Practical lessons from implementing a data-driven approach to passenger flow optimisation and airport capacity management

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Abstract

While airports have traditionally relied upon historical passenger traffic to plan for future operations, that paradigm is fast changing. Stakeholders, business partners and service providers all need insights into expected passenger activity in advance to better plan and support operations. This paper shares the innovative approach that Phoenix Sky Harbor International Airport (PHX) adopted to create a data-driven picture of passenger activity and utilisation of terminal facilities as part of its digital transformation initiative. It shows practical ways to take advantage of existing investments and data sources to create an end-to-end operating picture of the airport. This approach allows airports to quantify, with data, how 'busy' each passenger touchpoint is and how that provides a direct way to assess and improve passenger flow within their facilities. The applied methodology allows the airport to understand and maximise utilisation of its terminal square footage capacity and have a clearer picture of where and when congestion occurs. More importantly, the paper provides guidance on how to 'quantify' what that congestion means with data, something that many airports struggle with. With this approach, airports can create a detailed data-driven picture of their environments with the technology infrastructure they already have. Firmly rooted in advanced data analytics and modelling, the paper also illustrates how, by sharing detailed passenger demand data, PHX is empowering its business partners to proactively plan and improve service levels.

Keywords

digital transformation, data, analytics, passenger flow, optimisation, capacity

The COVID-19 pandemic hit airports hard throughout the world. Air travel fell sharply. Airlines cut capacity. Governments closed international travel routes or imposed a myriad of pre-departure testing requirements. Indeed, the global impact of the pandemic on air travel is without precedent and cannot be overstated. Recovery has been fragmented. Some regions, such as North America and particularly the US, air travel is recovering much faster than other areas.

Phoenix Sky Harbor International Airport (PHX) began to recover in early 2021. In fact, by spring 2021, passenger traffic was already approaching 2019 figures. (PHX recorded 3.9 million passengers in April 2019; the airport recorded 3.1 million passengers in April 2021.) This traffic continued to climb. In November 2022, PHX passenger traffic hit 3.9 million passengers; this surpassed the pre-pandemic November 2019 figure of 3.7 million. (For the record, the most passengers ever were recorded in 2019; more than 46 million.) While PHX welcomed the return of travellers, the unexpectedly fast rebound sparked several unforeseen challenges. Chief among these adversities were capacity constraints and the readiness of various stakeholders to process the throngs of returning passengers taking to the skies. The tight labour market conditions compounded these challenges. The drop in available labour impacted the ability of PHX's stakeholders and business partners to provide the desired level of service for passengers.

THE MEANING OF PASSENGERS RETURNING

In spring 2021, swarms of passengers re-emerged, flocking back to garages, stores, restaurants and terminals. Almost suddenly, the airport was confronted with the same challenges that had vanished during the peak of the COVID-19 pandemic, namely capacity constrained terminals and the need to improve passenger flow within its facilities. Airport technology partnered with operations, facilities and services and other stakeholders to see if they could 'quantify' what was happening in the terminal facilities, more specifically how passengers were moving about in the terminals.

Yes, it was apparent that the terminals and concourses were packed with passengers. And, anecdotally, when the airport's peak days/weeks were or when the queues were long was known. But that is all the 'known' there was. What 'busy' or 'long lines' meant had never been quantified. The journey to address passenger challenges and capacity constraints started with this most basic question: is what is happening at *every* passenger touchpoint within the facility known? Every footstep? The journey to learn this unknown would become the genesis for improving passenger movement from curb to gate at PHX. This is called the passenger flow optimisation programme. The aim of the programme was simple: to understand how and where the passenger flow at PHX could be improved through data, new technology implementation or operational adjustments. This broad-spectrum effort was entirely data-driven. As such, the programme represented a first-of-its-kind, collaborative exercise in data collection, analysis and utilisation. It is setting the basis for sustained improved passenger flow and long-term analytical management by the PHX team, its stakeholders and business partners.

Based on this, the desired outcomes illustrated in Figure 1 were established:

In spring 2021, PHX kicked-off a digital transformation effort in partnership with Copenhagen Optimization to
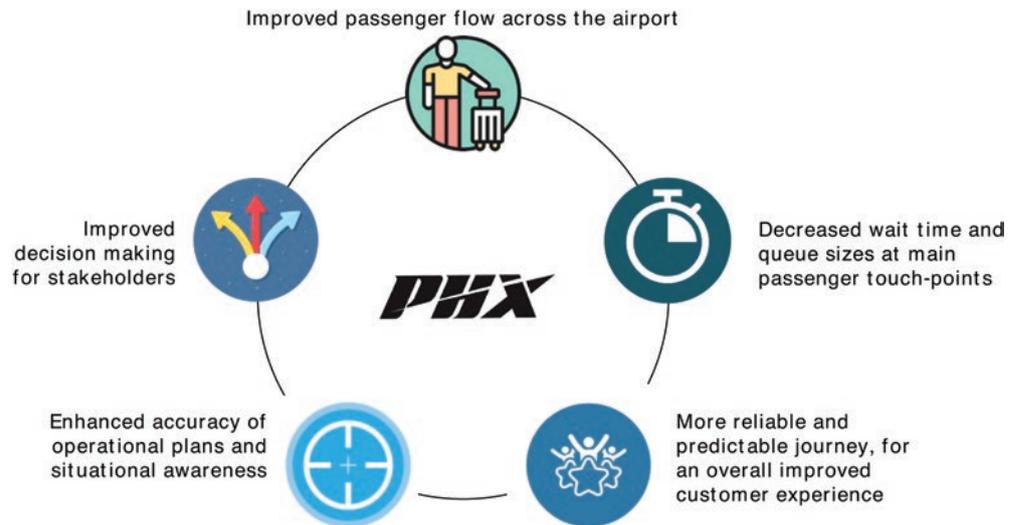
Figure 1 PHX Passenger flow optimisation desired outcomes

capture passenger flow across key areas: kerbside, check-in, security, retail, food and beverage, gates, immigration, baggage claim, PHX Sky Train® and escalators/elevators. In a perfect world, installing sensors and infrastructure to track each passenger's footsteps throughout the terminals would be ideal. It would yield precise traffic information. But the PHX team had to be reasonable. Such infrastructure would cost millions of dollars and take much too long to implement. It was not feasible or an option. So, a different route was taken to solve the vexing capacity and passenger challenges.

The roadmap to this journey is quite easy to understand. It is about exploring how airports can maximise their existing infrastructure and data they inherently have to gain a better understanding of their bustling environment and improve passenger flow. Everyone wins: Airport stakeholders. Airport operations. And Passengers.

