righteously. Below are some critical success factors.

➢ Strategic clarity: Airports have limited resources so they must overcome organizational siloes and channel these resources to a clearly defined set of digital priorities. Visible leadership support for the digital transformation agenda is essential if these internal and external dimensions are to be addressed and buy-in to the change journey created and sustained.

➢ Reinventing the business model: Engage the airport leadership team in the definition and review of the targeted business model, so that its requirements can be identified and anticipated and a strategy articulated, in order to engage with and gain support from the airport's stakeholders

➢ Coming up with a business case: It can be quite difficult to establish business cases that are able to clearly communicate the benefits and added value of digital transformation. These are mainly internal cost savings and externally increased revenues

➢ Positioning airports in the broader ecosystem: A key challenge for an airport is to ensure it opens its ecosystem and joins forces with other partners and stakeholders in the value chain. This will ensure the airport is able to benefit from market innovation and create more value for all its customers. By embracing collaboration, partnering can accelerate the process of learning about new technologies, identify process-specific applications for the technologies, and better manage implementation risks and costs.

➢ Recognizing data as an enterprise asset: Data must be valued and protected carefully. Each airport should set-up a total-airport management structure for the enterprise's data to leverage its value, manage its quality, promote its ethical usage and protect it.

➢ Influencing regulation: Digital transformation will require an update to existing standards and recommended practices, policies and best practices. This will involve global dialogue with civil aviation authorities, industry associations (ACI, IATA, etc.), industry partners and other airports.

➢ Developing a digital culture across the enterprise: Agility is a key factor for ensuring successful digital transformation, so it is important to promote a new way of working and managing projects by encouraging speed, risk-taking (fail fast) and experimentation (test and learn). Airports may need to challenge existing 'non-digital' mindsets and potentially rigid decision-making processes that may not be well suited to reaching decisions in a more dynamic manner that better reflects digital opportunities. Clearly, financial returns remain critical and airports should not turn their back on proven ROI-based principles. Equally, as an airport's digital capability grows, so decision-makers should seek to embrace a broader concept of value that can deliver financial, operational, and customer experience benefits for the entire ecosystem. The development of trust between the key airport stakeholder groups is an essential step to move from department-driven initiatives to a more holistic approach to digital transformation.

➢ Acquiring and retaining talent: The demand for digital talents is booming and competition to hire these talents is ferocious. Airports are recommended to identify key digital talents to acquire and train, as well as valuing and retaining internal resources who have both business and digital competencies.

➢ Human resource education and training: It is necessary to understand the objectives and the benefits of digitalization by each employee and to create an organizational culture of digitalization. It is necessary the anticipation of knowledge and skills needed for the large enhancement of this process and to ensure new interdisciplinary qualifications.

➢ Dealing with data privacy laws and regulations: Airports handle massive amounts of passenger and customer data throughout the digital journey. The storage and usage of this dataset must occur mindfully and in cognizance with data privacy laws and regulations imposed by different countries, such as the GDPR ruling.

➢ Resources and capability: Airports need to consider the resources and capabilities that they possess and how these must evolve. They are likely to require a minimum understanding of the key digital technologies and should plan to develop their own internal capabilities in parallel to partnering with external service providers. For existing airport employees, many of whom will be used to working in analogue-centric environments, this means clearly articulating how digital can bring value to daily roles by focusing on solutions that are simple and usable and can build trust. Business and operational readiness for change must be accompanied by the required skills and capabilities to make the transformation a success. (4) (5)

A contingency plan is also required for situations where IT failure takes place, when there is no electricity power, or in case of a cyber-attack. Manual processes should be creating for continuing operations in every case.

According to Arthur D. Little, the entire airport organization should be involved in an airport's digital transformation. They recommend two main teams: Transformation and business analytics. The transformation team involves the revenue and operation focused departments (Airline marketing, Commercial revenues & passenger marketing, Real Estate, Airport Operations – Airfield / Terminal, Airport Maintenance / Facility Management etc.) while the business analytics team consists of airport planners, designers & developers and support functions (Program & master-planning, Engineering (when in-house), Project management, Strategy, Finances, Human Resources and others). Achieving a Digital Airport Vision and Business Model requires the combination of a usual strategic planning approach and of Design Thinking bricks.
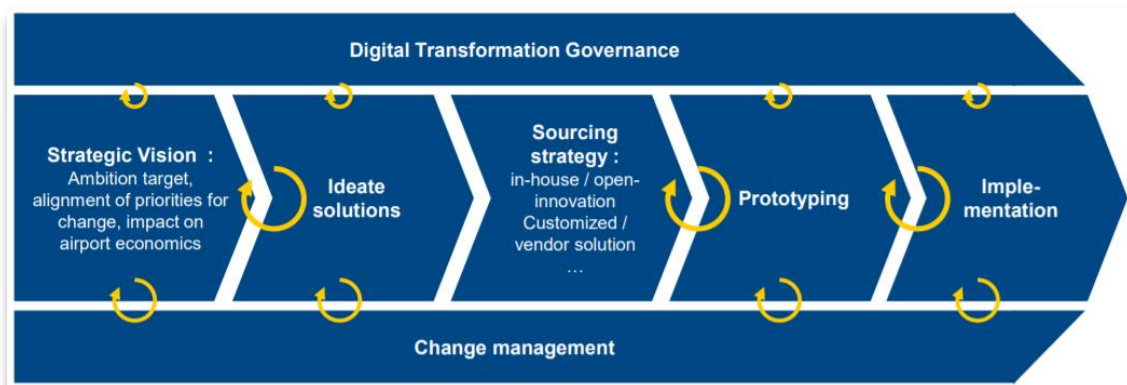
A successful Digital Transformation must provide tangible and economic benefit to every stakeholders of an Airport 4.0:

- ➢ Airports & Airlines: Transform into a «Smart airport», consider risk-sharing and value-based relationships and find a modus vivendi with airlines to manage the battle for consumer ownership through digital media
- ➢ Airports & Investors: Implement lean and agile business model
- ➢ Airports & The City: Contribute to the aviation industry green effort and Contribute to & prescribe mobility strategies based on digital-enabled solutions
- ➢ Airports & Consumers: Leverage big data & technology to understand «hyper-consumers» and boost both customer experience and commercial revenues. Find the right balance between being "a connector" and a "place of enjoyment". (7)

