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# Optimisation of check-in process focused on passenger perception for using self-service technologies at airports in Australia

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#### Abstract

**Purpose:** The use of technology is constantly evolving for various services at airports to enhance the passenger experience. However, the passenger's perspective towards the technology is different.

**Design/methodology:** A survey was conducted to know these perspectives and find the differences. The collected data was based on the passengers at Australian airports. The CAST software was used to analyse the simulation model.

*Findings:* The collected survey helped in identifying three types of passengers: the number of passengers who prefer traditional service, the number of passengers who prefer technology-based services and the number of passengers who prefer technology-based services only under the specific circumstances such as less crowded and less processing time. Each type of passenger was further analysed based on their provided arriving time at the terminal and processing time for check-in to evaluate the impact on waiting time.

**Practical implications:** The findings suggest that only one third passengers prefer technologybased services at airports and present the resulting impact on the waiting time at check-in facilities.

*Originality/value:* Given the current rate of technological innovations at airports, the findings provide insights for check-in facilities management at airports.

*Keywords:* Check-in process, Passenger flow analysis, Simulation, Airport terminal, Self-service-technology, Self-service kiosk

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#### 1. Introduction

There are three main passenger processes at airports which are the departure process, the arrival process, and the transfer process. The passenger flow which mainly impacts the airport operations is the departure process (Alodhaibi, Burdett & Yarlagadda, 2017). For instance, the performance of the departure process such as a check-in process, impacts both the passenger satisfaction and the cost involved in the process. For this reason, the analysis of a passenger process has become an important point of attention for the stakeholders associated with the airport operations/airport departure process. The analysis of this process involves the quantification of airport service quality to comply with the International Air Transport Association's (IATA) Key-Performance Indicators (KPIs) to maintain a recommended Level of Service (LoS) for the passengers at airports. However, improving an airport process in itself, is a challenging task as an airport operation is always connected with a downstream and an upstream process/operation. For instance, a delay in the check-in process may lead to a delay in flight departure and a possible conflict in gate assignments (Al-Sultan, 2018). Additionally, every decision related to a process at airports is associated with a substantial financial impact (Alodhaibi et al., 2017).

Maintaining LoS at airports is important for passenger satisfaction/experience, therefore, technological innovations are taking place at airports as they can help with the passenger satisfaction/experience improvement. Therefore, the traditional face to face services at airports are gradually being replaced by Self-Service-Technology (SST) such as the self-service kiosk and online services.

A Self-Service Kiosk (SSK) is a stand-alone device that uses software to provide an interactive interface to the customers and can also be used for an instant print of tickets or boarding passes (Orencia, 2017). A basic SSK aims to fulfill the following functions: (1) passenger flight number request; (2) passenger details confirmation; (3) seat selection on flight; (4) boarding pass issuance; (5) baggage weighing; (6) baggage check-in tag issuance; (7) checked-in baggage acceptance (Lee et al., 2014). However, some airlines provide four to five services only via an SSK. The SSKs help in reducing the direct interaction between the passengers and the staff, with an enhanced productivity and efficiency (Gelderman, Ghijsen & van Diemen, 2011). Also, the SSK provides a work force equivalent capacity at a lower cost (Kokkinou & Cranage, 2013).

Additionally, other technologies as biometrics, artificial intelligence, and interactive navigation, provide contactless solutions, hence, can play an important role with the current and post COVID-19 situation at airports for dealing with the health measures (Halpern, Mwesiumo, Budd, Suau-Sanchez & Bråthen, 2021). Moreover, an effective use of SSTs could boost the passengers' confidence amid the social distancing rule at airports due to the COVID-19 situation (Antwi, Ren, Owusu-Ansah, Mensah & Aboagye, 2021). Further, it is not always possible to expand facilities/services due to the space constraints, and the technology-based facilities/ services could help in those cases. In most cases, the technology-based facilities/services provide cost-effective solutions, and also play a crucial role for stakeholders in maintaining a top position in the competitive world of aviation. It is also believed that technologies could help with a smooth passenger flow, means by mitigating the congestion, long queues, and delays due to an increasing air travel demand at airports (Alodhaibi et al., 2017).

