Arthur D Little | amadeus

Airport digital transformation

From operational performance to strategic opportunity

Foreword

Unlocking the power of technology to build the airport of the future

The pressures within the airport environment due to increased demand for global air travel, infrastructure constraints in many markets and increasing traveler expectations are intense.

In this context, the challenge for airports is to maximize existing infrastructure, improve efficiency and ensure that their proposition delivers value to all stakeholders.

We initially commissioned Arthur D. Little to explore the role of technology in helping to reduce cost, an important issue for all businesses and indeed for many airports. However, it became clear throughout the research process that airports view technology, as do we at Amadeus, as an enabler of business transformation as well as a tool for cost reduction.

As a result, this paper provides valuable insights into how technology can be deployed to build the digital airport of the future. It highlights the different process areas where the application of technology can deliver the most value and the critical success factors toward digital transformation.

The paper also offers insight into some of the specific technologies that have a major impact on the evolution of the airport. The benefits of these technologies range from cost reduction and operational efficiency through to enhanced passenger experience.

And while understanding the role of technology in cost reduction was the primary driver of this research, we are delighted that Arthur D. Little has been able to set this into a wider and more comprehensive context.

We hope you enjoy reading this paper.

John Jarrell
Head of Airport IT, Amadeus

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Executive summary

In the context of sustained growth in air travel, rapid advancements in digital technology and ongoing cost pressures in the global aviation sector, Arthur D. Little has conducted a research study to examine the potential for digital technology to reduce total airport operating costs.

What the study highlights is that, while digital technology certainly has a role to play in helping airports extract greater efficiency from both OPEX and capital outlays, the benefits of effective digital transformation go far beyond cost reduction. Faced with multiple pressures, airports, it is argued, are rapidly approaching a 'tipping point' beyond which the needs and expectations of passengers, airlines and shareholders can no longer be met. In order to access the full range of benefits associated with more advanced levels of digital maturity, airports of all sizes need to re-evaluate traditional approaches to technology deployment, and embrace the concept of ecosystem-level digital transformation.

On a positive note, the progress made in transitioning away from the 'new normal' of self-service and process efficiency toward the use of digital to optimize flow monitoring and passenger processing, must be noted. In recognition of this journey – which for many airports is far from complete – this study highlights the role of specific digital technologies, including cloud and big data, but also Internet of Things, virtual modeling and simulation and collaborative smart machines and robots, in enabling transformation.

The promise of greater cost efficiency, but also enhanced capacity, operational resilience and passenger experience, resonates with all airports. Yet, if airports are to realize the full potential of digital transformation and its associated benefits, there remains much to do. As this study highlights, to achieve effective digital transformation, airports must confront and overcome a number of challenges. At the most fundamental level the issue is how to first understand the different technologies available,

and second, identify the practical applications that can deliver tangible benefits. To do this, airports must develop their own internal technological capabilities. Equally, while one could be forgiven for assuming that cost is a major barrier to the adoption of digital solutions, what this study finds is that, in many cases, it is the 'soft' cultural issues that are an even greater impediment. If airports cannot overcome the cultural and organizational barriers to change, then the material resources at their disposal will be of limited consequence, and the chances of digital transformation success will be much reduced.

Based on interviews with over 15 major airports and the views of selected industry experts, this paper demonstrates that the path toward airport digital transformation is not an easy one. Airport executives must consider key factors as they shape their strategies including the need for clarity of purpose and effective partnering and collaboration within the airport ecosystem. Furthermore, an ability to shape the required internal culture and sustained commitment needed to make effective decisions on technology selection and implementation are essential for success. For those airports that recognize and address these imperatives, digital transformation efforts can yield true step-change potential. Given the sector's CAPEX-intensive nature, the importance of strong cost discipline will not go away. Nevertheless, for those airports at the digital frontline, it is not holistic cost reduction but broader benefits in the areas of revenue generation, operational performance and the customer experience, that are likely to provide the strongest rationale for the digital transformation agenda.

1. Introduction: digital and the airport tipping point

The aviation sector continues to experience rapid and disruptive change. Arthur D. Little refers to this as the era of hyper-competition, characterized by intense competition for resources between industry players and the blurring of traditional competitive boundaries. In such a context, the consequences for airport business models and their partners in the airport ecosystem have become apparent at multiple levels.

Hub airports, defined as those airports serving in excess of 25 million passengers a year with at least 25% connecting traffic, face strong competition from rival domestic hubs, competing regional hubs and global 'mega hubs'. At the other end of the spectrum, smaller airports are often entrenched in intense regional battles to attract and retain airlines. This creates pressure to optimize their use of more limited infrastructure and finances. In addition, the evolving nature of inter-airline competition and business models exerts further stress on established airport models. Finally, customer expectations, enabled by rapid advancements in mobile and digital technologies, have not stood still, presenting airports with a fundamentally different set of physical and now digital needs relative to 10-15 years ago.

At the same time, airports remain inherently capital-intensive businesses. Although airport ownership structure may influence commercial outlook, all airports are under pressure to optimize the total cost of their operations, including OPEX and CAPEX, without compromising safety or business continuity. Furthermore, to offset growing pressures on aeronautical revenues driven by the growth of Low Cost Carrier (LCC) business models, airports must capitalize on new revenue generation opportunities, whilst always understanding the importance of the customer experience at every step of the journey.

To address these commercial realities, airports must embrace the challenges and opportunities presented by digital technology in a way that goes far beyond incremental process improvement. On the one hand, industry-wide initiatives such as IATA Resolution 753 on baggage handling standards and the recently launched NEXTT[1] program, are signs of growing

1 New Experience Travel Technologies

Figure 1: Arthur D. Little's digital airport maturity model

attempts to define a coordinated approach to digitalization. However, for the most part, airports have been left to define their own digital roadmaps, leaving leading practice to still be defined. Existing airport business models and related physical and IT infrastructures face a 'tipping point', since they were simply not designed to handle the volume of passengers or diversity of airport customer needs that airports are experiencing today.

Equally, faced with the prospect of heavy capital investments and protracted construction phases, airports must anticipate how so-called Airport 4.0 technologies can deliver step-changes in cost performance and investment returns in ways that traditional infrastructure and technology options cannot (see Figure 1).

Last but not least, the cultural change confronting airports, as they face up to the need to embrace digital, should not be underestimated and in many cases will require "radically different ways of working"[2] that are completely at odds with the age, skills and capabilities of the existing human workforce.

In the context of this varied landscape, Arthur D. Little's digital airport maturity model provides a framework through which to assess the different levels of digital airport maturity. As will be demonstrated later in this paper, it can also be used to outline key considerations for airports, as they prepare for inevitable business transformation, while all the while maintaining the safety and continuity of existing operations.

It is with this background in mind that this research paper throws the spotlight on the role that Airport 4.0 technologies can play, not only in helping airports optimize their total cost of airport operations, but also in enabling the holistic enhancement of airport value propositions.

2 Executive, leading provider of air traffic control services

Airport 3.0

Several focused initiatives to leverage digitalization to optimize flow monitoring and passenger processing

Airport 4.0

Full-connected with all stakeholders; superior proactivity and reactivity to adapt to the real-time airport requirements (e.g. operational needs, customer requests)

2. Digital airport transformation: why invest?

At their very heart, airports exist to facilitate the efficient and secure processing of passengers and goods, whether inbound, outbound or transit and transfer. They are also integral to the business models of a number of partner entities, ranging from airlines (in a variety of forms) to baggage handlers and other third-party service providers.

However, despite this common purpose, no single airport is the same and therefore they have different needs and priorities with digital transformation. For example, while for some the allure of digital may be in providing new 'point' solutions to address short-term operational issues, for others the ambition may be to transition to a fundamentally different business or operating model. There is also a more subtle point to make, in recognizing the role that digital has to play in reinforcing airport brands.

Reflective of these varying approaches, airports also exhibit different levels of digital maturity. While the majority of the airports interviewed in this study considered themselves to be transitioning away from the 'new normal' of self-service and process efficiency (Airport 2.0) toward the use of digital to optimize flow monitoring and passenger processing (Airport 3.0), this should not mask important differences between the airports that are on this journey. These include differences in relative technological understanding, ability to act on resulting insights, and the overall cohesiveness and focus of the airport's digital strategy. For example, some airports may be accustomed to extracting the insights from passenger flow monitoring so that they can be used to proactively manage the passenger experience. However, for others, the focus may still be on developing the fundamental monitoring capabilities (perhaps under a pilot) or developing a sufficient understanding of related technologies. The extent to which digital is perceived to replace, as opposed to reinforce existing manual processes also varies, and is a further indicator of digital maturity.