The initial focus was to produce or attain a realistic picture of the as-is passenger flow. Therefore, it was imperative from the beginning to establish a proper governance structure and secure explicit

support and direction from the executive level. This authoritative backing outlined how technology and operations departments were co-leading the data-driven initiative and required input from all areas of the airport. Nowhere was this structure more needed and helpful than in the very first task, which was monumental. The team looked at data from 57 unique systems, applications or processes across the airport over a two-month period. Some of the systems that were tapped into for data included check-in, baggage handling, ground transport, flight information, security checkpoint wait times, gate allocation, parking, etc. Figure 2 depicts a sample of data sources raked through to draw the baseline analysis of passenger flow.

An early lesson was that not all the data was usable. And not all the data resided in one neat place, either. Some of the data was stored in an enterprise environment, while some data was situated within respective systems and business units. Having stakeholders from those areas of the airport operation helped enormously. They not only knew the location of the
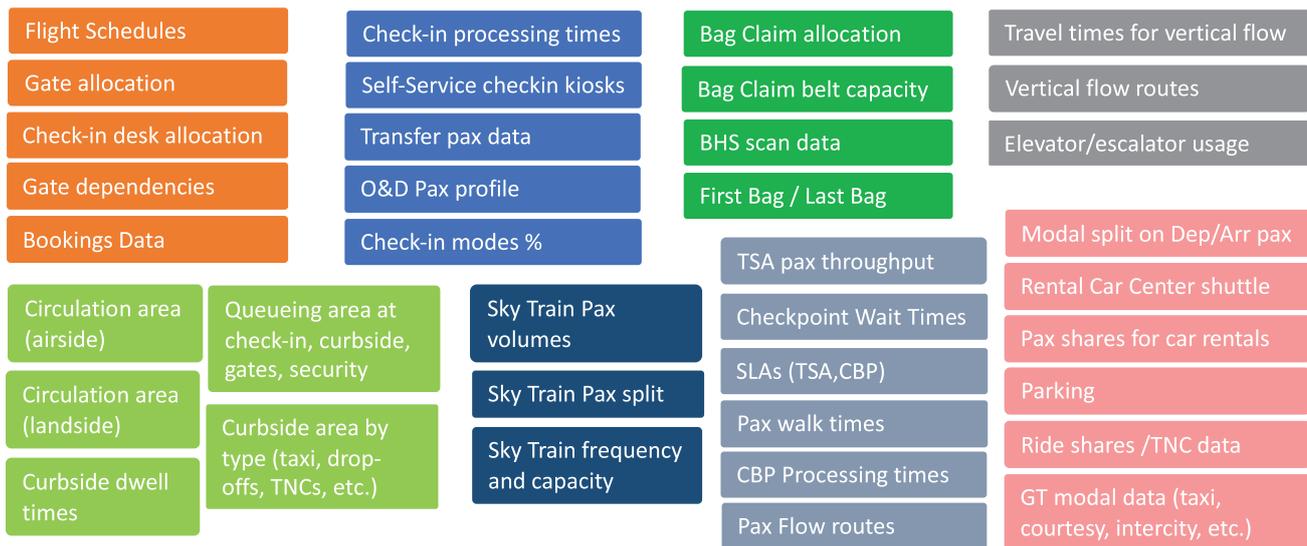
Flight Schedules	Check-in processing times	Bag Claim allocation	Travel times for vertical flow
Gate allocation	Self-Service checkin kiosks	Bag Claim belt capacity	Vertical flow routes
Check-in desk allocation	Transfer pax data	BHS scan data	Elevator/escalator usage
Gate dependencies	O&D Pax profile	First Bag / Last Bag	
Bookings Data	Check-in modes %		Modal split on Dep/Arr pax

Circulation area (airside)	Queueing area at check-in, curbside, gates, security	Sky Train Pax volumes	TSA pax throughput
Circulation area (landside)		Sky Train Pax split	Checkpoint Wait Times
Curbside dwell times	Curbside area by type (taxi, drop-offs, TNCs, etc.)	Sky Train frequency and capacity	SLAs (TSA,CBP)
			Pax walk times
			CBP Processing times
			Pax Flow routes

Right column continued:
- Rental Car Center shuttle
- Pax shares for car rentals
- Parking
- Ride shares /TNC data
- GT modal data (taxi, courtesy, intercity, etc.)

Figure 2 Sample data set used to develop the 'as-is' passenger flow picture

data but also what it *meant*. Some of the data, such as car hire centre shuttle bus ridership information, was tracked manually. So, a big part of the initial process was simply 'discovery' — What data exists? Where does it exist? Who owns and manages that data? Once those answers were found, the data was 'cleansed'. In other words, the data in some cases needed to be verified, clarified and/or reformatted to make use of it. This baseline enabled the team not only to identify flow issues and improvement possibilities, but also to replicate and see a daily operational experience with the data and analytics in hand.

Data maturity observations
- Data largely available, but not always easy to access and scattered across sources, systems and business units.
- Difficulty obtaining data usually indicated low utilisation in operations.
- Actual passenger metrics (presentation profiles, occupancy, etc) were scarce, suggesting the need for new measurement technologies.

- Understanding the contiguous passenger flow was hampered by the kaleidoscope of metrics used in each area, often not linked to others.

DIGGING INTO THE DATA: UNDERSTANDING THE KNOWN AND PREVIOUSLY UNKNOWN

Before a data-driven picture of the passenger journey could be generated, it was necessary to know when passengers show up at the airport. The team started by combing through the check-in and baggage handling system data. They analysed more than a year's worth of baggage data, zeroing in on the timestamp data every time a bag was scanned in the baggage handling system. Each conceivable angle was studied, from the moment a bag is dropped off at check-in to when it is sorted and then loaded off in baggage tugs. After walk time data was factored in, models could be built to predict when passengers would drop off bags. Cross-correlating that information with check-in and passenger walk times helped ultimately to
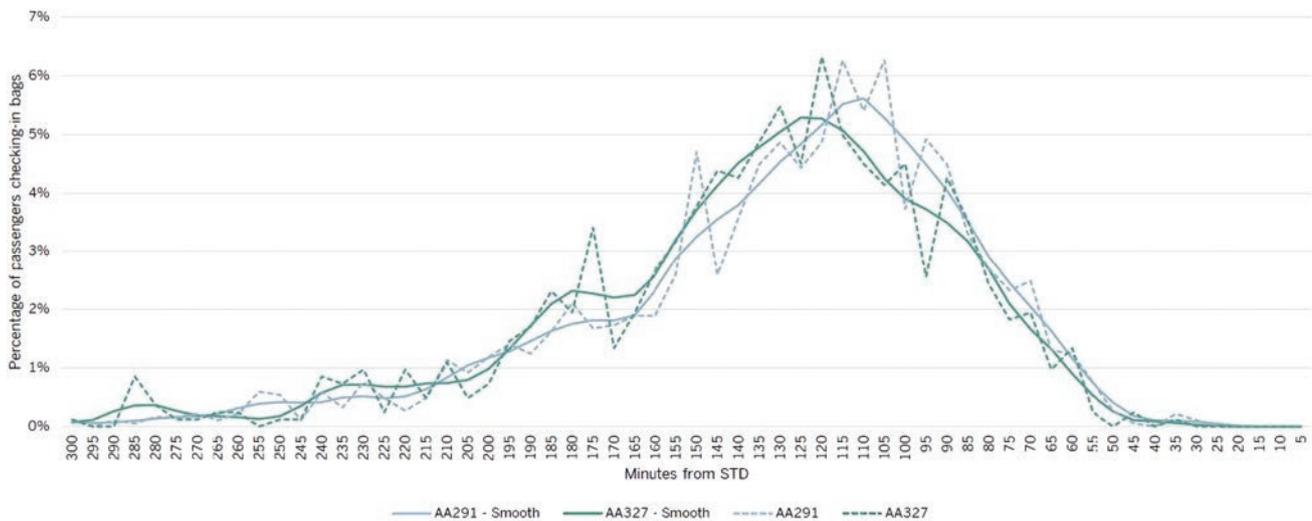
Figure 3 Passenger arrival profile for sample airline flights at PHX