Besides, it is important to know the passengers' perspective toward innovations before making an investment decision. Research shows that the technologies could improve the passenger process at airports. However, the proper validation of these technologies from the perspective of passengers is still lacking. Therefore, this paper aims to analyse the implemented technologies for the check-in process and to identify areas that influence the passenger process at Kingsford Smith Airport in Sydney (SYD). The study focuses on the point of view of passengers towards innovation. The study uses the CAST simulation tool for the check-in process analysis. In many industries, simulation is adopted as a tool to study the operational performance of stochastic processes.

Similarly, in the aviation industry simulation can be used as a tool to assist in predicting how a process behaviour will change as a result of a variation, such as the inclusion of a new technology, the redesign of an existing process, or a change in the passenger behaviour.

The reduction of the passenger processing time and waiting time at a service facility is used as an approach to improve the passenger satisfaction/experience and to maintain the LoS at airports. For instance, the total time required for a check-in process is one of the main criteria to evaluate the airport service quality (Chien-Chang, 2012). In most cases, the passenger servicing time is more than anticipated, as airports often overlook this during process designing. Therefore, this study investigates the passenger waiting time, from the time a passenger enters the terminal building to the time passenger leaves the check-in process, to evaluate to what extend the passenger waiting time can be reduced/ has been improved by the introduction of new technology.

#### 2. Literature review

Passenger processes at airports are divided into two categories: primary and secondary. The primary process includes: passenger check-in, baggage check-in, security, immigration and custom, baggage reconciliation. The secondary process includes: shopping, catering, and in lounge stay. Reduction of check-in time is important for passengers to reach the gate on time for boarding and enjoy other terminal facilities. Otherwise, passengers feel stressed and uncomfortable while waiting in the check-in queues as they might fail to reach the gate on time and could miss their flight. Therefore, this research study focuses on one of the processes of primary category. Specifically, the study focuses on the check-in process by assessing the passenger arrival pattern at the airport terminal and processing time at check-in facilities to evaluate waiting time.

For a better passenger experience, it is suggested that the airports should not focus only on the inclusion of innovative technologies, private firms, government agencies, space and information, but they need to include passengers' related activities, interactions and experiences throughout the terminal (Livingstone, Popovic, Kraal, Kirk & Kirk, 2012). In addition, passengers' expectations do not only include an efficient service and valuable information from the staff members; they also want efficient self-service facilities and definite online information. For instance, Singapore Changi Airport stands out as a global leader in the aviation industry due to its constant upgradation of facilities and improvements of the operational procedures (Lee, Ng, Lv & Taezoon, 2014). With the improvement of services at airports using a smartphone application, wearable technologies, biometrics, and SSTs, innovative technologies are benefitting air travel (Bogicevic, Bujisic, Bilgihan, Yang & Cobanoglu, 2017).

SST is considered an important economical option where a software interaction-based device such as SSK facilitates the check-in process for the passengers in a more efficient way. Here, the configuration of the SSK could be exclusive for an airline or for common use such as the Common-Use Terminal Equipment (CUTE) to share among airlines (Sabatová, Galanda, Adamčík, Jezný & Šulej, 2016; Young & Wells, 2011). On the other hand, data shows that the benefits from the modern check-in facilities are not too high and have been almost constant in recent years (SITA, 2018). Further, the research shows that the maximum use of technology adoption was for the online ticket bookings (SITA, 2019).

