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**Conference Paper**

## Airports - a Platform for IoT technology?

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**30th ITS Conference**

Track - IoT

Airports - a Platform for IoT technology?

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## Executive summary

This paper is a case-study exploring how and what makes IoT a very successful technology applied in the specific context of an airport. The author focuses on how IT systems and users interact in a unique environment which shares many characteristics with a city, hence the author starts his investigation into the concept of the airport as a Smart City and the Airport-City-as-a-Platform. After analyzing the City-as-a-Platform literature, notably Anttiroiko's work on the raise of participatory innovation platforms in Finnish Cities, the author posits that although cities and airports are both platforms for IT and IoT systems, cities has an inherent welfare element that airport management lacks *pace* key performance indicators such as Levels of Service (LOS). Moreover, the track record of IoT in the airport context, including early IoT precursors systems such as sensors and RFID tracking tags, have a longer proven record of success in the airport context, while in many other industries IoT is still an emerging technology.

The airport IoT success record and challenges lend itself to closer scrutiny, notably to consider in which phase of the technology life-cycle does the success lies. Driven by the experience of his colleagues in the Connected Airport sector, the author divides the technology life-cycle phases into three segments: technology choice, technology implementation and technology optimization and operation. In order to discern the success factors that work for IoT technology in the airport context, the author devised a survey to capture the areas where colleagues agree are the most conducive to success. For the purposes of this paper, the survey on "Implementation of IoT and Digital Transformation in the Airport Industry" was created and disseminated amongst airport IoT practitioners. The paper concludes with an analysis of results.

Key words:

Airports, Smart Cities City-As-A-Platform, survey, IoT integration, IoT technology maturity.

## Introduction

In Anttiroiko's (2016) seminal work on the City-As-A-Platform (CaaP), Smart Cities are defined as *"multi-dimensional urban development model[s], in which technological advancements are used to enhance collective intelligence and systemic capabilities, aiming to enhance competitiveness, effectiveness, quality of life, and sustainability in the urban community."* The article discusses how connected airports can be conceptualized as exemplar platform entities, yet despite similar business models serving both internal and external shareholders, airports notably differ from Smart Cities in that the former do not necessarily carry inherent welfare and community voting concerns. Moreover, IoT adoption in airports has a long positive track record and are considered a success story of early IoT adaption.

The long track record of IoT and proto-IoT adoption in airports has led the author to consider what phase of the emerging technology life-cycle – largely divided into technology choice, technology implementation and technology optimization – is responsible for the digital maturity of IoT in the airport context. This paper seeks to answer to that research question by surveying the IT consultants responsible for new technology implementation in airports. The 11-question survey in in annex and preliminary results are discussed in the second part of this paper.

## I. Airports and IoT

The Airport Cooperative Research Program (ACPR, 2018) define airports as the vital international hub of commerce, travel and logistics, which underpin the world economy. Divided into two large operating clusters, the airport is where representatives of the international aviation regulation system that regulates air traffic operations from within secure facilities (“airside area”) will meet the ground operations of the airport owners that provide services and facilities to passengers, cargo, concessions and airport-adjacent industries such as hospitality, parking, local transportation access (“landside area”).

Airport owners and operators are confronted today with the need to introduce new technologies and innovation to better integrate airport silos, and to better answer the expectations of global markets.

As in many industries today, from manufacturing to service-led city governments, digital transformation (DT) and service-oriented Internet of Things (IoT) technologies are becoming recognized and widespread solutions to meet the above goals.

In this context, IoT is considered a major technological enabler and opportunity for digital business. From a technical point of view, IoT can be perceived with Ginsberger (et al. 2011) as

*“Cyber-Physical Systems (CPS) [...] with embedded software [and ...] sensors directly recording physical data and acting on physical processes by means of actuators. This collected data can be evaluated and stored and interacted actively or reactively with the physical as well as the digital world. [This data is ...] connected among each other and in global networks [...], is globally available [and provides] services of dedicated multimodal human-machine interfaces.”*

From a business point of view, the Internet of Things can be understood as the convergence of informatics (IT) such as software and operational technology (OT), hardware and machines with the added business models that derive from data acquisition. In the IoT domain, the acquisition of information (“data input”) notably through sensors and collecting information from connecting devices. Data input also includes securely storing the information along with processing and analyzing the data. The “data output” function consists of describing the data, running prediction models, and using insights for prescriptive measurements and visualization to complement the data output.