COVID-19

The COVID-19 pandemic has impacted almost every aspect of contemporary life, including the travel industry. There is concern about the passengers' safety and how the need for social distancing will apply in queues. To reduce the spread of pathogens beyond COVID-19, airports should consider autonomous, hands-free passenger self-processing solutions throughout the passenger journey. Already, many Common User Self Service (CUSS) solutions in the market leverage touchless biometrics such as iris scanning and facial recognition. (8) Of course, there is the need to verify the identity of every passenger, but with the help of technology this issue has been overcome. Nowadays smartphones can read a passport or ID chip via NFC with the facial recognition technology to provide not just an instant facial match between selfie and passport, but also a genuine presence test to prevent spoofing. (9)

As Maurice Jenkins, Miami International Airport's Division Director for information Systems, stated in his interview (10) "Central to an airport's success is investing in technology services that can be shared across all airlines and services via our core common-use technology platform." Nowadays with the spread of COVID-19, there has been an emphasis on contactless and touchless solutions. More specifically, at Miami's International Airport the administration is exploring solutions such as using sensors to evaluate customer temperature and of course a camera that will be able to read the passport data. To verify passport authenticity, an RFID reader will be used too. With the Miami International Airport app, travelers are able to submit their customs declaration in advance.

Due to COVID-19, Elenium Automation has developed Elenium VITALS, an app that can be used even without touching the screen, only with someone's voice or nods, with machine learning. They also designed a process where a passenger is identified, and his face is reconciled with the face on the document by holding his passport or ID to a camera. Monitoring key vital signs together, including temperature, respiration and heart rate can predict if a patient has influenza with 93% accuracy. Elenium's temperature sensing is achieved using a camera and a thermal sensor. The camera output determines the position of a person's forehead in a frame. Through Elenium VITALS, respiration is measured by using a thermal image to detect nasal region temperature changes associated with breathing. The heart rate measurement is facilitated by using a near-infrared camera and a high resolution RGB camera. These cameras can detect the oxygenated haemoglobin in the blood flowing

through vessels as it absorbs light from a specific wavelength. The result can be further enhanced with the inclusion of health or travel related questions, without requiring touch to respond, enhancing the range of data for the decision matrix. (11)

It is expected that the demand for enhanced airport Indoor Air Quality (IAQ) will increase, following the pandemic outbreak and the associated concern for the spread of the virus in indoor environments. Based on local bio-risk analysis, airports might want to consider taking measures to decrease potential airborne contamination and diffusion levels, especially in high passenger concentration areas. (12)

The Center of Excellence has created the Smart Health Travel project to elaborate a health protocol and propose technologies which mitigate the health risks and set the foundations to gradually normalize the flights. The technologies are been structured into two categories: big data and tech devices such as IoT (Internet of Things), thermographic cameras, disinfection chambers, video analytics, SARS CoV-2 Antibody quick tests, among others. The ambition is to adapt and align the current interface with ACI's Aviation Community Recommended Information Services (ACRIS), a known global industry standard for aviation data and information exchange. (13)

COVID-19 has seen the mass grounding of airline fleets and airports consolidating operations, to the extent of closing entire terminals to reduce overall running costs. Likely, recovery by different airports could be disorderly as the pace of lifting of travel restrictions will be different across the world. It is hence essential to preserve maximum flexibility in recovery plans. Coordination between the key stakeholders of airlines, ANSPs and airports would be a key challenge. For example, in aircraft rotation, grounded aircraft may be rotated between grounding and active service, introducing greater demands for engine run-ups and towing activities, amidst the need to maintain airport operations. Last but not least, there is no way someone can predict what will happen, so airports should be ready for every case - for example, the evacuation of potentially infected inbound travelers. (8)

Roadmap

The road to become an Airport of class 4.0, as described before, is long. ACI recommends a path that shows dependencies in a reasonable sequence.
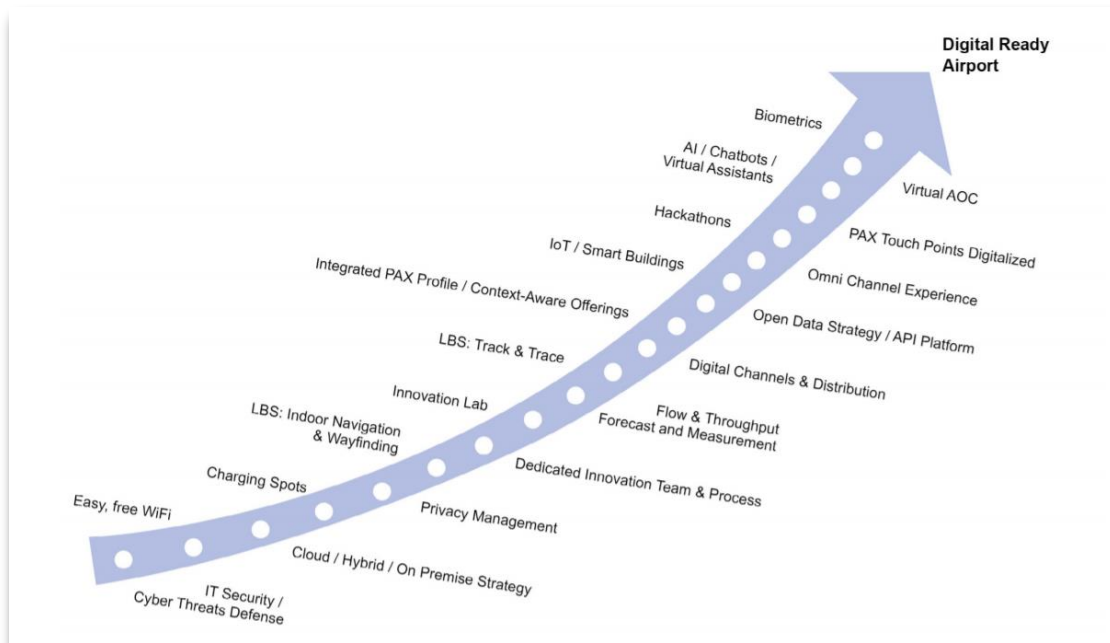
It is crucial that each airport understands the full scope of the environment in which it operates and align its business and operational objectives to it. Afterwards, the team who undertook the project will be able to exploit technology to match the airport's objectives. Because technology is evolving fast, airports should every few years, review the basic steps which are:

➢ Airport environment assessment: A multi-dimensional review of the airport's characteristics, including but not limited to its physical, customer, market, local community and economic characteristics and socio-political influences upon it.
➢ Airport plans and objectives: A specific step for airport C-level management to agree on the priority and actions of specific digital plans and identify areas where technology (existing or new) will improve the outcome or desired results.
➢ Internal organizational review and requirements: An assessment of the current organization and competencies versus what is needed to remain flexible and agile through the digital transformation and beyond.

At first the airport should prioritize and create specific digital transformation plans, considering the airport's current environment as well as its business context and objectives. Digital transformation impacts all aspects of the airport, in order to focus on the most promising area. It is critical to identify key domains where the digital strategy should be deployed to improve significantly processes and services such as:

➢ Airport operations: A resource management system leveraging the IoTs can provide more comprehensive solutions. Employee efficiencies will increase by leveraging collaborative and web-services platforms, financial services to streamline and dematerialize Account Payables and Receivables processes will improve revenue recognition and fund availabilities and intelligent building management will reduce electricity and gas usage and lower utility bills.
➢ Security: Leveraging artificial intelligence can deliver significant enhancements such as biometric recognition, unusual behavior detection, profiling, unattended-baggage management and monitoring and control of building and fencing access.

- ➢ Capacity management: A deep understanding of passenger flow can help optimize the capacity of airport infrastructure and retail services offerings, as well as offering predictive maintenance that will reduce maintenance costs and maximize airport-asset utilization.
- ➢ Passenger services and intimacy: Customer-focused mobile applications coupled with big data and Customer Relationship Management (CRM) can provide personalized e-services to passengers, allowing them to prepare and enhance their airport experience and enhance their consumption of airport services.
- ➢ Stakeholder management: A successful digital transformation can enhance airport stakeholders' relationship management, by providing tangible and economic benefits to every airport stakeholder— airlines, passengers, investors, local communities and employees.
- ➢ External: Airports are encouraged to leverage market innovation through strategic partnerships with key solution providers and service and/or technology providers, because these will help to accelerate digital transformation.

The second step concerns the management, in order to agree on the prioritization and actions of digital transformation plans. That depends mostly on the airport's internal and external factors, that are: social, political, economic, local, regional, national and even virtual. The ACI suggests that one way to determine priorities is to overlay the airport's digital transformation plan with its strategic plan. They must engage in strategic planning, including a thorough analysis of the conditions in which each airport operates. The results will clearly define the mission and objectives.

Before embarking on the digital transformation journey, it is important to assess the airport organization's internal readiness. This will help the airport's C-level management to understand the organization's strengths and identify areas requiring additional focus and improvement, to benefit from the transformation:

- ➢ Organization and culture: Digital transformation will impact everyone, regardless of the organization, so it must be an organization-wide effort. The assessment, application and results should be performed across all functional areas, because talent for new skills arising from and required by digital technology may be found in non-traditional areas. The outcome will be an organization and culture that promotes speed and agility for all structures, governance and incentives, risk-taking and experimentation.
- ➢ Process capabilities: An assessment of the airport's actual capabilities is necessary, in order to estimate the required effort to build working products and services and set up a prioritized delivery plan.
- ➢ IT infrastructure: The most important areas to pay attention are data management, the ability to interface the Airport Information System quickly and easily with external parterns and of course security.
- ➢ Technology portfolio: It is necessary to gain a comprehensive view of the technologies available, to understand what can be leveraged and what should be changed or upgraded to enable and sustain the digital transformation plan.
- ➢ Fostering a culture of innovation within the organization: Set up visible innovation governance to manage new proposals and initiatives, manage technology portfolios and federate an innovation ecosystem to allow open innovation. The airport should promote, recognize and value internal ideas and initiatives for innovation. (4)

Challenges

Any business, including airports, undergoing a digital transformation will face many challenges, some of them more important and difficult than others. A successful digital transformation arises not from implementing new technologies but from transforming organizations so they can leverage the possibilities new technologies offer.

There is a variety of technologies and apps that an airport can use, but in order to decide which will be more suitable, the management team should be aware of the maturity stage the airport is and what is the current objective towards the next step.

There is the energy efficiency challenge, the increase efficiency and flexibility of processes and the fast implementation of new technologies, which can be resolved by, for instance, intelligent air-conditioning, mobile and predictive maintenance and the Integration of building planning and building operation, respectively. (6)

Nowadays every organization has employees used to work in a certain way. With digital transformation most of their daily routine will change. Things can easily start to seem grim when routines are changed. Experiencing a digital transformation is the epitome of discomfort — so it may make employees feel threatened. People are usually afraid of changes (4) and may be threatened in many ways. Companies should keep their employees engaged through the process, to erase any doubts or uncertainties. Being consistent and transparent is key. (14) Creating a digital culture across the organization and encouraging employees and other stakeholders to grow accustom to the digital culture, tools, technology, and solutions will help businesses persuade the workforce during the transformation phase. Starting slow is the key. Explaining the transformation process and allowing the stakeholders to settle in, will ensure a successful business transformation. (15)

The key risk factor of Smart Airport is Cyber security and it is one of the most critical safety factors. It needs more attention in modern airport operation, because digitalization of operational processes and customer interaction is reinforcing the negative impact of malfunction and is increasing the threats posed by cyber-criminality. Apps are susceptible to cyber attacks and if they are successful access to personal information and other confidential data of the passengers can be extremely harmful both for the airport and the airlines. The reverberations of a successful cyber attack can be even more dangerous and threaten the physical security of an airport, so tests must be carried continuously.