Every passenger's perspective towards air traveling is different and this makes analysing passenger's behaviour more difficult (Kalakou, Psaraki-Kalouptsidi & Moura, 2015). Passengers can take different paths through the check-in process, they may encounter waiting times at various stages of the passenger process (Kokkinou & Cranage, 2013). For instance, a passenger waiting for a staff member for service may move to an SSK once the SSK becomes unoccupied. This passenger will have encountered some waiting time at the check-in desk and no waiting at an SSK. Similarly, an SSK failure will result in waiting passengers to wait again for staffed service. Moreover, waiting time at services where the presence of a customer is compulsory, is inevitable due to reasons as fluctuation in demand and uncertainty (Luo, Liberatore, Nydick, Chung & Sloane, 2004).

The significant number of challenges at airports can be seen due to the consistent growth of passengers from different socio backgrounds and demographic characteristics (Chang & Yang, 2008). For instance, the arrival pattern of the passenger influences the boarding processing and the security screening process (Kalakou et al.,

2015; Artur & Tomasz, 2017). The variables defining the arriving pattern are as follows: different time intervals before scheduled departure based on flight (international or domestic), check-in (traditional or self-service) and passenger's background characteristics (Al-Sultan, 2018). Here, the passenger background characteristics are associated with the passenger age, arrival mode (car, bus, and train), travelling class (business, first and economy class), number of travellers/bags (one or more) and flight time (early or late) (Alodhaibi et al., 2017).

Many studies (Simon & Usunier, 2007; Chang & Yang, 2008; Gelderman et al., 2011; Ku & Chen, 2013; Castillo-Manzano & López-Valpuesta, 2013; Taufik & Hanafiah, 2019) emphasise the role of the passenger's behaviour and his/her background characteristics towards the use of SST at airports. A passenger's behaviour and his/her background characteristics are based on permanent and situational factors. For example, an important difference between the servicing time at SSKs for frequent travellers and other travellers can be seen, with frequent travellers checking in faster than the other travellers. Here, the permanent factors are age and perception towards technology, whereas the situational factor is waiting time at a facility.

The passengers' perceptions toward the use of SST at airports are further categorised as perceived usefulness, perceived ease of use, perceived adoption, and personal interaction. Other parameters defining the passengers' perceptions toward the SST use are expected reliability, expected speed of delivery, expected enjoyment, and the expected control (Chang & Yang, 2008). Human behaviour is hard to predict, therefore, there are several parameters mentioned and analysed by several authors including (Ku & Chen, 2013). The authors further added some additional parameters to the definition of passengers' perceptions toward the SST use are as follows: facilitating conditions, actual usage, behavioural intention to use, and the service process fit. In addition, the following parameters can be used: innovativeness, role clarity, crowdedness, insecurity, and discomfort, to define the passenger's perceptions toward the SST use at airports (Gelderman et al., 2011).

A number of models and tools have been described in the literature to evaluate the users' response towards the LoS provided by the airport. For instance, the Multinomial Logit Model (MLM) can be used for the analysis of the factors defining the behaviour of the passengers using any of the check-in facilities from the available options such as online, kiosk and traditional desk (Castillo-Manzano & López-Valpuesta, 2013). For the use of MLM, depending variables should not be ordinal but would rather consist of two or more categories and the independent variables specific to the case only. Further, the MLM is also used to analyse the security screening point factors affecting the passenger satisfaction (Gkritza, Niemeier & Mannering, 2006). MUSA (Multicriteria Satisfaction Analysis), which is based on the aggregation-disaggregation approach particularly focussed on the principles of the multicriteria analysis and the linear programming modelling (Tsafarakis, Kokotas & Pantouvakis, 2018). The MUSA method can consider fully customer satisfaction data as in qualitative form unlike other models that cannot handle the customers' judgments as a qualitative form of data. The MUSA method results can provide a descriptive estimation of customer satisfaction data. Moreover, an analysis of the coherent benchmarking system can also be achieved using it. A user can assess effective and complete results using the survey-based MUSA system software, along with the estimation of understandable and concrete indices of customer satisfaction. The main aim of the MUSA model is to form a collective value function by aggregating all the individual judgments. The Analytic Hierarchy Process (AHP) is a multi-criterion based decision-making method and has been used in various decision-making situations (Yoo & Choi, 2006). Indeed, multi-criteria techniques can deal explicitly with several effects of decisions such as conflicting, incommensurable, uncertain and multidimensional, which make them the promising solution to assess decision-making factors. A customer service model with integrating three customer-specific service models such as the pleasure model, the intercultural model and the boomerang model as is used to study the existing dynamics within the UAE aviation industry (Arif, Gupta & Williams, 2013). The Delft Systems Approach (DSA) based model is used for modelling and analysing of the check-in process (Tyagi & Lodewijks, 2019).