IoT combining the data input and data output functions allow for “things” to perform more efficiently, to create new products, or/and to derive business revenue from new sources. (Zmud et.al. 2018). These three factors create possibilities for entirely new business models based on the convergence of physical devices and informatics such as in cyber-physical systems. Through CPS physical entities can be controlled fully not solely mechanically but by software. This revolution in IT applies to the logistics and transportation sector as well, of which airports are a significant part.

The aviation and airport industry are facing specific challenges. Foremost aviation is sensitive to safety and security which results in strict procedures, and process regulations. This may lead to a strong scrutiny of new technology. Moreover, the growing demand in air travel is set to outpace the capacities of airports. The IATA has estimated that 3,2 billion flights took place in 2016, and that this number will grow to 7,2 billion in the upcoming years. Constrains on this growth are limited airspace, limited capacity in airports and air-control. Environmental concerns such as carbon dioxide emissions become more important for consumers and legislators alike. Digital consumption is

already high in the transport and air travel agency. In many ways, the industry is a forerunner of using platforms such as online travel agencies, the international Amadeus system, or in more specific silos, the Airbus Skywise platform for plane maintenance. Digital technologies are profoundly transforming value chains and business models worldwide, and now airports face massive opportunities to extend their existing business models. (De Nadaillac 2019).

### 1.1. Airports as platforms or Airports as Smart Cities

The author's institutional employer, Atos, the digital service provider, conceptualizes Smart Cities as a multi-sided platform, involving public interest, public engagement, business viability, and market opportunities. These four factors shape the smart city environment for every participant from ordinary citizens, mum-and-pop shops to major corporations that engage in joint projects, targeting their own specific goals. Technology and a smart governance enable Smart City commercial activities, which is data driven and provide a return to the citizens (Atos 2015).

The setting of airports significantly differs from a city. Airports, like other large organizational structures, tend to have silos consisting of systems and data. There can be a moat between operations with high compliance regulations, and other parts of the airport. To understand airports as a multi-sided market, one needs to consider that revenue for airports are from several sides: from airlines and from passengers or cargo related services, as well as from services provided directly to these two sets of end-customers. This allows the author to consider airports to be platforms that link between passengers and freight or airlines. The airport industry adds value to all sides by internalizing network effects which exist between these groups. (Gillen 2009)

### 1.2. Airport IoT success factors in technology choice, technology implementation, technology optimization

IoT applications evolve around data, availability and quality of data provided. Even with the technology stack in place, projects spent much of their energy, time and resource cleaning and combining data from different sources, a characteristic shared with other data science or big data projects. The quality of the data determines the quality of the overlying applications. In the design phase, such data related requirements demand special consideration when building IoT based applications. The related cost for data quality control need to be taken into account when evaluating the costs of building and maintaining IoT solutions. Data quality of external sources need to also be considered.

Unlike a system failure in a smart home that probably won't cause a life-endangering situation, a glitch in connected airport may cause injury, loss of life and reputational risks. Therefore, security and safety measures are of utmost importance.

A connected airport requires smart IoT management able to cope with a heterogenic environment with potentially multi-vendor devices run by various companies. This may represent a potentially large number of managed components and devices, depending on the size of the airport. Airports are composed of complex relationships between service providers, e.g. private luggage handlers for delayed flight, and this dynamic environment must deal with sudden interruptions, such as flight cancellation and rerouting of luggage and passengers.

To implement new technology in this fraught environment, the airport authorities proceed with caution, and experience. Is it the airport-specific context, which is the reason why IoT technology has taken hold in the Aviation industry? Or is it on the contrary, the methods employed to choose, to implement and to optimize IoT technology in this domain that contribute to the success factors in

the “Connected Airport” field. In the following section, the author designs a stated choice survey for a specific focus group, in order to explore how and what makes IoT a very successful technology when applied in the specific context of an airport.