"We will not see complete substitution. Digital is an extra complexity - it does not mean complete substitution of manual processes."

Airport Executive, European Airport

The varying maturity that characterizes the digital airport landscape is also reflected in the different priority that airports attribute to the potential benefits of digital technology. Through interviews with senior leaders and technology experts at major airports worldwide, it is clear that operational efficiency, incremental revenue generation, cost efficiency and customer experience enhancement are normally at the forefront of airports' motivation to invest (see Figure 2). However, the relative priority attributed to each dimension varies in terms of airport size, geographical location, ownership structure, the regulatory regime and commercial mindset.

"Digital is no longer an afterthought addition to existing physical processes, it is becoming an intrinsic part of the airport brand."

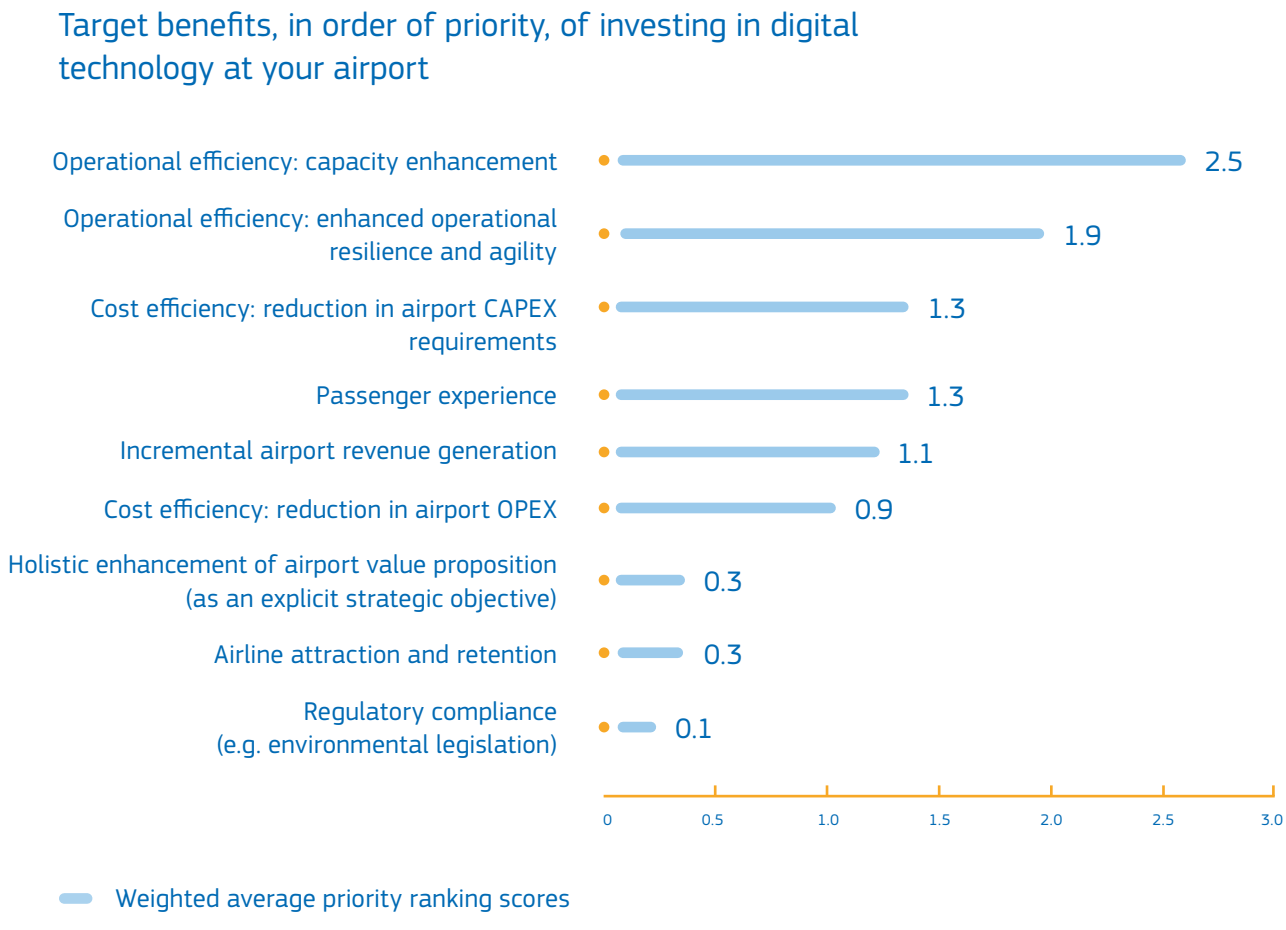
Chris Au Young

General Manager of Smart Airport at Airport Authority Hong Kong

Equally, operational realities cannot be ignored and are also a key determinant of what the top priority benefits are likely to be. While operational performance is important for all airports, capacity-constrained airports are likely to place the greatest emphasis on the use of digital to optimize capacity and enhance operational resilience and agility. By contrast, for smaller regional airports, digital may primarily represent a commercial tool used to attract and retain those airlines that are so essential to an airport's ongoing economic viability. In this light, the value of digital solutions lies in their ability to reduce airline set up costs, as part of an overall airport offering that is geared toward value for money, rather than strict cost optimization.

Nevertheless, while there are differences in an airport's 'digital appetite' according to operational scale, airports are likely to be receptive to the role that technology can play in aiding the recovery from disruption management, such as the lasting impact that severe or persistent delays can have on airport-airline relationships and the customer experience. Geography may also be relevant, not only in shaping cultural attitudes to investment and related approaches to airport regulation, but also because of the location-sensitivity of labor costs and therefore relative appetite to invest in labor-saving digital solutions.

Figure 2: Top priority digital transformation benefits



Finally, it should be noted that, in addition to the attainment of positive benefits, airports' digital investment decisions are also driven by the need to proactively mitigate the costs of non-adoption. Research conducted into the relative priority attributed to a range of so-called digital technology risks (see Figure 3) indicates that the risks of 'doing nothing' are widely acknowledged. Especially where airports see themselves in direct competition with other airports, they appear to be strongly motivated to use digital as a lever of long-term competitive advantage. However, airports are also sensitive to the need to maintain business continuity, and are wary of potential connectivity and resilience issues that could arise, for example, from attempting to transition from technology pilots into full scale implementation - before the application has been truly embedded into established ways of working - or from related cyber-security issues. Considering the prohibitive financial and PR costs of such failures, these concerns can understandably stunt the appetite for digital innovation.

Often, these risks are not exclusive to airports, but also affect their airline customers. In some cases this can result in the establishment of airport-airline partnerships, notably between national flag carriers with dominant home hub positions, to advance a mutually beneficial digital transformation strategy.

Figure 3: Prioritized digital technology risks

3. Current state of the digital airport journey

Top priority technologies so far

In assessing the potential of digital technology to deliver cost benefits for airports, it must first be acknowledged that many airports have already taken significant steps to transition from analogue to digital businesses. But what have been the top priority digital technologies on the journey so far?

Through interviews with leading airports globally, **big data & analytics and cloud computing** were consistently highlighted as the two digital technologies upon which airports had placed the greatest emphasis in recent years (see Figure 4). As one senior aviation executive notes:

"Because infrastructure projects are costly and often disruptive, a data-driven understanding of future demand — such as the expected number of aircraft movements, passenger traffic throughput and air cargo volumes — gives airport planners and investors the necessary information for effective decision-making."

Angela Gittens, Director General, ACI World[3]

Comments such as these reflect the importance of advanced data acquisition and interrogation capabilities, especially in CAPEX-intensive sectors, in enabling airports to move away from the traditional focus on siloed manual process enhancements toward a new modus operandi. This is characterized by an enhanced ability to proactively respond to operational realities and commercial opportunities, and to deliver wider cost, revenue and customer experience benefits for the airport as a whole.