There are very few software tools that have been developed specifically for the aviation industry, to name a few are GPenSIM, SimWalk, Space Syntax, AnyLogic and CAST Enciso et al., 2016; (Schultz, Luo, Lubig, Mota & Scala, 2021). GPenSIM is a discrete event system-based model and simulation tool. SimWalk is described as a simulation and analysis tool for the passenger, specialised for the airports to provide evaluation and realistic modelling of passenger operations. Space Syntax is a volume modelling tool related to pedestrian safety analysis.

AnyLogic can be used in three different simulation methods such as the agent-based, discrete event and system dynamics simulation. CAST software provides a scalable and modular solution for airport operations such as optimisation and allocation system.

The research studies using simulation for analysing airport operations such as (Le, Creighton & Nahavandi, 2007) studied the optimisation of the baggage handling system, (Fayez, Kaylani, Cope, Rychlik & Mollaghasemi, 2008) studied the operation management, (Chawdhry, 2009) studied the passenger departure process, (Enciso, Vargas & Martinez, 2016) studied the passenger traffic and (Moreno, Elejoste, Masegosa, Rodriguez & Perez, 2018) studied the travellers' behaviour and service optimisation, at airports using the simulation modelling. Other studies such as (van Dijk & van der Sluis, 2006) studied the computation and optimisation of check-in, (Bevilacqua & Ciarapica, 2010) analysed the procedure for check-in and (Artur & Tomasz, 2017) investigated the check-in management to reduce the variability at security points, using the simulation.

Both the equation-based evaluation and agent-based emulation methods can be called "simulation". It is of practical interest and with great ethical for the system simulators and modelers to understand the related capabilities of both the approaches. As opting for an incorrect approach to solve a problem could be resulted in the wrong results which may further turn the situation into an emergency in a real-world scenario (Enciso et al., 2016).

Airports experience unforeseeable changes most often in passenger behaviour. Therefore, it is important to analyse and validate the implemented technology or a specific passenger process frequently. A simulation model can help in frequent validation of a system or an operational process. To understand the impact of technology on the passenger flow and other associated activities, a model is designed using the software-based CAST simulation tool, to assist the airport/airline management to curb the bottlenecks in the system. Moreover, the research on the impact of technology on the passenger process using simulation modelling is very limited. Hence, this study focuses on the airport check-in service using a traditional and self-service method through a simulation model.

#### 3. Research methodology

The data required for this study is collected using an online survey. Simulation is used as a quantitative research method for this study. The software tool CAST is used as the simulation environment. CAST (from Airport Research Center (ARC)) is a simulation tool used by professionals in the aviation industry. Many airports use the tool for managing their operations. The object configuration feature of the model allows a user to configure passenger routing behaviour. All the required facilities for a terminal could be used according to the users' requirements.

The model was developed in three phases in CAST. Firstly, a general layout to provide basic information about check-in facilities at an airport was created as a base for the simulation environment. Secondly, all the required elements related to the check-in process such as entry to the terminal building, info desk, self-service kiosks, traditional check-in desks with bag feeders, dwell area and the exit towards security were defined (see Figure 1a). Next, all the elements were configured such as setting processing time for each check-in facility and passenger routing scenarios. The passenger processing time was given as per our collected data (will be discussed in the Section 4). In the third phase, a model circuit describing pre-processing passenger flow within the simulation model was added. The model circuit consists of an airport database, object generator and object configurator. An airport database is where we fed flight schedule data, a real data of SYD airport (see Figure 1b) The object generator generates passengers according to the input flight schedule where the arrival pattern (will be discussed in the Section 4) was defined based on our collected data. The object configuration defines each passenger's flow throughout the model as shown in Figure 2.