know when passengers would physically show up in the terminal.

The team built arrival profiles for passengers for each airline and in many cases for different flights. This reflected the likely percentage of passengers per airline per flight who show up, say 120 minutes before their departure time; 90–120 minutes prior to departure; 60–90 minutes prior to departure; and less than 60 minutes before departure. This was groundbreaking! Passenger activity could be pinpointed in the models using the known information of passengers present in the terminals at a certain time prior to departure. Figure 3 shows a typical passenger arrival profile by airline by flight.

ESTABLISHING THE 'LOWEST COMMON DENOMINATOR'

A recurring issue when working with a myriad set of systems and data sources is that they all have their own metrics and key performance indicators (KPIs). It was important for the team not to become paralysed with all these different systems

and data sources. For example, check-in counter allocation, security wait times, Transport and Security Administration (TSA) and Customs and Border Protection (CBP) passenger processed per hour, load factors, passenger walk times, number of check-ins per hour, number of bag tags printed, number of gate turns, share of passengers checking in at agent-assisted counter versus self-service kiosk or mobile, gate allocation, PHX Sky Train® trip frequency, etc, were all tracked through varying metrics. Their performance measurements made sense in their respective systems. Those entities knew what they tracked or measured. The team was not entirely sure how each process's metrics helped depict the holistic passenger experience. Regardless of what each system calculated, the goal was to establish a fundamental unit of measurement. A way to interpret and weave this data to show what passenger flow was like at a specific touchpoint at any given time. This criterion was of paramount importance. It was crucial to establish metrics that all stakeholders can identify with and understand. Technically

speaking, it meant establishing occupancy of the actual physical space as the lowest common denominator that would be utilised to evaluate passenger flow across all the steps in a passenger's journey.

It is vital to establish metrics that stakeholders can relate to. Occupancy of the actual physical space seemed a metric that most of the stakeholders could easily understand when it comes to passenger flow. A space is either occupied or not.

Generally, it is safe to say that everyone at PHX understands the meaning of square footage in an airport environment. Lease agreements are drafted based on square footage; space is allocated and facility improvements are planned, designed and built using square footage. So, it only made sense to present the airport's operating picture based on how the physical space at various passenger touchpoints was being used at any given time. It was making sense out of the airport's bustling aviation universe. It was putting together all the pieces of the puzzle in fashionable and understandable order. Moreover, analysing how terminal square footage occupancy fluctuated with time and conditions would also make it possible to manage the dynamic nature of an airport operation more efficiently. With numbers in hand, the challenge became translating real-life passenger activity into utilisation of existing physical spaces.

## STITCHING THE DIGITAL FABRIC

Research is tedious. Analysing vast amounts of data is a laborious and painstaking process. So, it was a welcome relief to delve into the next phase. It was interesting gathering insights from various areas to weave a cohesive picture of what all this data meant in respect of the use of physical space in the airport's terminals. These areas included passenger arrival profiles, passenger counts and passenger shares across different modalities (full check-in, self-service, direct to security etc). For example, at kerbside, how passengers used different modes of transport (taxis, personal vehicles, car sharing, hotel shuttle buses, intercity transport and the like) was studied. That data was taken, along with the passenger arrival profiles, to model how many passengers there would be on the kerbside at any given time. Passengers who checked baggage versus those with only carry-on bags or no bags at all were also modelled.

With this information, a passenger profile of the kerbside was created that would show how it was being utilised at peak times. The same methodology was extended to check-in, security checkpoint, immigration, gates, concourse walkways, etc. For gates, passenger arrival profiles, walking distances and walk times, flight schedules, load factors, bags vs. no bags, etc were studied to model how many passengers were likely to be present at peak times. With that information, it was then possible to quantify how the gate hold room space and walkways were being used.

Of course, it was always a given that certain concourses and gates were very busy and crowded at specific times. But it was all observational. What was not expected was for the models to show where there was untapped capacity and how the use of the scarcely-used gates and hold room space could be optimised.

Figure 4 shows overcrowding in A17–A23 gates. It also shows hold rooms with passengers occupying up to 180 per cent of the allocated gate hold room space several times a day. Those passengers spill over and interfere with the passenger movement in the concourse walkway. This provided direct insight into what overcrowding means for these gates and how much space is actually being used at peak times.
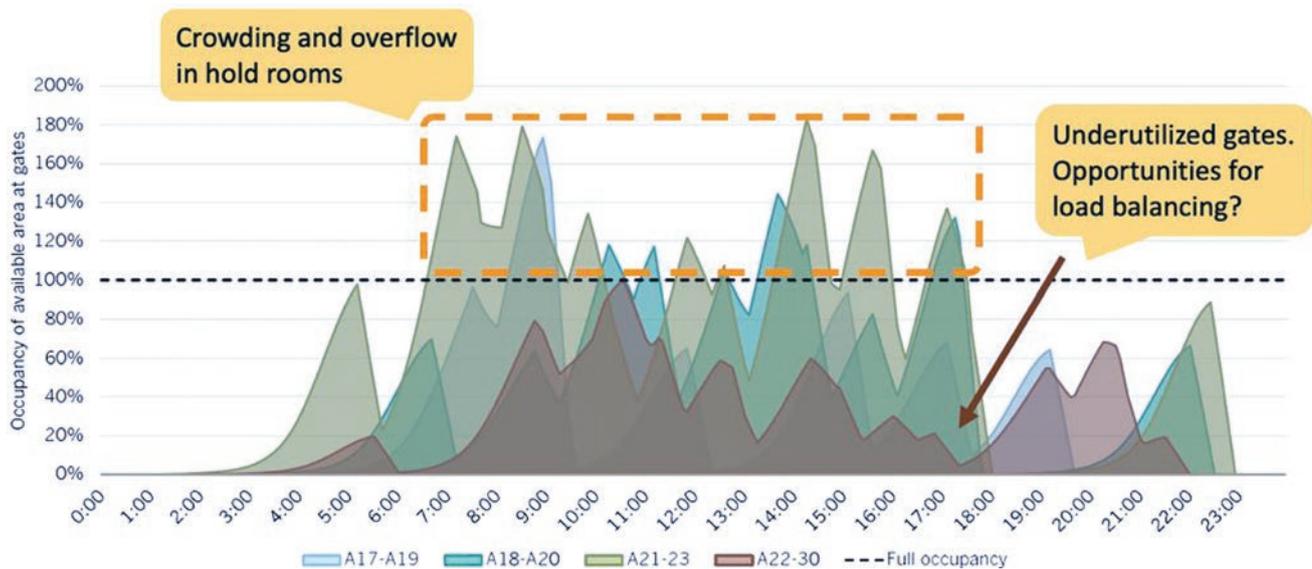
Figure 4 Sample passenger flow and space utilization analysis (Gates A17–A30)