Other digital technologies that have been prioritized by airports in recent years include Internet of Things (IoT), virtual modeling and simulation, and collaborative smart machines and robots. Between 38% and 50% of survey respondents confirmed to having either trialed or implemented digital solutions in these areas, in recent years. Examples include:

_Internet of Things: the sheer volume and diversity of physical assets that exist within the airport perimeter, and their criticality to business continuity, has driven strong interest in IoT-based solutions. These technologies focus on the development of enhanced human-to-machine and machine-to-machine interfaces to deliver real-time and online information on asset location and condition. Such solutions are well suited to being applied in airport environments, especially where there is a desire to increase process automation and where reliance on existing manual ways of working is high. They also pave the way toward the attainment of other benefits. For example, by installing remote sensors on motorized ground services equipment, such as push back tractors, airports can benefit from real-time information on asset location and performance (including maintenance needs). Such applications offer clear benefits for airport resource management and operational resilience. Fixed airport assets that also have a direct bearing on passenger flows and the customer experience, such as lifts and escalators, can also benefit from the application of IoT solutions to improve reliability and availability.

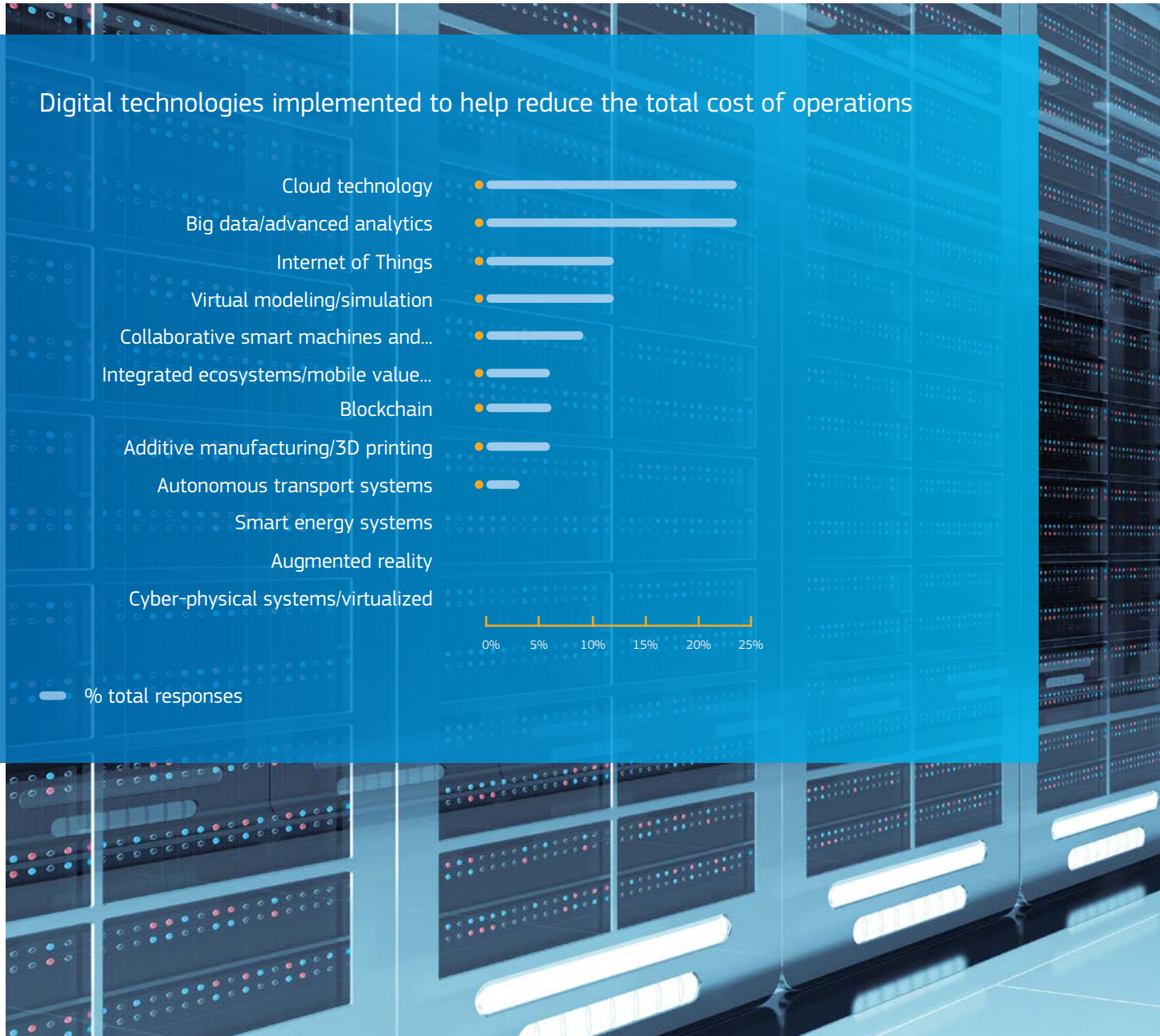
_Virtual modeling/simulation: the interest in virtual modeling and simulation technologies is aligned to the strong focus that airports have placed on optimizing passenger flows. These solutions can help airports more effectively anticipate the impact of different managerial decisions and better allocate human resources, especially at peak times. Since airports are commercial entities and understand the link between a passenger's experience at security and their propensity to spend at the airport, airports have a vested interest in using these technologies to help them to effectively match passenger flows and airport resources. Such applications are not limited to the airport terminal and can also help airports to improve flight management performance, for

3 ACI press release 26 September 2016

example by foreseeing the impact of flight delays and making optimal use of runway capacity.

_Collaborative smart machines and robots: already deployed across many airports in pilot form, smart machines and robots are increasingly gaining traction as permanent additions to the physical infrastructure of an airport. Check-in is a typical area for deployment, with robots such as Munich Airport's Pepper and Watson able to provide customers with clear and consistent information to facilitate their journey through the airport. Clearly, an airport's appetite to supplement, augment, or replace labor with machines and robots will be influenced by its cost of labor. Further, it is also affected by prevailing attitudes to technological innovation and adoption among key airport stakeholders and passengers themselves, so must be seen as context-specific.

Figure 4: Digital technologies already implemented



Typical implementation challenges

However, what is also clear is that, in attempting to realize their digital transformation plans, airports face a number of barriers to digital investment (see Figure 5). Although implementation cost is inevitably an important factor, the results of the study highlight that the inhibitors to digital transformation are by no means limited to 'hard' factors. Indeed, 'soft' issues related to airport ecosystem culture, failure to satisfy traditional Return On Investment (ROI) assessments and insufficient understanding of digital needs (or concluding that there is not sufficient demand for digital solutions) were more prominent barriers than cost. The net impact is to either impede the full realization of target benefits, or else mean that the proposed digital technology solutions never receive budgetary sign-off to get off the ground.

There would also appear to be a relationship between an airport's operational scale, and the kinds of implementation challenges that are typically encountered:

Smaller airports (i.e. with annual passenger volumes of around 10Mpax) often flagged limited financial resources, uncertain ROI and the prohibitive cost of failed investments as reasons to pursue a more conservative digital agenda. At the same time, the digital lever is still an important one for small airports, since it can help to offset the need for costly CAPEX investments that their balance sheets cannot afford. Therefore for these airports, a very selective approach is often needed to maintain a compelling value-for-money offer that remains attractive enough to airlines.

By contrast, for so-called 'mega hubs' (i.e. more than 50Mpax), up-front investment costs appear to be less of a brake on digital investment. Indeed, several of the largest airports that participated in the study indicated that, as part of an emerging 'spend to save' mentality among the more digitally advanced airports, they are prepared to spend more on digital solutions. In other words, while these airports certainly require a clear investment case, qualitative factors including the airport's investment mind-set and friction resulting from conflicting departmental priorities, were highlighted as the more typical sources of frustrated investment efforts.

Finally, while not directly related to airport size, ownership model and regulatory regime may also be important factors when assessing cultural attitudes to technology innovation and their ability to overcome related implementation challenges.

If there are differences in the barriers to digital technology investment, according to an airport's operational scale, there is also some common ground. For most airports, regardless of size, the sheer choice of digital technologies available was consistently flagged as an inhibitor of clear investment decision-making. Nevertheless, this issue would still appear to be accentuated for smaller airports, due to their more limited financial resources and reduced ability to weather the costs of failed investments.