Figure 1b summarises the total number of passengers in column "Pax Count". The total number of passengers in column "Pax Count" is split into two columns ("Pax Count (Tra..." and "Pax Count (Dire...") to show the number of transfer passengers and direct passengers, respectively. The number of transfer passengers in column "Pax Count (Tra..." is zero as the model has zero transfer passengers. Column "SOBT (Schedule Off-Blo...")

shows the scheduled departure date and time for the flight. The input flight data listed in an excel sheet was analysed for a day only therefore the column "SOBT (Schedule Off-Blo…" shows only one date. Further, the model uses the average load factor, where an average load factor is proportional to the average number of seats filled on a plane.

Figure 2 summarises the passenger flow inside the model. At first, the percentage of passengers using a particular check-in facility at the terminal was defined. Later, passenger routings from entering the terminal to reaching the check-in facility to the exit were defined. Finally, the model was used in a simulation and the computational time per simulation run was estimated in seconds using a 2.11 GHz PC. Here, the check-in process includes the process of check-in of baggage of the passenger except for the carry-on baggage which needs to be carried by the passenger (Hsu, Chao & Shih, 2012). After arriving in the check-in area, each passenger decides whether to go for the check-in counter or use the SSK. The traditional check-in process starts with a passenger arriving at the check-in counter which usually opens 3 hours before the scheduled departure time of their flight. Each passenger waits in a queue for his/her turn if staff is not available, otherwise the passenger moves directly to their respective check-in counter to get assistance from the staff. Once the check-in counter staff has finished the passenger checking-in, the passenger leaves the check-in counter. If all the staff members are busy with passengers, the arriving passengers join the queues feeding their respective check-in counters.

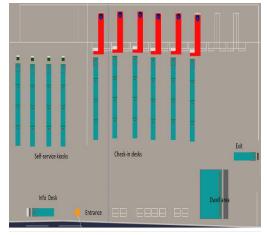


Figure 1a. Check-in process model implemented in CAST

Pax Informati			Milestones	
Pax Count	Pax Count (Tra	Pax Count (Dire	SOBT (Scheduled Off-Blo	
TXAT	TXAT	TFAT	TXAY	
211	0	211	15/01/2021 6:00:00 AM	
136	0	136	15/01/2021 6:00:00 AM	
136	0	136	15/01/2021 6:05:00 AM	
131	0	131	15/01/2021 6:30:00 AM	
139	0	139	15/01/2021 7:45:00 AM	
53	0	53	15/01/2021 8:10:00 AM	
141	0	141	15/01/2021 8:10:00 AM	
141	0	141	15/01/2021 8:55:00 AM	
139	0	139	15/01/2021 9:15:00 AM	
139	0	139	15/01/2021 12:00:00 PM	
139	0	139	15/01/2021 6:10:00 PM	
52	0	52	15/01/2021 7:00:00 PM	
131	0	131	15/01/2021 7:05:00 PM	
131	0	131	15/01/2021 8:05:00 PM	
131	0	131	15/01/2021 8:20:00 PM	

Figure 1b. Airport database generated flight schedule

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Figure 2. The object configurator of the simulation model

### 4. Results and discussion

This section discusses the passenger arrival pattern at the Kingsford Smith Airport in Sydney (SYD). Currently, Sydney airport is serving about 41 million passengers annually which is expected to increase to 87 million passengers by 2035. Sydney airport is Australia's most important airport and also recognised worldwide as the best airport in the 15-25 million passenger category, ranked 5 in the 40-50 million passenger category and 21 ranking in the top 100 airports of the world (Lloyd, 2003; Skytrax, 2019). The observed domestic terminals T2 and T3 of the Sydney airport are operated combinedly by several airlines and solely by Qantas, respectively.