Digital transformation can be quite expensive for any company, let alone an airport. In the future it will certainly be profitable, but it is crucial that financial resources must be handled carefully The budget involves the technology, infrastructure and resources investments to develop an intelligent digital solution. As customer demands constantly evolve, adjusting to the market requires more investments and may exceed the actual budget set earlier. This lack of clarity on budget slows down decision making and forces the leaders to step back when it comes to digital transformation funding. Changes should be made in many stages with the necessary education of personnel and the slow adoption of passengers into this. Digital transformation cannot run overnight and should be in rationalized approached on identified priorities. Having a strategy in place for the long-term with a budget in mind is recommended to avoid potential financial risks of the company. With meticulous planning and a thorough

understanding of the digital solutions and culture setting, a budget that deviates minimally from the actual estimation is highly possible. (1) (15)

A shortage of resources available and poor resource management planning can hurt businesses. So, even before developing a product roadmap, it is a must to analyze the resources available to set the project in motion seamlessly. Poor planning with a lack of resources results in below par results and this will eventually bring down the performance of the business. A finite strategic plan in place, even before getting started with the transformation process, is critical as this might help business heads understand how to plan resources accordingly. Airports should identify, prioritize and implement required digital solutions which are specifically relevant to the context of airport operations. This may be challenged by non-digitalized mind-set within the organization. It is required to change the mind-set of airport staff including regulatory agencies as well as concessionaries. They may have required training on how to operate their own systems and educate on basic features and importance of the system implementation. It is required to have the relevant technological knowledge and maintain the standards of systems up to the industry requirements. (1) (15)

Global air travel trends indicate increasing demand. Airport master planning is a complex process that can take years to realize, so infrastructure projects are ahead of capacity needs. Designing something new, after a few times, might seem ready to be constructed/used. But theory is quite different from action, so before something is implemented, tests must be run from people who are actually going to use them in order to evaluate it. With this cooperation the best result will be achieved.

CDO

At Lufthansa, digital transformation activities are coordinated by the VP of digital strategy, who works with a digital executive board that provides an institutionalized connection to key functional stakeholders. Among other activities, this remarkably lean function is orchestrating the company's award-winning innovation hub in Berlin. Lufthansa's VP of digital strategy comes close to the role of a "Chief Digital Officer" (CDO), a new C-level position which has gained popularity in recent years as organizations try to coordinate their digital transformation efforts under one roof.

A typical CDO works across the entire company on all the elements of the digital strategy and organization. Naturally, this encompasses a wide range of responsibilities. Specific job profiles will vary from company to company due to specific structural, cultural, and political conditions at the time the role is installed, but they usually cover a wide array of objectives, as outlined below:

Typical Task Profile of a Chief Digital Officer Touching Traditional Functional Roles
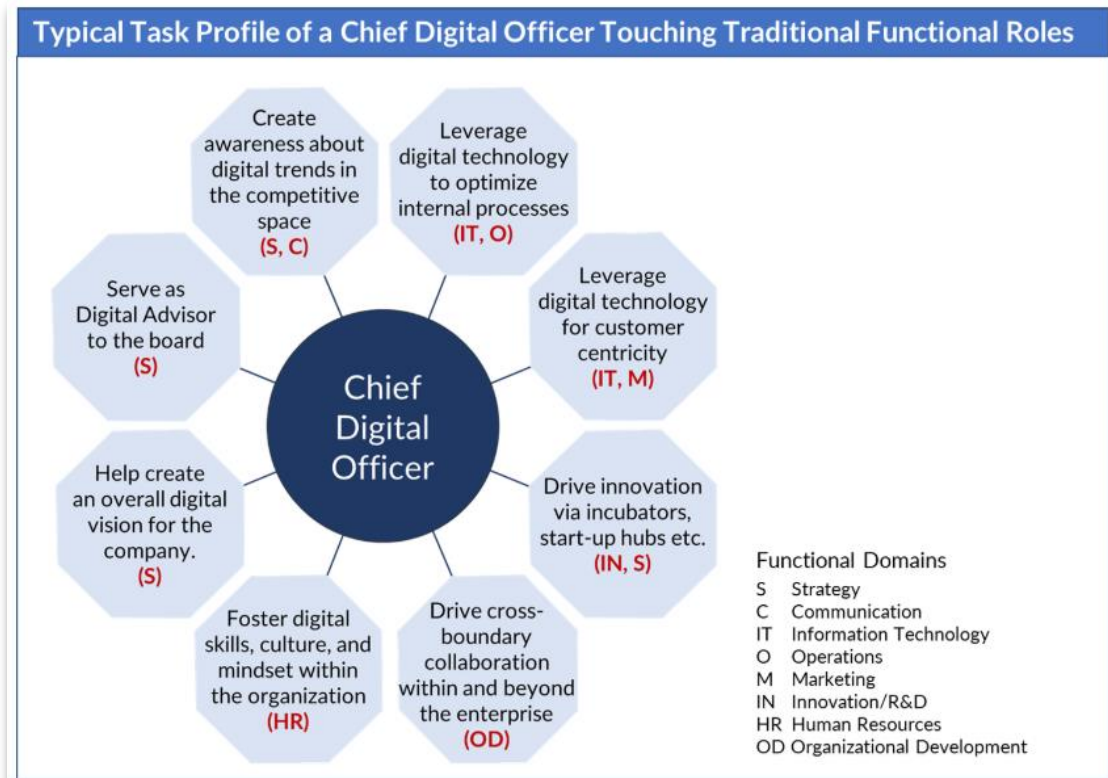
This massively multi-functional profile is a challenge for those who get tasked with the role, and it is a challenge for the traditional operating set-up of an organization. As it often happens with new functions, the chief digital officer role is still in the process of finding its identity. Many organizations just add the CDO responsibility to functions they feel are closest to digital disruption: IT and/or Marketing. Leading digital transformation asks for the ability to comfortably deal with a portfolio of functions, operating models, industries, and mental frameworks. Given the high strategic priority of the topic, CDOs are usually important stakeholders and members of the inner advisory circle of the CEO and the board, in some cases even members of the executive board. The CDO role stretches not only the capabilities of any executive, but it also implies structural conflicts with all those functions that traditionally carry the responsibility for the respective domain. (16)

Ground Operations

Definition

Airport ground operations, also referred to as ground handling, cover those services required by an airline between landing and take-off of the aircraft. The Turnaround Coordinator is responsible for the economic, punctual and safe planning and execution of the various aircraft handling processes during the aircraft ground time. There are four main core business processes: Passenger handling, Aircraft Preparation, Baggage Handling and Cargo Handling

and the supporting processes are: Planning & scheduling, HR and Training, Commercial, Financial, Management, Procurement and IT.