Finally, on a more practical note, airports of all sizes stressed the difficulties that can be experienced when attempting to transplant digital concepts into people's day-to-day roles. Especially where airports have developed well-established teams dominated by non-digital roles, one cannot assume that the in-situ analogic workforce will readily adapt to digital ways of working that are neither trusted nor familiar. While the technology may be ready, real-life experience suggests that the people-readiness challenge should not be underestimated.

Figure 5: Prioritized barriers to digital investment

4. Future outlook: the role of digital in driving cost and efficiency benefits

If the focus in recent years has been on the development of advanced big data and analytics capabilities, then looking to the future, what is the role that digital can play to help airports to reduce their total cost of operations and improve the efficiency of core airport processes?

To address this question, the study first considered the relative IT cost and efficiency of eight core airport business processes, ranging from resource management and baggage reconciliation to FIDS and business systems (see Figure 6). Following this, airports and other industry experts were consulted to provide specific insights into how they expect digital solutions be applied to reduce the cost and enhance the efficiency of these processes in the future.

IT cost assessment

Figure 6 provides a consolidated view of the typical allocation of airport IT OPEX and CAPEX across the prioritized airport business processes. While the actual sums invested can be significant across all of these processes, it is perhaps not surprising to see that flight management, resource management, CUTE/CUPPS and business systems are typically the major drivers of airport IT cost as a percentage of total IT expenditure.

Figure 6: Typical IT spend across core business processes (percentage of total IT budget)

Nevertheless, there are some key points to highlight:

_High cost processes not necessarily targeted by airport digital strategy. In discussions with leading airports, they were quick to differentiate between mission critical 'must have' expenditure, and other expenditure. In the case of flight and resource management, airport executives consistently saw these costs as an unavoidable part of day-to-day airport operations, and therefore not a major focus of the airport's digital strategy. In our experience, digital applications to date have tended to focus on process automation and passenger flow enhancement, not reduction of headline IT costs. This is consistent with airports that are on the journey from Airport 2.0 to Airport 3.0

_CUTE/CUPPS inefficiencies consistently highlighted: perhaps reflected by the relatively high proportion of IT spend that is consumed by CUTE/CUPPS applications, maintenance and hardware, airports see significant scope to reduce the cost of existing check-in systems and processes. To cite a practical example, a common challenge facing many airports is the need to cater to a variety of different airline needs with regard to check-in facilities and solutions. This means that, while the airport may see value in transitioning to common use platforms and interfaces, in reality the benefits of common use cannot be realized in full as long as some airlines are not ready to migrate and continue to insist on airline-specific platforms. Although this may be less of an issue in countries with access to cheap labor, in high cost locations the need to maintain a multitude of airline-specific applications and network connections at a single kiosk exposes the airport to incremental cost and can be very expensive over time.

"There is an ongoing need for airports to provide lowest common denominator solutions [to airlines], meaning that airports must still provide check-in kiosks. That means that the cost does not go away."

Executive, leading provider of air traffic management services

_ACDM regarded as a major opportunity for digital transformation. Although ACDM spend is not the biggest IT cost item today, most of the airports interviewed expected expenditure on ACDM to increase in the future because of the broad benefits that improved coordination can bring for the wider airport ecosystem. For example, one major German airport highlighted its implementation of an ACDM solution to optimize aircraft movements, thereby reducing average taxi distance, on-ground congestion and resulting delays.

_Passenger flows remain a key focus area for all airports. Even though passenger flows are not the biggest cost line item in airport IT budgets, as borne out by the feedback from the airports surveyed, optimization of passenger flows is essential for operational and commercial reasons. It should also be noted that a key part of passenger flow optimization is associated spend on security systems. This spend is not included in the passenger-flow data, however was highlighted as a major cost item by nearly all of the airports that took part in the study.

_Relationship between IT cost and asset lifecycle. Finally, while these findings are informative, care should be taken not to draw premature conclusions on the relationship between airport business processes and typical levels of IT expenditure. For example, the level of spend on CAPEX-heavy processes such as FIDS and baggage systems is highly dependent on the age and condition of the existing installation. There will naturally be some variation on IT OPEX and CAPEX costs across these business processes, with some airports enjoying a lower cost.

Cost and efficiency assessment

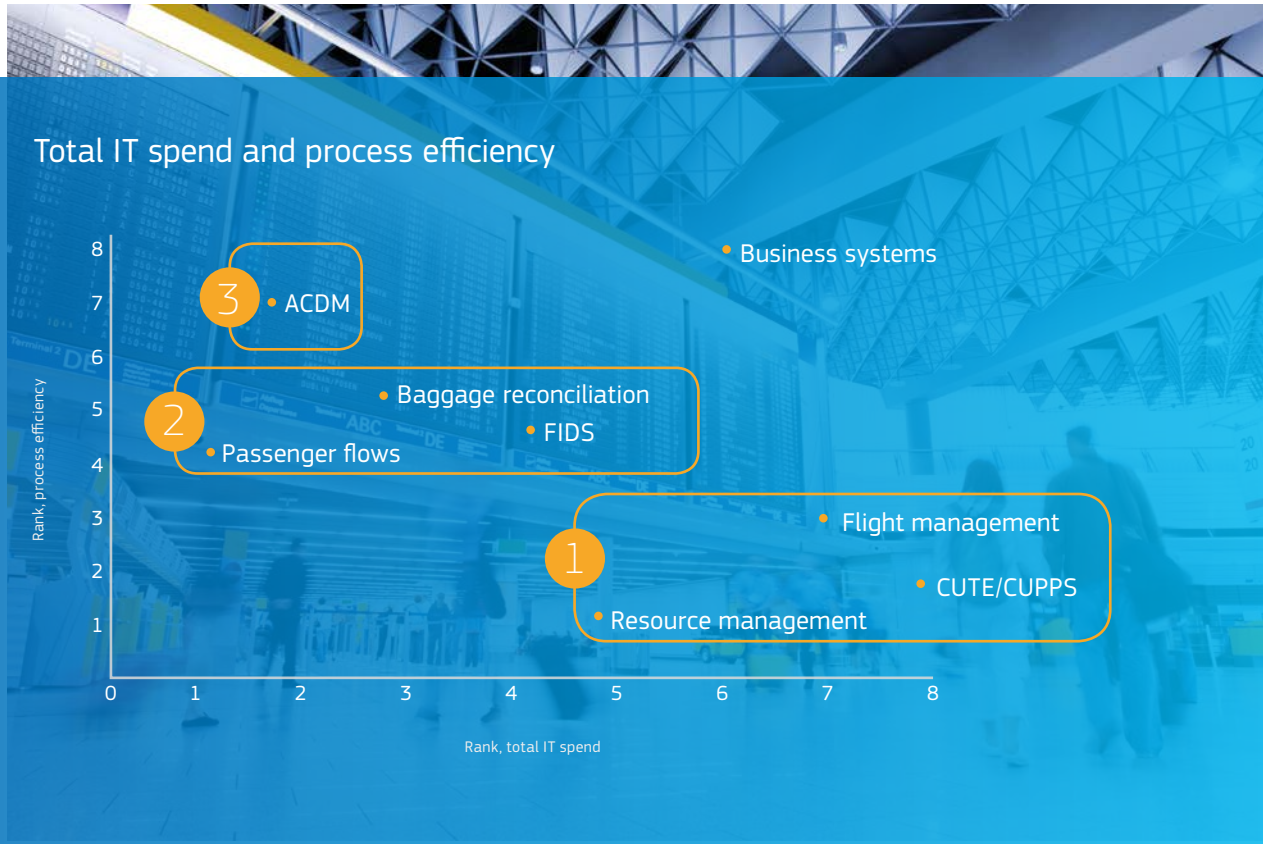
Complementing this view of IT process cost, participating airports were invited to highlight those business processes that they felt were ripest for the application of digital technology solutions based on their perceived efficiency. These cost and efficiency dimensions were then combined (see Figure 7) to provide an indicative view of potential focus areas for digital transformation in the future.

While the attractiveness of digital technologies to airports is highly context-dependent, at a high level this analysis outlines three process clusters:

_Process cluster 1: higher spend, higher inefficiency. Resource management, flight management and CUTE/CUPPS were highlighted by participating airports as being the core airport processes that typically consume the greatest share of IT budget, and are seen as being relatively inefficient. Although there is not necessarily a direct relationship between high IT spend, high process inefficiency and potential to apply digital solutions, the fact remains that incremental efficiency gains in these areas have the potential to deliver material savings, if implemented and sustained.