Surprisingly, significant available space was also seen at peak times at adjacent or nearby gates and hold rooms. This illustrated, with real numbers, the over and underutilisation of gates. Load balancing options could be presented and staffing suggestions could be made to stakeholders. In the past, all that was known was just that some of the gates were maxed out. End of story. Now, the passenger activity impact throughout a concourse and how passengers could be shifted to other underutilised gates could be seen first-hand. Good stuff supported with real-case scenarios.

This was powerful data to share with PHX's airline partners. In some cases, they are responsible for gate allocation. While an airline might over allocate gates for below-wing efficiencies, this new insight allowed the airport to highlight the negative impact of this practice on mutual customers at the gates and those navigating the facilities.

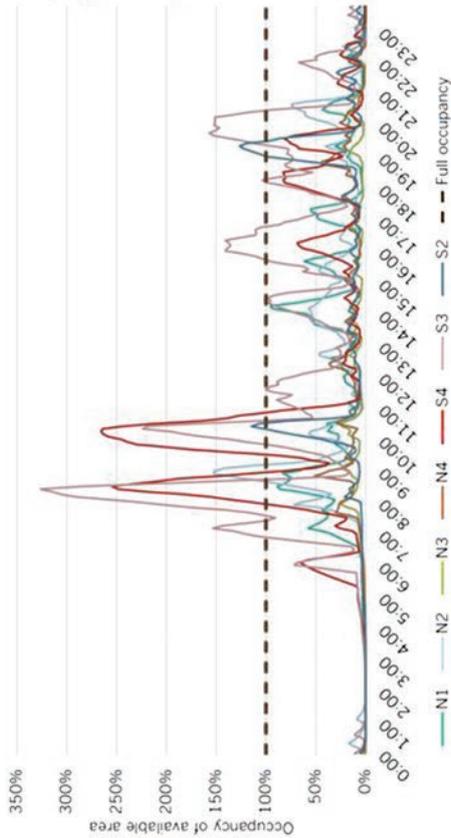Similar analysis was performed for the check-in lobby, security checkpoints, concourse walkways and escalators/elevators. Figure 5 shows peak occupancy levels at these touchpoints. Occupancy greater than 100 per cent reveals significant overcrowding and spillage into adjacent areas.

Nothing brings more power and joy than being prepared. So, with this empirical data, the customer service and terminal operations teams could proactively deploy and better manage passenger flow and crowding instead of simply reacting to long lines at a check-in lobby around noon. Knowing how much queueing to expect and its predicted spillover into the walkways was compelling information. As the cliché goes, knowledge is power. And now PHX teams and PHX's business partners had the power to manage, improve and manipulate operational efficiencies across the board.

Analysis of baggage claim passenger flow produced another gem. This analysis revealed a propensity by airlines to override assigned bag claim allocation. It resulted in certain baggage claims carrousels being used significantly more than others. This in turn sparked larger passenger crowds and longer wait times around
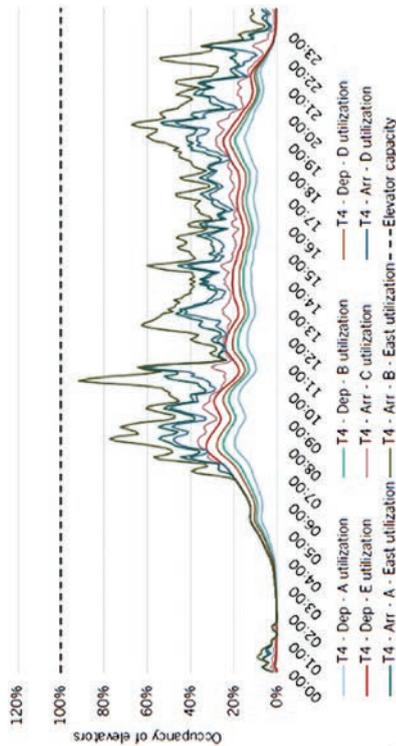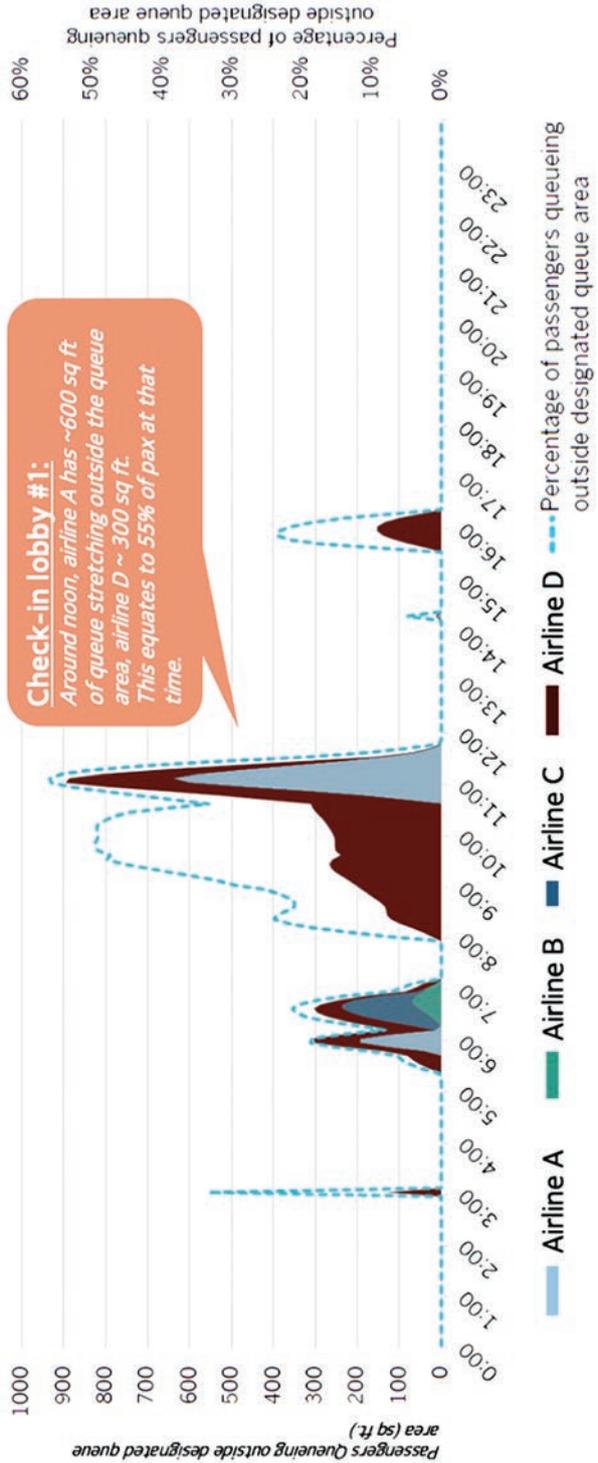
Elevators 9 – 14, Capacity reaches ~90% during morning peak, underlying the relevance of directing the majority of passengers towards escalators