Passenger handling consists of the arrival (passenger de-boarding, transfer, baggage delivery, lost & found services, arrival lounge) and departure processes (ticketing and reservation, check-in, waiting area, lounge, boarding). Although most passengers will arrive at the airport with tickets in hand, there are provisions at most terminals for on-the-spot purchase. Arrangements should be made for wheelchairs or other transport to the departure gate for mobility impaired passengers and will process, safeguard and supervise any unaccompanied minors (UMs) from check-in to aircraft boarding and from aircraft deplaning to release to a parent or other authorized person. There is also always someone who will be available to accommodate Irregular Operations requirements such as rebooking passengers who have missed connections or providing meal and accommodation vouchers, or alternate transportation arrangements, in the event of delay or cancellation of flights. Ground agents assist in aircraft boarding, they make appropriate boarding announcements, conduct final passenger screening and document verification and provide a final passenger manifest and customs documentation to the aircraft crew. If passengers must be bussed to the aircraft or otherwise be compelled to walk on the ramp, ground agents ensure their safety. Upon the arrival of an aircraft, ground staff will receive any inbound customs paperwork and accept arriving passengers at the aircraft and facilitate their transfer to the terminal building, dealing as necessary with issues arising from inbound delay or cancellation of connecting flights

While cargo handling consists of processes such as (un)loading, customs clearance, storage and others, baggage handling covers, for instance, baggage drop-off, x-raying, sorting, load planning, loading and transportation. It also covers the cases of over-sized baggage. Provisions will be available, usually at a secondary location, for the acceptance of over-sized or very heavy baggage items. Bags will be electronically or manually sorted by flight and either loaded into Unit Load Devices (ULD) or placed on baggage trolleys in preparation for aircraft loading.

The planning processes includes lobby management, where agents must ensure that the appropriate number of check-in desks are available, staffed and have the appropriate identification signage as well as directing and controlling the flow of passengers in an orderly and efficient manner. Lounge management is also part of the planning process, as lounges should be available to qualified passengers. Another task is gate assignment, where in coordination with the airport authority, aircraft gates will be assigned and the gate information relayed to the passengers.

The marshalling process at some airports starts as the aircraft approaches the apron with the provision of a Follow Me Vehicle to guide the aircraft to its assigned parking stand. Wheel chocks will be inserted and external services such as passenger bridge(s) or boarding stairs, ground electrical service and ground air conditioning units will be positioned or connected as required. As the departure time approaches, these items will be disconnected and removed as directed by the flight crew. Baggage and freight on the inbound aircraft will be off-loaded and the outbound bags and freight will be loaded. There may need to move the aircraft to or from a maintenance facility, a remote parking stand or from one gate to another.

The aircraft preparation includes refueling, toilet and water servicing, where toilet waste holding tanks will be emptied and serviced as required. Potable water tanks will be refilled. In the cleaning process garbage containers are emptied and the contents removed from the aircraft. Toilets are restocked, passenger comfort items such as pillows and blankets are

replaced as required and, where applicable, newspapers brought on board. The catering trolleys and oven inserts from the inbound flight will be removed and the catering for the outbound flight boarded. Galley and bar stock will be replenished. Prior to departure, the flight crew will be provided with the appropriate documentation. In some circumstances, a high pressure air cart may be required to start at least one of the aircraft engines. When required, either or both Aircraft Ground De/Anti-Icing and Engine Core and Fan De/Anti-icing will be carried out. Engine core de-icing is most often accomplished at the parking position whereas aircraft de-icing may be done either in situ or at a remote facility.

Whilst the aircraft is on the ground, engineers will also perform routine inspections, rectify minor maintenance issues and make the appropriate entries in the aircraft technical log. Flight crews will perform a preflight inspection of the aircraft in preparation for flight. (17)

Digital Transformation Suggestions

Passenger handling: Digital transformation applies here with self-service check in kiosks, self-boarding, indoor navigation, smart wheelchairs, digital processing of irregularity vouchers, smart wearables and biometric services. Most of them are quite familiar in most airports, while others are only suggestions that could be applied. Irregularity vouchers are free cash vouchers for meals, hotel accommodation, airport transfers, and bag replacement provided to passengers by an airline (or ground handling agent on behalf of the airline) in case of a flight delay and are usually personalized. Businesses that do not receive many vouchers or do not use an electronic system, usually physically mail the vouchers to the airline or ground handling agent in order to receive payment. Digital processing of irregularity vouchers has reduced processing costs for service providers, airlines and ground handling agents. Smart watches may also be used, as ground handling agents can use this channel to broadcast real-time information to passengers outside of traditional visual display monitors, voice announcements and send messages to other mobile devices. Biometric technology has already several applications such as biometric travel documents, airport access control, biometrics in security and biometrics in baggage claim.

Aircraft preparation involves parking, (un)loading, load control, fueling, push back and towing, deicing and others. Ground support equipment (GSE) is usually found on the ramp (i.e. servicing area of airport, also referred to as the apron). GSE includes, for instance, refuellers, container loaders, belt loaders, transporters, water trucks, ground power units, air starter units, lavatory service vehicles, catering vehicles, passenger boarding stairs, passenger buses, pushback tractors, de-icing vehicles, container dollies, cargo pallets, and others. All the above have to be scheduled and achieving that automated is a huge plus for ground handlers as it minimizes the total number of GSE vehicles required to handle flights and, consequently, reduces ground handling agent's capital expenditures. Advanced scheduling and routing algorithms minimize the overall apron traffic and reduce ground handling agent's fuel costs.