_Process cluster 2: medium spend, medium inefficiency. Passenger flows, FIDS and baggage reconciliation are highlighted as having moderate IT spend and moderate process efficiency. Although the passenger-flow process spend is on the lower side, it is included in this cluster because of the significant security-related costs that airports have flagged not reflected in the passenger-flow spend data. This cluster indicates that, while some progress has been made, efforts to improve the efficiency of passenger flows and baggage reconciliation should remain a focus going forward, not least because of the potential to deliver benefits for the customer experience. It should be stressed that perceptions of FIDS efficiency can vary significantly from one airport to the next. This reflects both differences in the age of existing FIDS installations and also airports' different aspirations in terms of the value they

Figure 7: Relationship between total IT spend and relative process efficiency



are trying to extract from their FIDS investments. In other words, while for one airport the need to maintain an existing legacy FIDS set up, focused solely on the provision of flight information would not be a cause for concern, more avant-garde airports might view this approach as rather inefficient, because they are aware of the potential to realize far broader benefits from FIDS as part of a multi-channel marketing tool.

_Process cluster 3: ACDM. Finally, we have singled out ACDM as being worthy of a separate cluster in its own right. Although the ACDM does stand out relative to the other airport processes, based on the cost and efficiency results alone, there are other reasons for treating ACDM as a special case. As will be demonstrated later in this paper, many airports consider ACDM to be a major driver of cross-airport benefits in the future, therefore perceptions of relative cost and efficiency should not be interpreted in the same way as for other airport business processes. Further, while IT expenditure on ACDM is currently rated as being relatively low, we would certainly expect this to increase in the future given ACDM's enabler status and role in facilitating broader, airport-wide benefits.

Regarding business systems, while some airports reported relatively low levels of expenditure on back office systems related to billing, invoicing, analytics and reporting, the results also reflected significant variation from one airport to the next. The insight here is that, linked to historical decisions on make/buy, airports maintain back office systems and processes in a variety of states with some much further down the road toward back office consolidation than others.

Technology assessment

The result of the cost-efficiency analysis provides an indication of where the greatest opportunities for digitally driven airport business process optimization could lie in the future (see Figure 8). Following this, a next step was to establish the relative priority of a range of digital technologies in helping airports address these opportunities.

Again, the results can be clustered to provide an indication of which technologies airports are likely to focus on in the future:

_Technology cluster 1: core enabling technologies. As demonstrated, big data, advanced analytics and cloud technology have played a central role in the transition from Airport 2.0 to Airport 3.0 and will continue to be a major focal point for airport digital strategies. This also reflects the fact that the application of big data and cloud technologies is not process-specific but can bring value across a wide range of airport business processes.

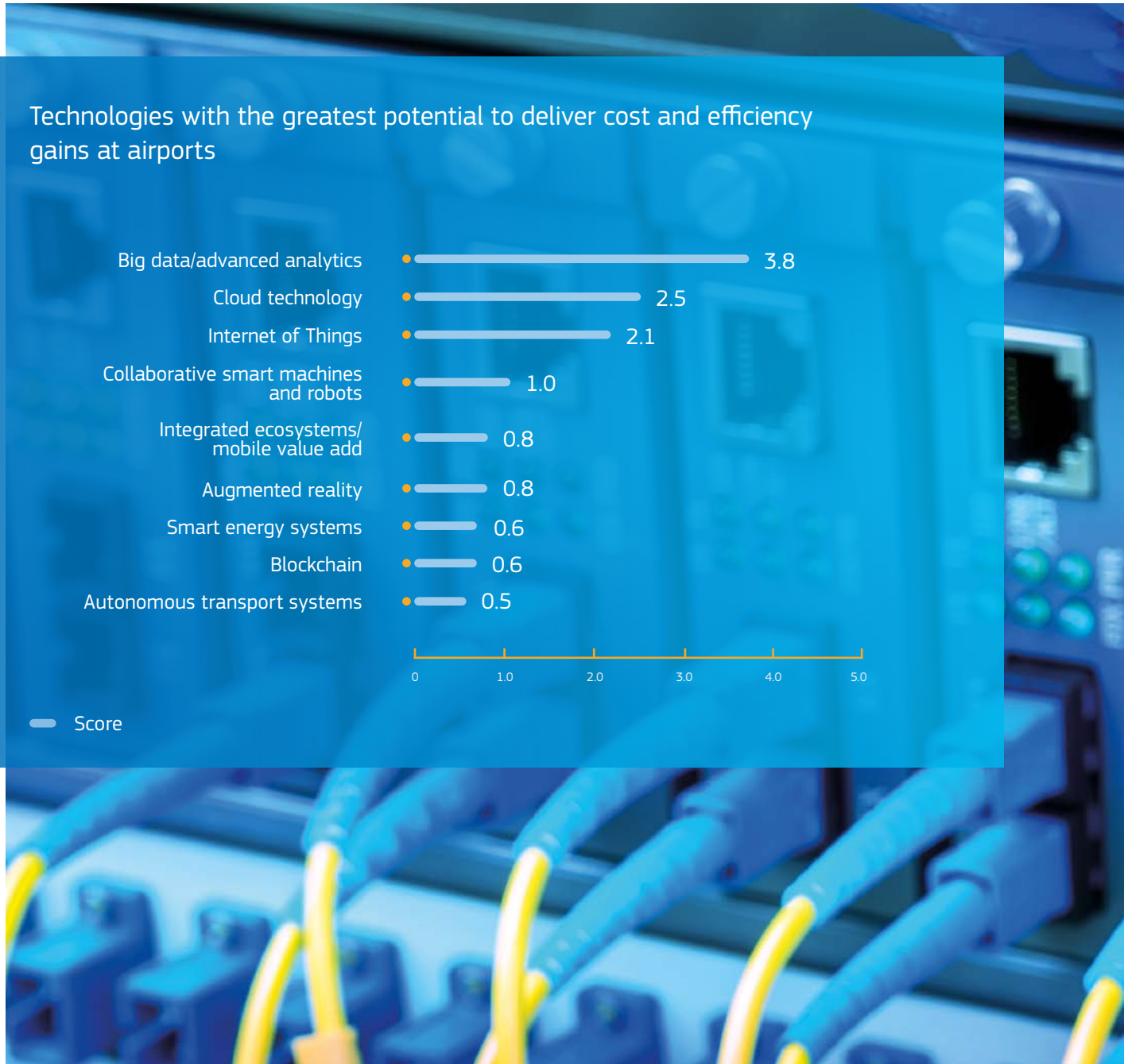
_Technology cluster 2: process automation and integration. Four digital technologies stood out as being central to the ongoing efforts of airports to enhance the efficiency and effectiveness of their operations. These include technologies geared toward increasing the automation of core airport processes, the introduction of solutions based on integrated ecosystems, mobile value-add and Internet of Things technologies to continue to break down organizational barriers and improve data sharing, including across human-human and human-machine interfaces. Smart energy systems, while not a top priority up to now, were consistently flagged as an area in which airports see potential to do more. Overall, the high priority attributed to these technologies reflects the ongoing need for all airports to optimize the use of their existing landside and airside capacity.

_Technology cluster 3: fringe technologies.
These technologies, including autonomous transport systems and augmented reality, received lower priority rankings. While these technologies may be important to some airports including the most mature global hubs, based on the representative cross-section of airports engaged with, we can expect investment in other digital technologies to take priority in many cases. This also reflects the fact that for some technologies (notably, blockchain), the opportunities for airport-specific applications are still at an early exploratory stage.

Application of digital technologies to airport business processes

Considering the cost, efficiency and technology assessment findings, the eight core business processes were then examined in turn, according to the process clusters in which they sit. For each process cluster, the objective was to identify specific digital technologies that we can expect to be applied in future.