## II. Survey “Implementation of IoT and Digital Transformation in the Airport Industry”

A core tenant of this paper is that IoT is a very successful technology applied in the specific context of an airport. This is moreover confirmed by a comment left by “senior practitioner” who partook in the author’s study:

*“Airport traditionally have remote sensors (to count passenger flow, to check gate status), use mobile vehicle location systems for airport airside vehicles and have databases with business process and milestone management for ground staff. IoT is a buzzword but the reality of deployment at airport since the end of the last century has not waited for the general [public] to speak about IoT”*

As ascertained in the previous section, the Internet of Things has found a fertile ground for application in the airport context. Our survey on the “Implementation of IoT and Digital Transformation in the Airport Industry” does not seeks to determine if IoT exists in airports, but instead what exactly contributes to the success of the many new IoT case study adaptations and digital transformation in the “Connected Airport” domain.

### 2.1. Methodology and choice of respondents

In designing the survey and its administration, the author chose one target focus group of experts that are potentially willing to honestly respond to a survey and to best reveal the actual mechanisms of the technology implementation world: the author’s colleagues working as well in the aviation and avionics sector. The “Aviation Community” colleagues are an internationally group of experts who are work “on site” and on per specific project basis on airport-related technology projects. The global market leader for transport sector, to which the Connected Airport as a topic belongs, promoted the survey on an internal collaboration platform to gather respondents through this channel.

Data is collected through a stated choice questionnaire (SC) otherwise known as a stated preference (SP) survey with elements of revealed preferences (RP) techniques. According to Hess and Rose (2009), a correct SP survey design allows for robust results with smaller sample sizes. Although for clarity purposes the author chose to design a discrete choice type model, also known as the traditional “pick one choice”, the simplistic binary choice sets which do not bear resemblance to real-life scenarios were avoided. Instead to increase data richness, the author offered greater variability in alternatives and attributes for each question. The SP survey was designed, administered and analyzed with the Microsoft Form apps.

This technology-agnostic survey seeks to determine the experience of implementing IOT and DT solutions in the airport industry by the practitioners tasked to instigate change in this unique environment. The 11-question survey was designed to determine which part of the technology life cycle – technology choice, technology implementation or technology operations – is the main explainer for the success of IoT adaption in the airport sector. To this end, the three main themes were interwoven in the survey so that between 1 to 3 questions were allotted to each phase. After leading with a consistency check in the first questions that helps ascertain that the respondent has at least several months of experience on specifically “connected airport” projects, and whether

these projects fall within the scope of our study, the remaining of the questions can be divided into three groups. Those that pertain to the technology choice (question 4 on the planning processes, question 5 on business goals, question 6 on the decision process). A second group that related to the technology implementation (solely question 7 on the initial roll-out.) And a final group that refers to technology optimization (question 8 on the wider airport context and question 9 on what emphasis had technology integration). Question 10 directly asks which of the above aspects best explains the success of IoT in airports. The recursive nature of question 10 that ask overtly about the success factors in IoT adaption in airports, which are covertly studied in the previous questions, enriches this survey with aspects of RP techniques. The last question captures additional qualitative input.

## 2.2. Discussion of Results

The respondents are experienced practitioners, with 40% percent of the respondents declare having worked over 24 months on IoT projects in the airport context. The remaining 60 % of responses were equally distributed over the remaining choices of 1-5 months, 6-12 months, and 13-24 months of total months spent on “Connected Airport” work. The scope of the projects shaped the experience of the respondents. The scope was a tie between projects that dealt with customer experience (4 projects) and projects that dealt with efficiency and optimization (4 projects) whereas two projects dealt with monitoring system use or security. One respondent noted that the scope of their specific projects was at the crossroads between customer experience, and efficiency and optimization such as *“passenger process, aircraft and flight preparation process”* (The quote is from a comment left in the Other attribute that allowed respondents to write-in a response).

The projects the experts worked upon fall within the scope of our study, as none of the projects were one-off solutions or single-point solutions (such as automated check-in kiosks) but instead all projects required some level of integration across airport silos and either new or existing technologies. Most of the projects were facility-wide solutions (40% of responses) with about a further 25% each on airport operating systems and a specifically an “ecosystem approach”. In the Other attribute, a respondent wrote-in that he worked on a project that dealt with online platforms for customer service – a project that combines at once an ecosystem approach, a facility-wide approach and integrates airport-specific operating systems.