Baggage handling: RFID baggage tags are commonly used, whereas self-tagging is one of the latest ideas, where passengers tag their own bags and track them on smartphones. Digital bag tags are the digital alternative to conventional paper-based baggage tags. Bags receive a permanent bag tag that displays a digital bar-code. Airlines or ground handling agents can change this bar-code remotely, if the flight plan has changed or a passenger has been re-

toured. Combined with a tracking device, that is stored inside the bag, passengers are able not only to track the luggage on smartphone in real-time, but also to use fully automated machines to receive them without any interaction with ground staff or airline employees. Several airports have already installed automated bag-drop machines. Of course, lost luggage kiosks connected to the global database for lost luggage, could not be missing from an airport's digital transformation.

As far as lounge services goes, different airlines have different rules about passengers entering a lounge, for example one may allow a passenger to bring guest, whilst another allow entrance only to passengers with business or first class tickets. Ground handling agents need to know such regulations for several airlines and lounge clubs and addition, lounge personnel need to be able to apply these rules immediately. Automated access gates have installed at lounge entrances, which are connected to a back-end application with the rule sheet. As soon as a passenger has swiped the card or scanned the boarding pass, the application applies the rule sheet and decides if the passenger is able to access the lounge.

Since labor costs in airport ground operations account for 60 to 80 percent of the total cost, automation of staff planning and scheduling is a top priority for every ground handling agent. According to Ivan Kovynyov and Ralf Mikut, automated centralized planning is the most common approach reported in the literature. This approach is based on prior demand modeling and stepwise reduction of the planning horizon. Usually, the planning process begins six months in advance, using the flight schedule forecast for the next season (winter or summer). The aggregate flight schedule forecast is achieved via the production management system, and is likely to be just a distribution of flights by month, airline and destination. The aggregate flight schedule forecast is used for holiday planning and strategic workforce planning. Two months in advance, the aggregate forecast is transformed into a detailed flight schedule forecast. Based on the detailed forecast, the shift plan is compiled. The shift plan is a result of balancing demand quantified in the flight schedule forecast against the available workforce. The shift plan includes the distribution of different shifts per day throughout the month and associated skills required for performing these shifts. The shift plan is usually performed using a dedicated planning application. Next, the shift plan is transformed into the rostering plan. The rostering plan assigns employees to particular shifts and is prepared at least two weeks before its application. The rostering plan is usually completed using the time and attendance system. Hours prior, the rostering plan is incorporated with the task schedule. The task schedule assigns particular tasks to the shifts. Usually, the task schedule is created using a dedicated real-time application with broadcasting capacity to the employees' hand-helds.
De-peaking is a strategy whereby air traffic between peak and off-peak times is scheduled to distribute traffic more evenly throughout the day. Conventional planning approaches do not include de-peaking by default. Many ground handling agents now include additional de-peaking strategies into their planning procedures.
Another useful process for ground handlers is sift trading, as it eliminates conflicts between employees and gives the freedom of choice, not to mention that employee self-organization is more cost effective for the company.

Digital transformation has also an impact in HR and Training Department as ground handling agents have many employees and need to access employee information quickly. Digital employee profiles create a centralized overview of employees by integrating multiple sources of employee-related information: personal (age, gender, address, civil status), financial (compensation, including rewards and benefits), qualifications (certifications, trainings, skills, performance reviews), and workforce data (productivity, absences, holidays, overtime

balances). They also use web-based learning programs instead of classroom training. Such trainings can be accessed as desktop applications or from a mobile device. Web-based training includes single and recurrent standard training programs (code of conduct, health and safety), management training (anti-corruption and fair competition guidelines), and technical training for operational staff (dangerous goods, security regulations, customer service), that do not require interaction with trainers. Web-based training frees up in-house trainers from routine tasks and reduces training costs. Furthermore, web-based training can be easily translated into other languages or enhanced using local information.

Ground handling agents need to be able to distribute the latest news, reports and corporate announcements to a large number of employees (e.g. bomb threats, aircraft damages, irregularities in airport operations) so many of them have installed visual displays in lunch rooms and offices, developed corporate mobile apps or started engaging with employees via social media networks. They also manage large numbers of employees and must be cost-sensitive and highly efficient in executing their tasks at the same time. For example, they can tap into social networks to engage with potential candidates, publish job openings via internal job markets, or ensure job application submissions are quick and easy to review, responding to candidates promptly, relying on cost-effective selections methods.

Finally, ground handling agents use ratios to measure and track corporate performance and have to provide them to the management at least on a daily basis. These ratios are designed to address key areas of concern, which include operations, finance, human resources, safety and quality and their calculation requires an intelligent combination of information from multiple sources, so they all should be calculated automatically while advanced analytics and big data technologies create the possibility to develop further insight into the business. (3)

Case Studies

As mentioned above, most airports are in the second phase of digital transformation. In this section, airports with distinctive operations and processes will be cited.

Munich International Airport

Munich, one of the best European airports, in association with Southern Bavaria Aviation Office have introduced state-of-the-art CT scanner to the passenger terminal which is capable to find solid and liquid explosives. Passengers are not required to take out laptops, smart phones and any permitted liquid from their baggage to declare and they can easily process through the scanner for screening requirements. After placing their personal belongings in the large bins, they can proceed to the body scanner. While around 100 passengers could previously be security-checked per hour in one screening lane, the new technology can handle up to 260 passengers per hour. (18)

Munich Airport has a project called Optimized Campus Mobility project and employee mobility is a part of it. With 3 apps everyday working life is already easier. «ShuttleMe» is a free transport service that all Group employees can order via smartphone app. Three minibuses service more than 40 stops on the airport campus in accordance with demand. Users can track on the app where the shuttle is currently located and how long it will be before it reaches the pick-up or drop-off point. This flexible and convenient mobility service increases efficiency and minimizes negative environmental influences.

The «Passngr» app provides passengers along the entire travel chain with individually tailored traffic updates and information on route alternatives, on the availability and prices of parking, on the expected duration of check-in, waiting times at security, and offers from restaurants and shops. «Passngr» was extended in 2019 by a number of features and its user-friendliness enhanced. The airports in Frankfurt, Berlin Schönefeld and Berlin Tegel, as well as Vienna were also incorporated. The plan for 2020 is to extend «Passngr» as a traveling companion that can be used worldwide with the inclusion of new services and flight data for other airports.