Figure 8: Priority future digital technologies for airports



Cluster one: higher IT cost, higher inefficiency

Focused specifically on the allocation and management of fixed and mobile assets, including lifts, escalators and airside mobile assets, many airports highlighted **resource management** for its high cost and relative inefficiency. This included more digitally advanced airports that had already made progress in optimizing their resource management activities, but nonetheless felt that further step-change improvements could be achieved. The drivers of cost and inefficiency include:

_The sheer scale and diversity of the asset base
_The absence of complete management information
_The operational strain that the resources are under

These pressures mean that it can be difficult to apply a coordinated approach to resource allocation. Further, since the costs of non-availability are so high (e.g. mobile stairs not being ready to meet an aircraft resulting in delayed disembarkation and turn-around, plus possibly missed flight connections), the result is that traditional resource allocation methods have tended to build redundancy into the allocation plan. Without a complete view of asset location and status, the result can be a system in which assets are not fully utilized, and where there is a cultural reliance on manual interventions by people to make sure that the (underutilized) resources are allocated to the required location, often on a 'just in time' basis.

Faced with these inefficiencies, it is clear that Airport 4.0 technologies such as **big data and advanced analytics, Internet of Things and augmented reality** can all play a role in helping airports deploy assets in a more efficient manner, as part of a 'total airport management' solution. Where an airport has a dominant home carrier, there can also be potential for the carrier to form a collaborative partnership with the airport, so that both parties achieve a better understanding of resource allocation needs and can work toward a transparent resource allocation model that meets these needs in an efficient and effective manner.

The two other airport business processes highlighted as costly and inefficient were **check-in and flight management:**

_Check-in (CUTE/CUPPS): while the arrival of self-service kiosks has introduced greater automation at the point of check-in, this nevertheless remains one of the processes where airports believe there is the greatest opportunity to drive further efficiency savings. Many airports still host fixed check-in terminals at the check-in area; further, the diverse range of airline needs has resulted in a plethora of airline-specific applications, which typically require their own secure data feeds.

"Nobody likes to do check-in, it is an administrative task. We want to make it seamless and easy."

Chris Au Young, General Manager of Smart Airport at Airport Authority Hong Kong

Faced with such engrained complexity, **cloud technology** offers the potential to remove, or at least reduce, the need for costly hardware at airport premises with resulting benefits for IT manpower and hardware costs.

Nevertheless, it should not be assumed that these kinds of developments will lead to the wholesale elimination of check-in counters at the airport. One airport executive stressed the significance of airlines' varying requirements, and contrasting levels of readiness to move away from incumbent CUTE/CUPPS solutions. This does not stop airports from offering alternative solutions with a lighter IT footprint. However, it may mean that it takes longer to realize envisaged cost and throughput benefits. In addition, passenger readiness to adopt digital solutions such as iCUSS[4] varies from one passenger group to the next; therefore, while some passengers may readily adopt digital solutions, others will place far higher value on face-to-face 'moments of truth',

4 iCUSS check-in kiosks deployed at Hong Kong International Airport are portable devices that, thanks to wireless Amadeus ACUS technology, can be rapidly deployed and relocated for use by the travelers to check in themselves or with the help of airport staff.

To help address the challenges posed by capacity constraints and deliver a faster, easier and happier experience for its passengers, Hong Kong International Airport is challenging conventional thinking related to airport check-in. Working closely with airlines, passengers and other business partners, the airport has deployed an innovative Common Use Self Service check-in solution called iCUSS. Built around the concept of a fully mobile check-in terminal, the solution will deliver greater convenience for passengers by enabling them to check in remotely, from a variety of locations. This avoids the need to use an in-airport or fixed check-in counter. Furthermore, the solution enables the airport to deliver direct, cloud-based data connections to airlines, meaning that airline-specific check-in applications can be downloaded to the airport in real-time, and the cost of maintaining legacy, airline-specific data feeds is greatly reduced. By removing the need to check in at fixed counters inside the terminal, the airport is positioning itself to better manage passenger flows (especially at peak times) and deliver an improved passenger experience.

leading to airports needing to maintain multiple service delivery channels, with implications for cost and complexity of operations.

_Flight management: another strong candidate for digital transformation based on airport feedback, airports are already targeting flight management with digital solutions. For example:

One rapidly growing tier-two Chinese airport with more than 30Mpax is using a **big data and advanced analytics** solution to enhance its flight management activities. Using a united open data platform, the airport is able to share a diverse range of data sets, including information on flight status, connecting bus services and traffic congestion, with multiple airport stakeholders. The ability to more effectively share information across interfaces results in improved operational decision-making, with a positive knock-on effect for the customer experience.

Flight management extends to the effective observation and maintenance of mission-critical airport infrastructure, including the runway. For example, one leading Asian hub airport is using high-density imaging technology to enhance foreign-object detection (FOD) on runways that left undetected can lead to flight disruption.

Cluster two: medium IT cost, medium inefficiency

For those airports in transition from Airport 2.0 to Airport 3.0, **passenger-flow optimization** remains a priority. These airports may include slot-constrained mega-hubs, but also other airports, due to the need to optimize passenger flows through limited landside infrastructure, and drive incremental airport retail spend. As exemplified by the technologies that are showcased in Changi Airport's new Terminal

Four, **biometrics** are likely to play an increasing role in enhancing the efficiency and security of passenger processing. Although biometrics is not a new technology, it is the emergence of integrated end-to-end biometric authentication solutions that encompass automated check-in and bag-drop, security, immigration and boarding that is different and that has potential to deliver step-change operational and financial performance for airports and their users. The passenger also stands to benefit from reduced waiting time and a more seamless process. Amadeus' work with VisionBox and Idemia on biometric solutions, plus Gemalto's Fly-to-Gate solution are examples of the kinds of integrated solutions that are already coming to market.

That said, biometric-based solutions are not the only lever available to enhance passenger flows. For other airports, who are not yet ready to embark on a full-scale biometric implementation, **mobile devices and integrated ecosystems** are perhaps a more practical way to optimize passenger flows, while at the same time bringing a more 'personalized' service to the passenger. As the below case example demonstrates, the availability of commercial off-the-shelf applications means that airports do not always need to develop airport-specific apps to enable **real-time monitoring.**

Digital wayfinding and i-beacon technology is now also enjoying widespread adoption. This includes major slot-constrained European airports with a strong LCC presence, where passenger-flow enhancement and "AI-powered indoor navigation" is essential to delivering a 'quick turn-around' business model. Equally, **AR-based indoor navigation technology** has also been adopted by rapidly growing airports in second tier Chinese cities where effective flow management is critical in enabling these airports to cope with the strong year-on-year growth in passenger volumes.

Beyond passenger flows, digital solutions are also finding practical applications in the areas of boarding, baggage reconciliation and FIDS:

_Boarding: the ability of digital technology to enhance process efficiency is by no means limited to landside applications. As demonstrated by the recent implementation of a complete end-to-end e-boarding solution at a major Indian airport, digital technology can also be used to optimize the airport-aircraft interface. In this specific example, the airport applied **e-gate and digital barcode technology** to deliver a fully automated boarding experience. The elimination of paper and reduced manual interface offers passengers a more convenient and consistent customer experience. The move to an automated solution also enhances security, by eliminating the chance of human error. Through enhanced access to passenger data, the airport has also been better able to coordinate its **resource management** plans. The improved use of passenger data also provides a commercial benefit: for example, the airport is able to monitor passenger dwell times and optimize its marketing strategies to drive the performance of the airport's retail offering.

_Baggage reconciliation: consistently highlighted as one of the processes most in need of improvement due to its impact on customer satisfaction and cost, baggage is the subject of industry-level initiatives. IATA Resolution 753 requires airlines to maintain an accurate baggage inventory and to create a strict 'chain of custody' for baggage along the customer journey. Although not specifically mandated by 753, emerging digital technologies may find mainstream applications in core business processes like baggage in the future. While the long-term applicability of these technologies remains to be proven, existing baggage reconciliation solutions continue to offer airports and airlines a tried and tested way of pinpointing baggage throughout its journey, helping to limit

One medium-sized European airport has recently implemented the FLOW app to enhance passenger flows, while also gaining better access to passengers data that can be used to support a more targeted e-commerce offering. Already in use at over 1000 airports, FLOW means that these benefits are accessible, without the need to commit to costly airport-specific app development. In addition, the airport is one of several airports to capitalize on the strong take up of Facebook's Messenger service, choosing to use this established platform as the basis for its Messenger bot app that delivers automated communication with passengers.