The remaining survey results serve to be discussed within their specific topic area to best ascertain which point in the technology adaption lifecycle is most conclusive to IoT success in airports.

### Technology Choice

Questions pertaining to the process during which the technology was chosen aimed to carefully separate how the technology was chosen (question 4) from the business goals (question 5), and from the decision process management (question 6).

In terms of how the technology was initially chosen, the responses tied on the airport providing an agile iterative procurement mechanism (33.33% of responses) and a mixture of waterfall project management and iterative procurement (33.33% of responses). Worth noting is that none of the projects utilized a design-assisted methodology such as Design Thinking, the Business Model Canvas or the Business Model Navigator to determine what technology should be implemented. A comment left behind by a respondent stated instead that *“Airports are (often) in full control of the design.”*

However, in terms of the exact decision process management, 80% of the respondents agreed that airports favor a collaborative approach engaging users and stakeholders, and not a decision process that relies on a single source of accountability or leadership.

The query related to the business goals allowed for multiple choices, therefore it is worthwhile to note which two choices were not chosen by any of the respondents as being a determinate factor: neither the business goal to capitalize on existing resources nor that on the value of new data. Instead four other business goals gained in prominence: (a) the service-centric goal, or the ambition to provide a better service for a given aspect of the airport operations, (b) diminishing transaction costs, or following Coase theorem, the goal of optimizing service, (c) Long-term relationship perspective, or a future-oriented business goal, and (d) Environmental or Corporate Social Responsibility, or a variation of the future-oriented business goal.

The choice of the attributes to question 6 follow the guiding principles for designing business models for the Internet of Things, as discussed in Chia Tai Angus Lai *et al.* (2016). The authors offer this solution to exemplify that all IoT business applications will evolve into business models that focus on developing an ecosystem around IoT.

Before determining if the success factors lie in the method by which technology is chosen, it is worthwhile to analyze the survey results as pertaining to technology implementation and technology optimization and operation.

#### Technology Implementation

Question 7 pertains to how the project roll-out was planned – per a controlled space environment (eg. in one pilot area), in a constrained time window (per single iteration in an agile workstream) or instead was the new technology “switched” on throughout the facilities at once.

60% of the projects were rolled out in a pilot area first scheme, the rest of the responses were evenly divided amongst the option of a facility wide sudden switch and a roll-out by iteration. Given that the majority of the projects started with a pilot area, in a controlled environment, this indicates a conservative philosophy of technology roll-out that doesn’t necessarily indicate process innovation in how the technology is served to the end-users.

If the success factor of airport IoT is due to the technology roll-out method, this would put into question the usefulness of the novel methods of procurement and agile project management. However, technology implementation is the focus area of the Connect Airport practitioners, and our focus group in particular. There may exist a bias in favor of technology implementation as a major source of the success of IoT in airport simply because experts in a given field believe their own efforts to contribute to most to the success of their projects.

#### Technology Optimization

The following two questions relate to technology optimization and operations. Question 8 asks whether the focus of the solutions was rather on optimizing the efficiency of the service that the new technology is applied to, or to enhance interaction and streamlining of the service with other airport systems, or if the focus on a wider, more holistic, future-oriented approach. Question 9 seeks to determine directly where in the context of the “Connected Airport” was the focus on system integration the strongest: at onset, at implementation or was the focus minimal after all.

Nearly 60% of the responses indicated that the focus of the solution was applied to optimizing a given service, while 28% indicated that the solutions focused on adaptability and scalability or other



long-term considerations. A final 14% indicated that the solution was focused on optimizing interactions with other airport systems. Focusing solely on the system integration angle, the respondents confirmed that the integration element was not a negligible part of the project, however opinions were neatly divided into whether the challenges related to integration were thought-through at the onset of the project (33.33% of responses) or whether the new technology in one system area did or will require a new technology upgrade or retrofit in another (33.33% of responses).