Utilization of escalators/elevators

Space occupancy for various concourse walkways

Check-in lobby #1:
Around noon, airline A has ~600 sq ft of queue stretching outside the queue area, airline D ~ 300 sq ft. This equates to 55% of pax at that time.

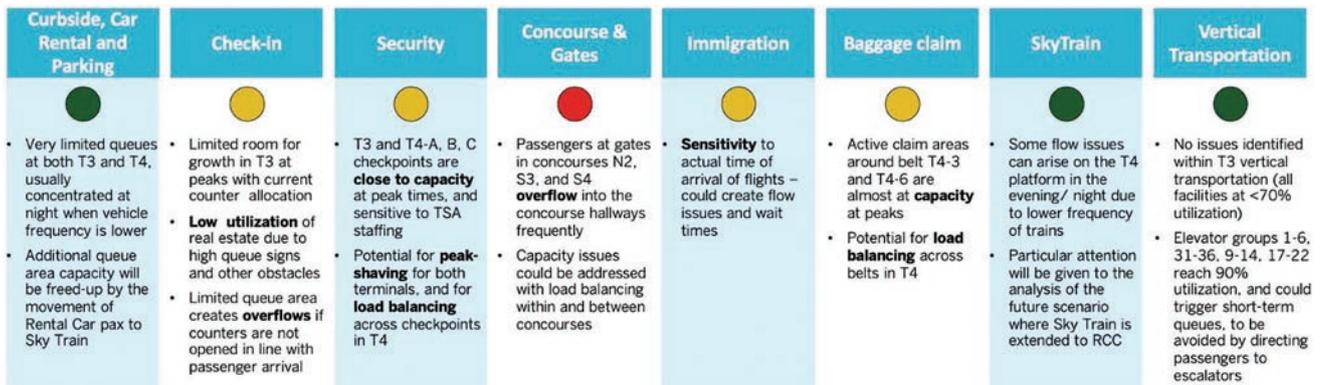**Figure 5** Spillage of passenger queues outside of the allocated check-in area

Figure 6 Baseline passenger flow analysis data by location

those carrousels. One airline was overriding the bag claim allocation by *up to 30 per cent.* Not only did it lead to bumpy overcrowding, but also it was an inopportune, negative passenger experience at the end of their journey. It did not reflect well on PHX, regardless of the responsible party. However, by sharing the researched data with the principal stakeholders, this negative experience could be converted into a positive, fine-tuned service for passengers.

Gradually, a baseline picture was developed for various passenger touchpoints. Invariably, the baseline data showed improvement opportunities across the aviation platform: in passenger flow at kerbside, check-in, security, concourse hallways and gates, immigration and baggage claim, to name but a few. The dashboard that was created was simple. It was an easy to understand and actionable digital stage. Figure 6 shows the executive dashboard used to convey the main outcomes of the baselining effort. A simple 'traffic light' themed dashboard was intentionally chosen to convey which areas were performing well and where passenger flow needed to be improved. For the first time, there was a complete data-driven operating picture of the terminal environment. It was possible to point out precisely where the logjam

points were, quantify them and show their impact on other passenger movements.

RISE OF THE LEISURE TRAVELLER

Another trend that surfaced with the resurgence of travel was the rise of leisure travel, which constituted the bulk of passengers who were travelling to/from PHX. Many of these travellers were not seasoned. In fact, many had not flown in years. These travellers could use any help the airport or airlines could offer. That is when the digital transformation journey from which so much was learned came back into play to provide inspiration and ideas to help this new travelling segment.

Going through airport security can be especially trying for many passengers. Often, they do not know what to expect or how long it will take to go through a checkpoint. However, giving passengers more control and predictability through the security process can make the air travel experience less stressful, more convenient and even more joyful. That was the genesis of the virtual checkpoint queuing programme called 'PHX Reserve', which the airport launched in partnership with Copenhagen Optimization and CLEAR. From the digital journey and understanding of the passenger flow, how passengers

moved within the facilities was known. The team had specifically zeroed in on quantifying queues at various passenger processing points. With that understanding of the operating environment, the approach could now be tailored to address specific bottlenecks. Leveraging virtual queueing to improve the security checkpoint experience for passengers emerged organically as one of the early initiatives. Through PHX Reserve, passengers can reserve a time to go through the TSA security checkpoint. This is helping travellers manage their trips and eliminate uncertainty and stress over the security process. It essentially puts the passenger in charge of one of the key travel processes — going through the airport security checkpoint. Instead of not knowing what to expect at airport security, passengers can now control the timing element of this experience ahead of time (Figure 7).

PHX Reserve is an easy-to-use service that allows passengers to save time and therefore take advantage of other amenities at the airport, such as shop at a boutique or dine at one of the award-winning restaurants. As recovery from the pandemic continues, the technology also provides an opportunity to impact non-aeronautical revenues. The airport's customer surveys are showing that about 50 per cent of passengers who saved time using PHX Reserve spent that time dining or shopping.