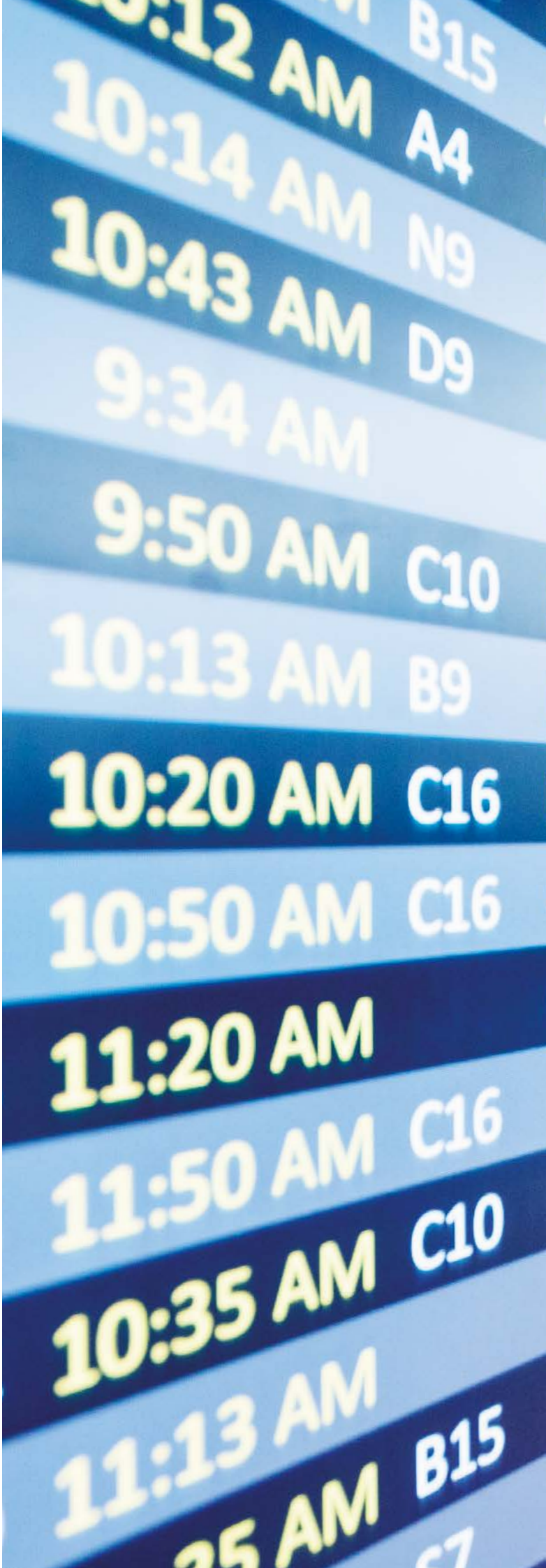
compensation payouts and associated processing costs. At a more practical level, airports are already using other more established technologies, specifically **mobile apps**, to ease passengers' anxiety while waiting for bags to arrive. For example, a major Asian hub airport has introduced a mobile app that provides the passenger with a message to notify them of when their bag will be delivered. We should expect this incremental process innovation to be complemented by the increasing role of **smart machines and robots** at the point of baggage acceptance, not just to be limited to the behind-the-scenes baggage system itself.

_FIDS: the amount that airports spend on FIDS depends on a number of factors, including the age of the existing FIDS infrastructure. Looking to the future, potential exists for digital technology to at least reduce the criticality of FIDS (and therefore associated OPEX/CAPEX), but also increase the value-add that FIDS delivers to airports, airlines and passengers. The mass adoption of mobile devices, combined with strategic investments in **digital wayfinding technology such as i-Beacons,** can reduce dependence on physical FIDS infrastructure. Although uptake varies by demographic, **personalized FIDS** is already delivering real-time flight status updates to passenger mobile devices, helping airports optimize dwell time in commercial areas. The second trend is the shift toward multi-purpose displays that not only fulfil their original role of flight information provision, but further reinforce the airport's retail offering. By leveraging existing FIDS infrastructure as an additional means to drive the in-airport retail offer, airports can achieve incremental revenue growth for only a moderate investment in existing infrastructure. This would see the role of FIDS change from flight information provider, to multi-faceted marketing tool.

Other processes: business systems

While the variability between one airport and the next has already been stressed, **back office systems and processes** related to billing, invoicing, analytics and reporting can represent a major source of IT expenditure for airports. It is not uncommon for these systems to have been developed gradually over the years, which may result in multiple legacy systems, and system architectures that are unnecessarily complex with implications for ease of use and overall cost. Digital technologies that can help airports enhance the efficiency of back office processes and systems include **robotic process automation (RPA).** By mimicking the role that humans traditionally play in highly repetitive administrative tasks (e.g. handling of data between different airport systems), RPA has the potential to increase the consistency of administrative decision-making and reduce cost by enabling staff to be reduced or reallocated to more value-adding activities. As the application of RPA matures, there is also the potential to integrate RPA solutions with big data and artificial intelligence systems to further reinforce an ACDM-centric approach to technology deployment. The flexibility and scalability of RPA makes it especially suitable for deployment in airport back office environments[5].

5 E Tech, 25 September 2017



5. Outlook: Toward the digital airport of the future

The future of airport IT expenditure

Given that these are some of the most promising opportunities to apply digital technology, what is the expected direction of airport IT expenditure in the digitally enabled airport of tomorrow?

One could be forgiven for assuming that as airports become more digitally mature and continue on their journey toward Airport 3.0 and beyond, a key benefit is the ability to realize efficiencies in terms of total IT spend. In some regards, this is a logical conclusion: cloud technology, for instance, offers the possibility to replace (or at least reduce the number of) CAPEX-heavy on-site servers and data storage facilities, with more cost-effective, cloud-based solutions.

Similarly, the introduction of generic customer-facing platforms for check-in can be expected to help airports to reign in the cost of maintaining multiple different, airline-specific applications and network connections.

However, the assumption that digital transformation will reduce airport IT expenditure would appear to be premature. In our interviews with the leading airports that took part in this study, the clear majority did not associate digital transformation with a corresponding reduction in airport IT spend. On the contrary, the consensus was that in order to realize cost, revenue and customer experience benefits for the wider airport ecosystem, airports must expect to spend more, not less, on enabling IT solutions.

"We get healthy pushback from the Board on the fact that our IT budget is growing. This is good corporate governance and doesn't mean they object to us spending more on digital initiatives."

Senior Manager, European Mega Hub

By considering big data and analytics as an example, we can better understand this expected future trend. To reap the benefits of real-time decision-making capabilities, airports must invest in big data and analytics solutions and capabilities. This is not a one-off investment and requires sustained investment over many years as there is often a degree of 'catch up' required, meaning that the investment sums involved are not small. As airports become more digitally mature, they see the value of their investments in big data and analytics and therefore opt to invest more to create a virtuous cycle of IT investment. Of course, over time the airport will hope to recoup its investments in the form of cost, revenue and customer experience benefits for the wider airport. Nevertheless, from a pure IT expenditure perspective, we can expect that as airports advance their digital transformation agenda, this will go hand in hand with a sustained upward trajectory for IT spend.

"The amount we spend on IT is definitely going to go up. I would not be surprised to see it double – but we expect to recoup that investment in other areas."

Airport Executive, European Airport.

The transformative role of ACDM

In the context of growing IT expenditure, the ability of airports to deliver against their digital transformation strategies will increasingly depend on their ability to form and embed collaborative working relationships with the many other stakeholders that make up the airport ecosystem. In this regard, ACDM can be singled out as having a special role to play in enabling airports to complete the transition from Airport 2.0 to 3.0 and beyond.

Almost without exception, participating airports in this study agreed that by making it easier for the multiple parties in the airport ecosystem to work together and reach better decisions, ACDM is a major opportunity to optimize the efficiency of airport operations and reduce the total cost of airport operations. As one study participant put it:

"ACDM gives an airport a common understanding, with the goal being complete situational awareness, in a way that other solutions cannot."