Both questions taken together seem to indicate, as expected, that integration is a core factor in the “Connected Airport” domain, nevertheless the bulk of the work remains optimizing one given service. If the success factor of airport IoT is due to the technology optimization and on-going operations, it could indicate that the easy maintenance of the systems or simple integration contribute to the proven success of IoT in the airport context, which could translate into business models that revolve around better service-level agreements and long-term technology partnerships.

What are the success factors?

The last question of the survey directly asked the respondents which of the above questions most directly influenced the continuous multiple applications and high success factor that IoT is currently experiencing in the airport context.

The author divides the previous questions into 4 loose categories: the airport-specific context (question 1-3), the initial methodology of technology choice (question 4-6), technology implementation (question 7), and technology optimization and operations (questions 9-10).

Regarding success factor for the project it should be highlighted that despite fears that there may exist a bias in favor of technology implementation as a major source of IoT airport success given the focus group, on the contrary of this assumption, none of the respondents chose “technology implementation” as a factor contributing to the success of IoT in “Connected Airports”. This could indicate that the exact implementation methodology is like the IoT implementation in other industries such as manufacturing or city government, which does not explain the success factor in the airport context.

However, the specific airport domain - such as airside and landside management - doesn’t explain the success of this technology in this context either, since only 14% of responses attributed the success to where the technology was specifically applied (question 2). This is the same amount of responses that attributed the success to the IoT technology optimization and integration (question 9). This does not indicate that the context is negligible, since airports are a highly unique focus area. One anonymous respondent writes in the comment section:

*“Important in the [airport] context is also the interaction between airport systems and airline systems (arrival/ departure, frequent traveler programs, booking systems, passenger identification, security). The airport typically focuses on a single location, the airline has a subset of data needs, but for many destinations.”*

Moreover, airports and airlines host many subcontractors which brings upon the airport difficult management choices. Another respondent anonymously writes:

*“One of the main topics in the project where I worked on was data ownership. Many subcontractors bring in their own IoT and want to have the data. However, this airport is keen to have all data centralized in its data platform, owning all data.”*

Additionally, it is important to keep the Airport specific regulations into account. An anonymous colleague mentioned, that success depends on considering the high degree of Airport specific regulation into account.

Instead of choosing the airport-specific characteristics or the actual method of IoT technology implementation, a strong 71% of responses clearly indicate that success lies in the methodology of how the technology was chosen. Within this area, 20% attribute the success to the decision process, 20% to the technology selection mechanism, and a resounding 60% specifically indicate that the airport management's business goals are the single most noteworthy attribute that explains the success factor of IoT in the "Connected Airport" context.

## Conclusion

The long track record of IoT and proto-IoT adoption in airports has led the author to consider what phase of the emerging technology life-cycle – technology choice, technology implementation and technology optimization or is it the "Connected Airport" context by itself – is mainly responsible for the digital maturity of IoT in the airport context. This paper begins to answer this question by a SC survey of IT practitioners who seems to strongly indicate that success lies in the methodology of how the given technology and the approach were chosen, with a majority leaning towards attributing IoT success to the airport management's business goals, which are service-centric, future-oriented and aimed at diminishing transaction costs.

Connected airports are exemplar platform entities, with similar levels of governance and services as a small smart city. However despite similar business models serving both internal and external shareholders, airports notably differ from Smart Cities in that the former do not necessarily provide a voting or participation process for their "citizens" - and IoT instead of being an emerging technology, has instead a long and positive track record in the airport context.

IoT solutions, that have clear and tangible benefits, more easily communicable and implementable. Safety and security, solutions providing information to deal with sudden interruptions and a better use of resources are low hanging fruits, these kinds of projects have been implemented.

This paper seeks to make a major effort in providing a solid contribution, interesting for academics and practitioners alike, in the question of what drives success in a complex technology platform integration project. For both academic inquiry and practitioners' best practices, more work needs to be accomplished in pinpointing the areas to focus upon in a digital transformative journey. Although the paper highlights Connected Airports as an area where IoT technology is flourishing, more research can be led on supporting a multidisciplinary approach to Smart City platforms and this could stimulate further research on Connected Airports and other facilities that can act as City-As-A-Platforms.