Successful airport operations are the result of collaborations and partnerships. And airlines have played a critical role in this venture. The pilot programme was launched in Terminal 3 with Alaska and United Airlines in March 2022. To their great credit, both airlines actively reached out to their passengers as part of their pre-travel communication and informed them about PHX Reserve. Later, the programme was expanded to Terminal
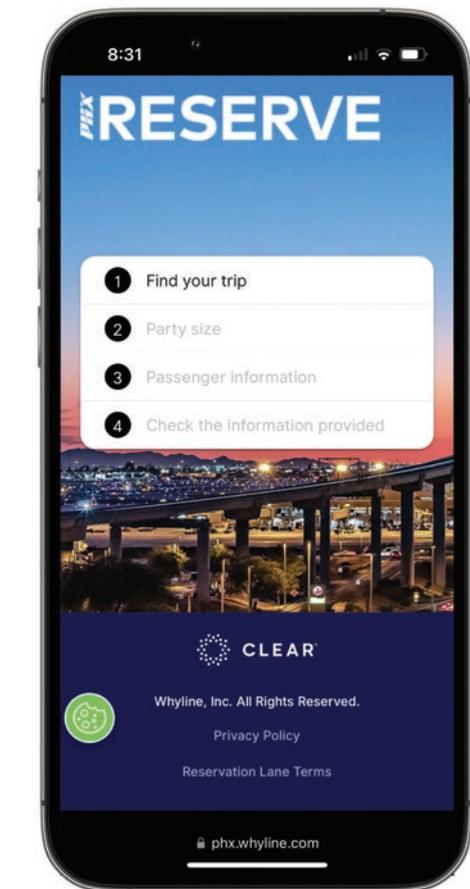

Figure 7 PHX reserve virtual queue booking page

4 in partnership with American Airlines. Since the initial launch, PHX has partnered with Southwest and Delta as well.

Of course, the TSA also played a key role — as did the airlines — in planning, developing and rolling out the programme. Likewise, the team worked with many airport divisions like operations, public safety and security, facilities and services and public relations to launch this new service. It was the operations team that was instrumental in working with TSA to develop the concept of operations and determine operating hours, as well as which checkpoints to use and where to add a dedicated lane to process PHX Reserve passengers (Figure 8).

Figure 8 Dedicated PHX Reserve lane at Terminal 3 security checkpoint

While the pilot programme continues to move along, the passenger feedback is very promising. They absolutely love the value this new service offers and the ease of using it at airport security checkpoints. About 90 per cent of passengers who have used the service are either very satisfied or satisfied with the service. About 97 per cent of these passengers indicated they used the service for peace of mind and less stress, as well as saving time. About 96 per cent indicated they would use the service again. Ultimately, it is a win-win-win for the passengers, the airport and the airlines.

SPRING 2022: THE TIMES, THEY ARE A CHANGIN'

Something unforeseen happened at the start of 2022. While passenger traffic surged close to 2019 levels, many of PHX's business partners and stakeholders struggled to provide the needed level of service due to staffing shortages. Labour shortages have impacted virtually every industry in the nation, and the aviation industry is no exception. PHX's concessionaires and custodial partners in particular grappled with this issue. The tight labour market conditions, coupled with the swarm of workers who left the workforce during the pandemic, created a perfect storm of high demand and low capacity. Passengers routinely expressed their frustration with lack of services and amenities at the airport. While business partners worked hard to hire new employees as quickly as possible, PHX, too, realised it needed to examine how its partners could use the resources they had as efficiently as possible. A helpful solution was in the airport's lap courtesy of the passenger flow analysis. A new service was introduced: providing passenger forecasts to business partners and stakeholders.
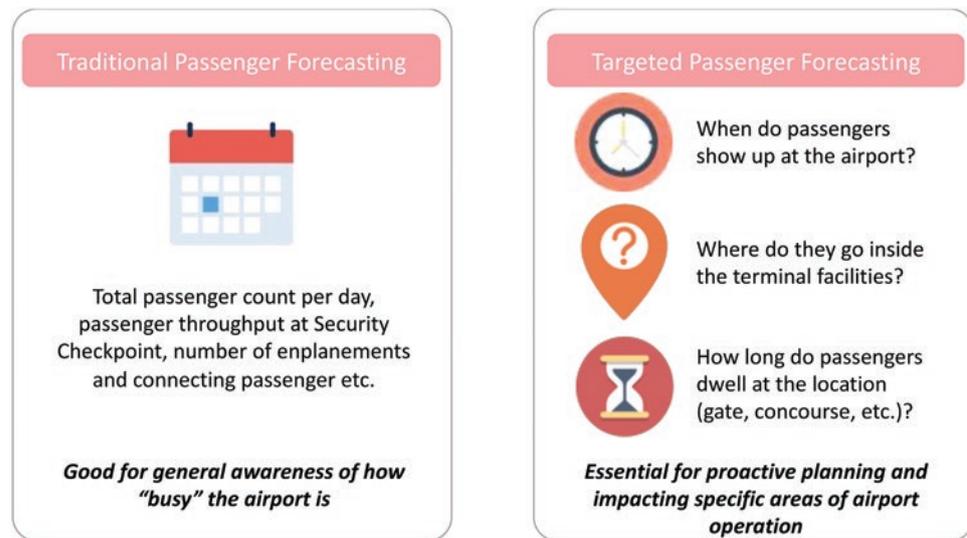
Figure 9 Targeted passenger forecasting approach used at PHX

Again, the idea was simple: help the airport's business partners better plan and address passenger demand beforehand instead of reacting to the predictable spikes in passenger volume. The passenger flow optimisation work completed in 2021 built a strong foundation of knowing what to expect in the airport's facilities. That baseline was used and an additional predictive capability for forecasting purposes was factored in.

Generally, PHX has always known the expected passenger flow through security checkpoints based on TSA data. But there was no solid information on where those passengers went following the checkpoint. For example, knowing 40,000 passengers would pass through the security checkpoint on a given day was not much help to the concessionaires or custodial teams. What was needed was to map out a passenger's entire journey, not just the aggregate passenger numbers for a day, and help the airport's business partners understand how many passengers to expect. Figure 9 shows the key attributes of targeted passenger forecasting

that PHX set out to understand and share with the airport community.

The data and insights that were gathered had to be shared with the airport's stakeholders and business partners. At PHX, its value was recognised. Various internal teams at PHX were ecstatic with the power the data provided them. There was confidence that the numbers crunched would also be embraced and celebrated by PHX's partners. So, armed with the passenger forecast model, the team met with the airport's retail and food and beverage operators. They were plainly asked how they planned for the influx of passengers on a daily basis. Surprisingly (which is a mild understatement), they readily admitted they relied on flight information monitors throughout the terminals. That is right. The flight information monitors were dictating their staffing and operational calendars. It was clear PHX's business partners were not planning, but rather reacting to the ever-changing airport environment. To complicate matters, the already short-staffed operators had no way to skilfully

pre-empt passenger demand and plan their operations.

This was seen as a huge win-win opportunity. They were shown the passenger forecasts and asked if this type of information would be helpful. The initial response was passively positive. So, PHX partnered with one of its prime concessionaires (Paradies Lagardiere), which operates many of the retail stores at the airport, in a pilot project. The forecast provided was robust. It charted passenger volumes per concourse (pier/gates) for every 60, 30 and 15-minute interval. In other words, it was possible to show how many passengers would be physically present in a particular concourse (say gates A1–A15) between 6am and 7am. That information told the operators the demand for which they should plan. But once again there was a surprise in store. The team learned that most concessions do not plan staffing and rosters for the day of operation. Due to the inherent shift-based nature of their business, rosters are set ahead of time, generally a week in advance. In other words, the day of operations passenger forecast was not of much value. What they really needed was a weekly forecast. What had seemed a great tool to help the concessionaire plan had failed to incorporate the most fundamental aspect of their business operation. So yes, the team was surprised, but not dejected. It simply meant revisiting the drawing board.