Independent Airport Technology Expert

To achieve this, airports and their business partners need access to consistent, reliable data, available in real-time, in which the shared data sets are supported by a common set of definitions. The benefits presented by ACDM include avoidance and reduction of delay-related costs and the gradual reduction of operational slack, thereby enhancing the airport's total operating efficiency. One major Asian airport group that took part in the study implemented an ACDM solution in 2016 based on **web technologies and handheld devices.** While the airport benefited from reduced noise and emissions, improved punctuality and optimized gate/stand planning and management, similar benefits were passed on to airlines and ground handlers. For example, airlines benefited from reduced taxi times and improved On Time Performance and ground handlers have been able to more effectively allocate resources with resulting benefits for productivity and customer satisfaction.

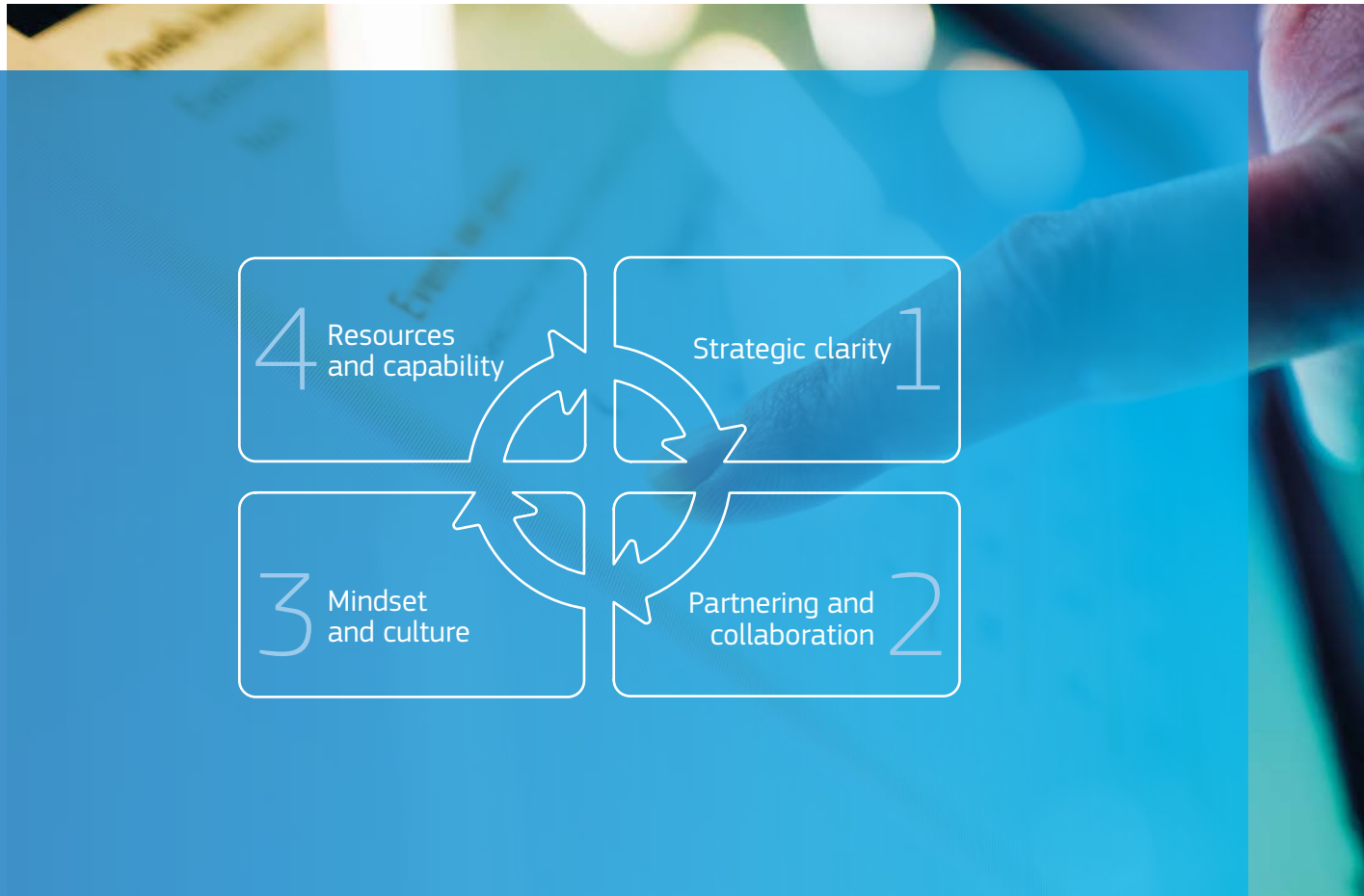
6. Conclusion: critical success factors for effective digital transformation and holistic value creation

Through interactions with the wide range of airports that have taken part in this study, it is clear that digital technology has a major role to play in the airports of the future – in many cases the change is unavoidable and should be welcomed.

As passenger volumes continue to grow exponentially, and the needs and expectations of passengers and airlines become even more diverse, airports can no longer satisfy these expectations using traditional approaches. Faced with the prospect of capital-intensive expansion projects that take years to deliver, digital technologies can, at the very least be used in a tactical way to help airports extract the maximum value from their existing assets, especially by enhancing passenger flows and reinforcing the On-Time Performance (OTP) that is so important for airlines and passengers.

However, what is also clear is that in order to reap the full benefits of these new technologies in the future, airports are not at the end of the road, and must continue to evolve on a daily basis. In conclusion, this paper identifies four strategic imperatives for airports to consider, as they continue on their journey from Airport 2.0 to Airport 3.0, and achieve a new digital norm, in which the focus moves beyond tactical cost reduction or operational enhancement, toward the holistic enhancement of airport value propositions.

Figure 9: Strategic imperatives for airport digital transformation



_Strategic clarity: in the context of a rapidly evolving digital landscape, the importance of establishing and maintaining a clear yet concise digital strategy, closely aligned to the airport's overall strategic priorities, should not be underestimated. This need for strategic clarity has both an internal and external dimension. Internally, airports regardless of size have limited resources so must overcome organizational siloes and channel these resources to a clearly defined set of digital priorities. This includes the effective channeling of 'digital demand' (i.e. ideas, requests) that may emanate from a variety of stakeholders to achieve a coherent overall approach. It must also be based on a very clear view of who the ultimate target of an airport's digital strategy actually is: airlines or passengers? From an external standpoint, airports must recognize the inherent ambiguity in the digital landscape and put in place the required capabilities and structures to manage this. 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.

_Partnering and collaboration: as has been stressed throughout this paper, airports do not exist in isolation but within complex, multi-party environments in which digital maturity is driven by the entire ecosystem. Therefore, their ability to forge collaborative (or at least, cooperative) relationships across multiple interfaces is likely to be vital in charting an effective course from 2.0 to 3.0 and beyond. Ongoing commoditization of digital technologies may facilitate the 'trickle down' of proven solutions from leading airports to airports that are less advanced in terms of digital adoption. Nevertheless, even if implementation costs become less of a barrier, inter-airport collaboration, whether part of a formal partnership or not, is likely to play an important role. By embracing such 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. Such partnering is not limited to airports, and may see the continued development of hub airport-based carrier relationships, to work toward mutually beneficial digital objectives.

_Mindsets and culture: critical to the ability of airports to continue their digital journey is the ability to identify, prioritize and implement those digital solutions that are most relevant to its particular context. In this light, 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.

_Resources and capability: finally, airports need to consider the resources and capabilities that they possess today and how these must evolve in order to meet the digital requirements of tomorrow. While sourcing strategy will vary from one airport to the next, for a variety of reasons, airports are likely to require at least 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.

The findings from this study indicate not only that the four areas highlighted above are mutually reinforcing, but also that to deliver sustainable digital transformation, strength is required in all four quadrants. For example, airports that invest heavily in the required skills and capabilities but do not address issues related to organizational culture are unlikely to reap the full benefit of these investments. Equally, a focus on partnering and collaboration is unlikely to be rewarded if an airport's digital strategy is unclear or not clearly aligned to the airport's overall strategic objectives.

Digital technology presents airports and their users with a wealth of new opportunities. As demonstrated in this paper, these opportunities extend beyond a focus on cost reduction and can also deliver step-change benefits for revenue generation, operational performance, and the customer experience. To deliver and sustain these benefits, airports must develop the culture and capabilities to anticipate future digital technologies, innovate so that the technologies find tangible applications that are relevant to the specific airport, and invest in the capabilities and partnerships that will be needed to deliver sustained digital transformation.

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