## Acknowledgements

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Annex:

### Implementation of IoT and Digital Transformation in the Airport Industry

Airports, a major national resource, are also the vital international hub of commerce, travel and logistics, which underpin the world economy. The airport is considered a terrain where international aviation regulation system regulates air traffic operations. This is from within secure facilities ("airside area"), which will meet the ground operations of the airport owners. These operations provide services and facilities to passengers, cargo, concessions and airport-adjacent industries such as hospitality, parking, local transportation access ("landside area"). This industry today is confronted with the need to introduce new technologies and innovation to better integrate airport silos and to better answer the demands of global markets. To this end, digital transformation (DT) processes and service-oriented Internet of Things (IoT) technologies are becoming recognized and widespread solutions adapted by airport operators. This technology-agnostic survey seeks to determine the experience of implementing IOT and DT solutions in the airport industry by the practitioners tasked to instigate change in this unique environment. All or part of the results of this survey will be presented at the International Telecommunications Society Conference 2019 "Towards a Connected and Automated Society" in Helsinki, Finland. Results may also be used in the thesis for a degree in Wirtschaftsinformatik at the University of Bamberg. For more information, please contact: Peter Baum Senior IT Consultant – Business and Process Optimisation - Atos [Peter.Baum@atos.net](mailto:Peter.Baum@atos.net)

1. What is the total amount of months you worked on projects relating to DT or IoT integration in the airport industry ("Smart Connected Airport")?

*1-5 months*

*6-12 months*

*13-24 months*

*more than 24 months*

2. What was the technology scope of the project(s)? (please tick all that apply)

*Customer experience*

*Monitoring (system use or security)*

*Efficiency/optimization*

*New product/revenue stream*

*Autonomy/robotics*

3. What was the application area of the innovation(s) or new technology adoption project(s):

*A single-point solution (ex: automated check-in kiosks)*

*Facility-wide solution (ex: IT for airport specialty systems)*

*Airport operating environment solution (ex: from airside to landside security response system)*

*Ecosystem approach (decentralized connection of independent systems/operators)*

4. In your experience, how was the initial technology-selection process planned with the airport operator?

*With a design-assisted method such as Design-Thinking, the Business Model Canvas, or the Business Model Navigator.*

*With agile or iterative technology procurement contracting*

*With traditional waterfall procurement contracting*

*Mixtures*

5. What was the business goal during the technology selection process? (please tick all that apply)?

*Service-Centric goal*

*Value co-creation goal (product/revenue stream)*

*Diminishing transaction costs*

*Capitalize on the value of new data*

*Existing resource integration*

*Business Ecosystem management*

*Long-term relationship perspective*

*Environmental or Corporate Social Responsibility issues*

6. What was the decision process during the technology selection process?

*A single source of accountability or leadership*

*A collaborative approach engaging users and/or stakeholders*

7. How was the initial roll-out planned in the airport context?

*Roll-out per pilot area (controlled space environment)*

*Roll-out per agile iteration (controlled time environment)*

*Whole facility/staff/environment switch*

8. How was the solution applied in the wider airport context?

*Focus was given to enhance current interactions with other airport systems*

*Focus given to current technology optimization (ex: operational efficiency)*

*Focus given to scalability and / or stakeholder, ecosystem or other long term considerations*

9. What was the focus on the integration between airport systems?

*The focus on technology integration was minimal (or technology integration with other airport systems was not a focus of the project)*

*The integration was streamlined in the technology selection process (and therefore all or part of the integration challenges were anticipated and mitigated)*

*The integration required or requires a technology retrofit*

10. Which of the topics touched in the questions had the largest impact on the success of the project(s)?

*Please choose up to 3 topics*

*Choice of Technology field (Question 2)*

*Application area of the innovation(s) or new technology adoption project(s) (Question 3)*

*The initial technology-selection process and planning (Question 4)*

*The business goals during the technology selection process (Question 5)*

*The decision process during the technology selection process (Question 6)*

*The initial roll-out planned in the airport context (Question 7)*

*Form of application in the wider context (Question 8)*

*Focus on the integration between airport systems*

11. Please share any relevant observations, experience or comments you have to the questions above.

Submit

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