INNOVATION DONE INCREMENTALLY

A challenge in compiling targeted forecasting is knowing where passengers are going to be. And one of the most important element is the gate allocation data. At PHX, there are two operating models. One model is in Terminal 3. It is a common-use model, which means PHX assigns the gates for all flights in advance,

sometimes up to two weeks in advance. However, Terminal 4 is a dedicated environment spearheaded by American Airlines (AA) and Southwest Airlines (WN). These airlines, which are the two top airline carriers at PHX, are responsible for gate assignments.

In most instances, the gates are not assigned by the airlines until the day of operations. Therefore, doing a weekly forecast was not possible through conventional means. This is when the team turned to advanced analytics and asked: 'What is the probability of a flight being assigned to a specific concourse or pier?'

The team sifted through six months of flight data and created a model showing the gates where flights were typically allocated. Modelling based on historical data provided sufficient information for a sample set to predict a specific flight being assigned to a certain gate. More importantly, instead of focusing on the gate assignment, the team focused on the probability of a flight being assigned to a specific pier/concourse. Once established, the same formula was applied across the board. What was believed to be a fairly accurate picture of flight assignments was produced that could then be utilised to put together a seven-day forecast. Unsurprisingly, the concessionaires immediately found this data extremely valuable. But it was this out-of-the-box thinking and 'pressure' from business partners that propelled the team to creatively draft a fairly precise long-range forecast. Figure 10 shows a sample day forecast data shared.

It is not inexact to describe the pilot effort with Paradies as having proved an operational blessing for PHX's partner since they first joined hands in June 2022. Since then, the programme has been expanded to all concessionaires at the airport. This includes approximately

Passenger Forecast by Concourse (pier) by Hour
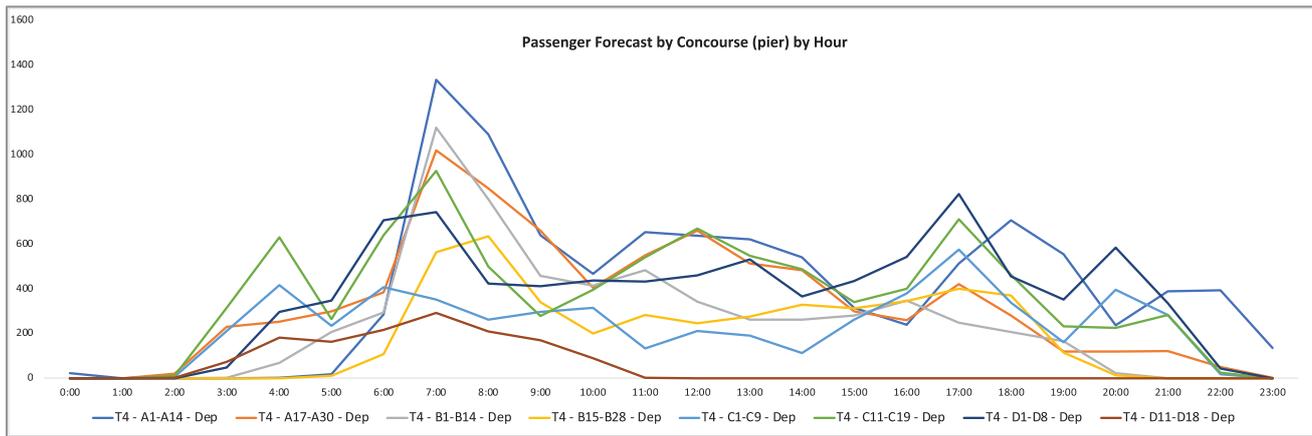
Terminal 4	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Concourse N1 - Gates A1 - A14	22	0	0	0	1	19	284	1334	1090	640	466	653	637	622	541	316	239	512	706	555	236	388	393	135
Concourse N2 - Gates A17 - A30	0	0	20	230	253	298	385	1019	850	660	406	551	660	512	484	300	260	422	280	120	119	121	51	1
Concourse N3 - Gates B1 - B14	0	0	0	2	68	207	294	1120	801	457	413	484	342	263	261	281	347	249	206	165	23	0	0	0
Concourse N4 - Gates B15 - B28	0	0	0	0	0	10	107	564	634	340	200	282	247	276	329	313	344	401	371	115	14	0	0	0
Concourse S4 - Gates C1 - C9	0	0	6	212	417	235	408	353	261	297	314	133	211	191	112	263	380	576	337	161	396	283	19	0
Concourse S3 - Gates C11 - C19	0	0	10	315	631	264	639	928	500	278	395	540	669	547	487	340	401	711	463	232	226	283	24	0
Concourse S2 - Gates D1 - D8	0	0	0	49	297	348	706	743	424	411	437	433	461	531	365	435	542	824	456	351	585	336	43	0
Concourse S1 - Gates D11 - D18	0	0	1	73	182	164	216	292	210	169	90	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure 10 Sample passenger forecast data 'by concourse/pier by hour' shared with concessions at PHX

150 retail, food and beverage, specialist retail and other stores. They all receive weekly forecasts. The pilot programme does not resolve the labour shortage, but it does provide them with helpful action-able data and insight. They can plan work schedules more effectively and allocate resources to meet specific demand when and where it is needed.

For example, if an operator with mul-tiple stores throughout PHX knows the expected passenger demand in certain piers throughout the day, they can proac-tively allocate resources where passenger demand surfaces the most and then real-locate resources when the demand shifts. It is simple. Likewise, the airport is also sharing the forecast data with the custodial contractor, Flagship. They are utilising the data to optimise cleaning operations across all passenger-facing areas of the airport. Flagship has a clearer picture of peak/drop cleaning demand of toilet facilities in various concourses. As such, they can pro-actively allocate staff and schedule cleaning

based on projected passenger numbers versus fixed cleaning schedules regardless of passenger traffic. Obviously, this allows them to focus on those terminal areas that are hosting the most passengers at any given time on any given day.

WHAT IS ON THE HORIZON?