Airport employees in operations areas will benefit primarily from the new «Airport Community» app: All real-time information relating to operation of the airport has been available to them in bundled form since 2019, including flight details, current waiting times at security checkpoints, as well as irregularities and disruptions in flight operation. The app also creates a cross-campus communication platform – apart from FMG, the app is also authorized for use by airlines, authorities, service providers, and external companies operating on the campus.

Considering the changes in demographics and to protect the health of the workforce, Munich Airport is investing in technologies to reduce the burden of physically demanding activities. Baggage handling is one example of this. A fully automatic loading and unloading system is currently being developed specifically for this area as part of a cross-organizational project in collaboration with the Fraunhofer Institute. (19)

Singapore Changi Airport

Changi Airport in Singapore, crowned as the best airport for the 8th consecutive year by Skytrax World Airport Awards, introduced automated baggage drop machines for their terminal-4 with passenger facial recognition technology. Every passenger's face is the token that gets them through checkpoints. Once a passenger's passport is scanned at the check-in kiosk his face will be the one common denominator at all other touch points until he boards the aircraft – without compromising security. There is no requirement for manual identity checks by security staff as the entire departure screening process automated by allowing flexible, secured and convenience departure process for passengers. (1)

More specifically, at the Automated Check-in Kiosk, the passenger scans his passport (or enters the booking reference) and receives the boarding pass and luggage tag. He then tags his luggage. The passenger places his luggage on the Automated Bag Drop machine, where his bag is weighed and its dimensions assessed. He then scans his boarding pass and passport. A camera captures his photo and compares that against his passport photo using facial recognition technology. Once his identity is verified, his bag is accepted into the baggage handling system. At departure immigration, the passenger scans his passport at the Automated Immigration Gate, which uses both facial recognition and fingerprint verification technology. His boarding pass is also scanned for validation. The passenger places his bag on a tray that goes through the new 3D CT X-ray machine. An automated system speeds up tray return and reduces waiting time. The passenger then walks through a metal detector or steps into the whole body scanner for final screening. Once the passenger is screened, he enters the transit area where he has time to shop, dine or relax before his flight. Once the flight is ready for boarding, the passenger goes to the Automated Boarding Gate where he scans his boarding pass and has his photo taken. The photo is verified against the photo taken earlier at immigration for a final identity check.

As far as the security goes, the tomography-based X-ray screening machines at all security lanes to scan carry-on luggage covers it all. The ability to have a 3D bag image with auto-threat detection capabilities greatly enhances the security performance of the screening staff. With

such capability, it also eliminates the need for passengers to remove laptops and other electronic items from their bags. This improves checkpoint efficiency and passenger experience. An automatic tray-return system with parallel divestment stations has also been installed, with two clear advantages. The system no longer requires security staff to manually return trays, freeing them up to pay closer attention to passengers. It also allows two passengers to present their belongings for screening simultaneously, speeding up the entire process. Taking mere seconds to do its work, T4's non-invasive body scanners can detect both metallic and non-metallic objects, right down to pin-pointing exactly where the item is on the body, meaning that staff only need to conduct targeted search in the event of any security alarm. As a consequence, airport staff are able to pay more attention to the behavior of passengers during the screening process, making this a safer and more efficient process.

Although the management at Terminal 4 invested a lot on making the passengers' journey seamless, they did not forget its employees. Dumbwaiters – motorised lifts that help transfer bulky items on aerobridges – were installed at the apron. Workers at T4 now do not have to physically carry heavy items such as wheelchairs and prams up and down the stairs. Also, behind the mirror of every toilet, a single container with tubes linking to all dispensers now refills the soap automatically, reducing the workload of toilet attendants, who previously had to refill every soap dispenser manually. Sensors are placed that track how much is left in each roll of paper, alerting staff when it is time to replenish. CAG (Changi Airport Group) has also invested much time and effort to introduce autonomous cleaning machines, with each type specifically modified to handle different areas, such as the tiled check-in facility, carpeted transit area and even T4's car park.

Smart bins alert cleaners when they are full and trash does not have to be carted across the terminal. Work is made more efficient with 12 disposal-points across T4, all fitted with a pneumatic system that transfers trash to a central bin in the basement. An upside to these staff-focused efforts is a major boost to productivity.

In order all of the above to work efficiently from Day 1, Changi worked with its various partners to put its systems through robust tests, even with "live" flights. They ran over 150 rigorous trials involving more than 10,000 volunteers and airport employees, and 11 "live" flights before the operational opening. (20)

The airport, occupying 13 sq. km and always evolving, has many ongoing construction works. To enhance safety work team supervisors, register their work areas using the Online Work Declaration System. These areas are then displayed on an online, digital map of the Changi East site. Workers are also issued with a transponder, which will alert them if they enter restricted areas. Smart glasses are also used to provide real-time line of sight footage by ground inspectors and streamed to the Changi East Command Centre so that duty managers can accurately see what is happening on ground. As specific parts of the airfield have height restrictions to ensure aircraft safety, the Automatic Height Infringement Detection System was also introduced, where sensors and GPS locators are placed on equipment to detect when the equipment has exceeded an area's height limit. (21)

Incheon International Airport

Incheon Airport in South Korea already introduced "Airstar" robots to the terminal process for passenger ushering. These robots placed in passenger congesting areas such as departure lobby, duty-free stores and baggage belts at the arrival area. Furthermore, they are improving passenger convenience and smart experience services for airport users by guiding, transporting, vehicle parking, self-driving vehicles and indoor terminal location finding technology. An Airport Collaborative Decision Making (A-CDM) system is used since 2017 to

integrate real-time data with ATC Tower & Apron Control Tower, improving the response capabilities with departure times and runway queues. (22)

The Smart Airport Team is working to enhance the service offered to Passengers with Reduced Mobility (PRMs) using robotics technology and automated vehicles. Meanwhile, a big data platform is being developed to increase technology-driven operational efficiency.