This story is not over. Not by a long shot. It is still evolving. There are sev-eral potential areas in which the digital forecasts can improve operational efficien-cies. Many of PHX's ecosystem partners, including facilities management, ground transport providers, car hire operators, landside and airside operations, etc, can benefit from these data-driven predicting models. Moreover, the customer service team plans to use the data to position vol-unteers and guest services staff at strategic locations throughout the terminals based on projected passenger activity. Similarly, security and public safety teams want to use the data to get better situational

Figure 11 Applications of targeted passenger forecasting in other areas of airport operation at PHX

awareness of the airport environment from a safety perspective. Knowing how many passengers are expected to be inside each concourse at any given time or where most passengers are going to assemble is priceless information, especially during an emergency event or incident from a safety and security standpoint. Another big upside to this data is its ability to optimise the ground transport operation. Specifically, the taxis, courtesy shuttles, limos and the like can use this projected passenger volume data to craft tailored work schedules. The landside operations teams can utilise the same data to proactively plan kerbside traffic management, reduce congestion and ultimately enhance passenger experience. The airport has formed a working group with these stakeholders who are now leveraging passenger activity and forecast data to proactively plan and manage their specific area of responsibility (Figure 11).

This is just the beginning. The more this data is shared with stakeholders, the more untapped efficiencies and ways to better serve customers are uncovered. As noted above, it is a win for the airport, a win for the airport's business partners and a win for the lifeblood of the industry: the passengers. At the heart of it, this is part of PHX's broader digitalisation journey.

LESSONS LEARNED

The passenger flow optimisation and passenger forecast data sharing encompassed a journey of understanding the PHX airport environment and depicting it through data. It also uncovered discernible, tangible opportunities for improvements in many areas. However, this journey has sprung several valuable and some unexpected lessons.

KPIs and metrics are great, but have room for the unexpected

KPIs and metrics are essential. They are the pulse of the business and are invaluable to ensure the organisation does not stray from its goals. However, when trying to establish new insights centred on passenger

flow, it was important to be open and receptive to whatever data emerged. A perfect example is the insights regarding passenger arrival profiles that were created using baggage handling data. Previously, the possibility that this data would be helpful had never been considered. Similarly, leveraging historical gate assignment data to predict future gate assignments and flight assignments to a pier or concourse demonstrated how data led the way, and the team complied. Trusting the data paid huge dividends even when there was no clear value upfront.

Start with the data you already have

Often, there is a misconception about data in the aviation industry. It is widely thought that every possible data source must be in the mix when delving into numbers and analytics. This also includes 'new' data sources that involve implementing new systems and applications and their results. Not too long ago, a common refrain for the industry used to be 'We don't have all the data' or 'We need lot more data before we can do something with it'.

It was surprising to realise the insights that could be derived from data already possessed or that could be secured immediately. All that was needed was to have the right teams look at the data and massage it to maximise its use. This point is particularly important because it is very easy to turn this type of initiative into a science project. Everyone becomes consumed with collecting more and more data. Inaction and paralysis can easily take over, and all this research is just that, research. In today's world, business needs require quick insights and fast answers. Spending six to 12 months collecting, analysing and cleansing data does not work. The competition will sail right by you. They did not start out wanting to create a data

lake. The aim was to optimise passenger flow promptly within and let that guide the data that was needed and analysed. This approach also helped keep stakeholders engaged because the team was not working on a data project. Instead, it was working on a business operations challenge they saw immense value in.

Robust stakeholder participation

Having dependable, staunch stakeholder buy-in and engagement was critical. There was active participation from operations, security, public relations and customer service, facilities and services, design and construction, planning and environmental, business and properties and a slew of third-party entities. This collaboration made it possible to freely discuss various approaches for baselining the passenger flow. The team benefitted from the expertise that each business unit brought to the table. Also, each stakeholder could spot check what the data was saying because they knew their operation first-hand. Evaluating each passenger touchpoint within the airport environment would have been impossible without the stakeholders working with the team from the outset. They knew the operational nuances at each step. A huge achievement and benefit were having full stakeholder engagement in every weekly meeting with the team. Equally significant was having an anchor stakeholder (PHX Deputy Director of Operations) at the table who was wholly vested in the effort from the launch and every step of the way.

Customer feedback

This project underscored the value of being open to customer input, specifically, stakeholder feedback. For example, the team believed it had the precise daily

operation passenger forecast model for concessionaires. The pilot partner, Paradies, set the team straight immediately. Their input made it clear the model was off target. They told the team how their business community worked. It was a real-world lesson that emboldened, rather than disheartening, the team. Such feedback provided impetus to find innovative ways to do the seven-day targeted forecast by pier cherished by the concessionaires.

Messaging to the executive team

The project opened a multiplicity array of insights and operational perspectives. With so many possibilities, there was a risk of having too much output. So much that would make communicating to the executive team an insurmountable challenge. Instead, the focus was on an outcome-focused messaging approach. The idea was to simplify various operational phases and status from data analysis into a simple instrument. This instrument would act like a compass, pointing to where the issues were and where the focus should be. Accordingly, a simple 'traffic light' report was chosen for the passenger flow initiative. This simple visual concept allowed the executive team to see where passenger journey was encountering flow issues and where capacity was hard hit. It eliminated the need to understand tons of data analysis reports. This approach allowed the team to win executive support for the subsequent phases, including the passenger forecasting and virtual queueing programmes.

100 per cent data accuracy is a good goal to have, but business operations can work with less than that

You do not need 100 per cent data accuracy to attain your goals. Mid-stream through the data journey the team was forced to think about the 'relative' value of data and the insight being produced. Yes, a 100 per cent accurate forecast would be great, but the team was realistic and aimed for less. Not inaccurate, just slightly less. Traditionally, all that was available was just a broad TSA security checkpoint daily throughput or enplanement data. Anything above that was a windfall. So, the team stopped obsessing about whether or not the forecast was 95 per cent or 96 per cent accurate when contrasted with actuals for Q2 and Q3 months. The team stepped back and asked: 'What are we trying to achieve?' The answer was profoundly clear: to provide a forecast to enable business partners and stakeholders to proactively plan and allocate resources to meet the demand at any given time. That was the long and short of it. So, it was less important to forecast precisely to the last passenger than to give them a trustworthy idea about the relative 'occupancy' of each concourse. Ask yourself: is an additional 2 or 3 per cent data accuracy worth the cost, time and effort versus one with a lower bar yet just as effective? Each use case is different and should be evaluated independently.

Value of partnerships

From the start in 2021, the team readily acknowledged its strengths and weaknesses from a technical and operational standpoint. The team was well positioned when it came to understanding airport operations. But that was about the only certain thing. It had very little experience developing data models. And even less experience in creating a 'cause and effect' relationship between operational data models and passenger activity and facility utilisation. Just too many variables. Among other things, it involved

studying correlations between the various dynamic elements of an airport operation and using advanced statistical modelling and other technologies. But the team recognised this gap, a gap that had to be addressed if business operations were to be improved. Hence, the needed partnerships for much-needed technical expertise were established. Such partnering injected instant credibility to the project team and made it possible to continuously focus on creating the value through new insights. If your airport has limited expertise in data governance, data modelling and analytics, you are not alone. Do not let it deter you from embarking on a digital transformation journey. Do not hesitate to partner with third parties and leverage that expertise. PHX did. And PHX's passengers are loving it every step of the way at America's Friendliest Airport.

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