Incheon Airport adopted innovative technologies such as 5G, IoT, and big data, to increase convenience. In 2019, the 'double loading detection system for baggage' was developed which automatically detects double-loaded baggage and moves it to manual handling area to completely eliminate the root cause of double-loading issue and finished patent registration. In late 2019, the double loading detection system for baggage was applied to all 8 courses in Passenger Terminal 1, leading to a 30% reduction of late baggage cases. (23)

Incheon International Airport Corporation (IIAC) has most recently pushed to evolve the facility's digital prowess. By 2023, Incheon plans to implement the following technology-enabled services:

- ➢ Facial recognition technology enabled SmartPass check-in and boarding.
- ➢ Home baggage drop-off courier service enabling passengers to have baggage items delivered to the airport and loaded onto aircraft.
- ➢ Walkthrough tunnel-type security screening system.
- ➢ Deployment of 14 artificial intelligence robots at passenger terminals.
- ➢ Autonomous low and high-speed shuttle bus services.
- ➢ Automated parking valet robots.
- ➢ Intelligent CCTV security surveillance system.
- ➢ Unmanned duty-free retail outlets using Internet of Things technology.

SmartPass is a service enabling passengers to board international services at Incheon using preregistered facial recognition and other biometric data. The information would replace boarding passes and passports. Paired with SmartPass is a service enabling departing passengers to have heavy baggage items delivered to Incheon Airport by a courier. Delivered baggage would be registered and loaded onto aircraft. IIAC is undertaking negotiations with Korea Customs Service to offer a similar service for arriving passengers, enabling them to have baggage items collected from aircraft, screened by customs officials and delivered to their home address. The tunnel-type system is designed to enable passengers and their baggage items to be screened simultaneously, rather than separately, while walking through the tunnel. Also, IIAC's idea of intelligent is a system capable of detecting abnormal behavior, stressful body language and odd facial expressions in real time. The system is expected to enhance IIAC's ability to respond to security threats at the airport, or perhaps identify a threat before it comes to a realization. (24)

Kempegowda International Airport

Finally, another remarkable process is implemented in Kempegowda International Airport. In order to give passengers a seamless, paperless and hassle-free journey, using facial biometrics as a single token for passenger verification and identification, while also having a digital process to validate tickets and boarding passes at the airport, the India Government introduced Digi Yatra (Digital Journey). In short, through the DigiYatra Platform, the passenger creates a Digi Yatra ID. On first travel, the Pax must go to registration kiosk at the airport for validating the ID and a photo will be added to each passenger's profile. When passengers initially make a booking, the airline shall make a provision to collect the Digi Yatra ID of passenger for domestic travel as per Digi Yatra policy. Airlines shall share the passenger data

including Digi Yatra ID, with the biometric boarding system of airport operators at least six hours before the flight on a secure link for the purpose of ticket validation and ID validation. At the entry point E-Gate will scan his boarding pass or e-ticket and on scanning the bar code/ QR code will validate the passenger details and flight details. Digi Yatra ID will then verify the identity by Face Recognition and e-Gate will open. Also, Face with ticket PNR is made in to a single token for the rest of the journey at the airport. (25) (26) Below is the passenger flow from the arrival to the airport to the boarding into the aircraft.

Digi Yatra: Conceptual Passenger Flow
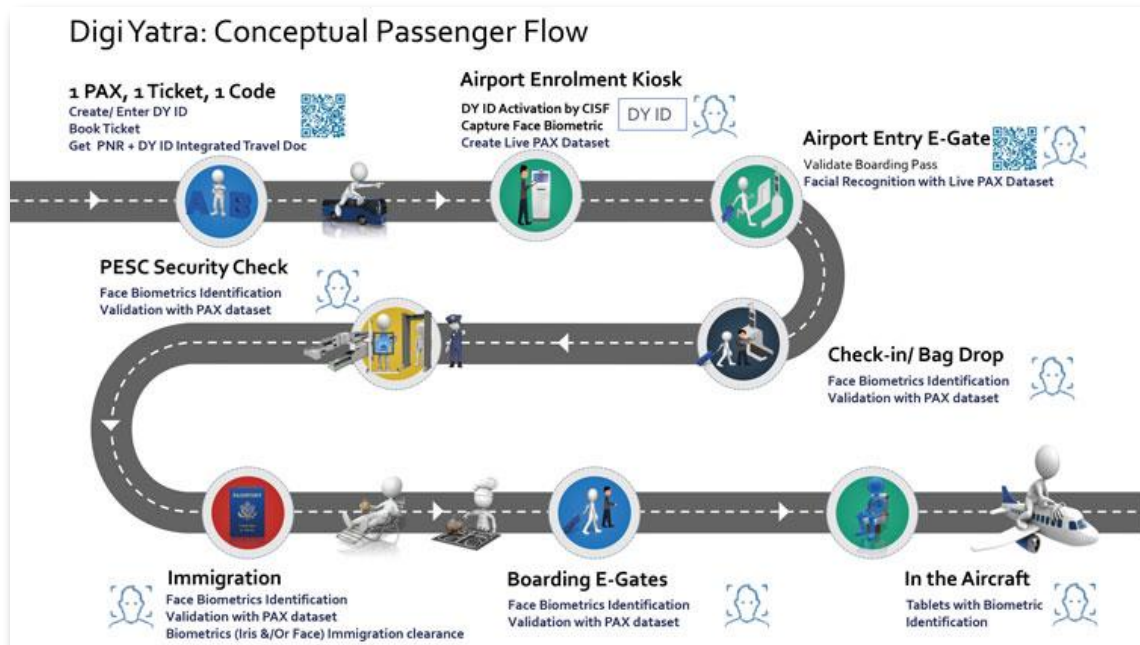
Conclusion

The biggest risk to any airport will be to ignore digital transformation. Every business and organization will be impacted by digital transformation, either directly or indirectly, and airports are certainly not immune to digital disrupters. Ground operations are essential for an airport, as it focuses mostly on a seamless passenger journey, but non-aviation earning structures are also important. Digital transformation is a complex process that is not going to be implemented over night, so a step by step approach is required. The key to success is having the right, digital-savvy leaders in place, empowering people to work in new ways and giving day-to-day tools a digital upgrade.

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