An arrival pattern of passengers influences the boarding processing and the security screening process (Kalakou et al., 2015), therefore, a statistical arrival pattern from the collected online survey data is used as an input for the model. Airlines open the check-in desk facility for approximately 3 hours before the scheduled flight departure time. Table 1 shows the percentage of check-in desk and the SSK users with respect to their time in hours before the scheduled flight departure time. Here, the passenger arrival pattern depends on various items such as the check-in mode (check-in desk or SSK) and passenger background characteristics (Al-Sultan, 2018). Further, the passenger background characteristics are mainly associated with the passenger age, arrival mode (car, bus, and train), travelling class (business, first and economy class), number of travellers/bags (one or more) and flight time (early or late) (Alodhaibi et al., 2017). For instance, a passenger with an early morning flight prefers to arrive a little later than average (Chun & Mak, 1999; Artur & Tomasz, 2017). Furthermore, Table 1 shows that the passengers who arrived closer to the flight departure time, preferred to use the SSK. In addition, maximum passengers who used SSK arrived within the two hours before the scheduled flight departure. The overall maximum number of the passengers arrives 2.0 - 1.5 hours (peak time) before departure. The overall minimum number of the passengers arrives 2.5 hours before departure.

Hours before the scheduled flight departure	Check-in desk users (%)	SSK users (%)
3	16.5	8.5
2.5	8.5	8.5
2	50	33
1.5	16.5	33
1	8.5	17

Table 1. Passenger arrival pattern

Table 2 shows the four different time intervals specific to the check-in desk and SSK users from the collected online survey data. The collected online survey data depicts the different processing time intervals for the check-in desk users and SSK users, see Table 2. It can be noticed in Table 2 that most of the SSK users experienced a processing time of less than 5 minutes, however, a maximum of desk users experienced a processing time intervals be noted that there are various factors that play a significant role in determining the processing time intervals shown in Table 2. For instance, the frequent flyers or experienced passengers spend less time in check-in than the other users (Kokkinou & Cranage, 2013). Further, the check-in process for international traveller includes documents verification and, in most cases, passenger carries excess baggage which accounts for longer processing time at the check-in facilities. In addition, checks in with more baggage than average for a certain destination need more time to process (Bevilacqua & Ciarapica, 2010).

Next, the variations (Table 2) in the chosen check-in mode (check-in desk and SSK) and the respective processing times at each facility varies from passenger to passenger and depend on various factors like passenger's behaviour and background characteristics. These behaviour and background characteristics of a passenger are further influenced by the permanent and situational factors. Here, the age and perception towards the technology (SST) are the permanent factors, and the waiting time at a facility is a situational factor. For instance, the young passengers, female passengers, and higher level educated passengers prefer the SSKs (Castillo-Manzano & López-Valpuesta, 2013). The authors (Kokkinou & Cranage, 2013) added that 79.11% of passengers would prefer SSKs when there are no waiting passengers at SSKs and two waiting passengers at check-in desks. Researchers (Chang & Yang, 2008) have further identified factors associated with passenger's perspectives towards the technologies that mainly include the perceived usefulness, perceived ease of use, perceived adoption, personal interaction, expected reliability, expected speed of delivery, expected enjoyment, and the expected control. In addition, factors like facilitating conditions, actual usage, behavioural intention to use, the service process fit, innovativeness, role clarity, crowdedness, insecurity, and discomfort, are also associated with the passenger's perspectives toward the technologies (Gelderman et al., 2011). Although some of these factors are already being considered in the designing process at airports, there is a significant demand and requirements for considering many other factors discussed in this paper, especially with the current pandemic situation.

The check-in process using a different mix of check-in facilities is analysed using DSA for modelling and CAST for simulation. The overall goal of this study is to assess the impact of the number and mix of facilities on a tolerable waiting time. For a better level of service, the waiting time should be in line with the IATA's recommended LoS mentioned in Table 3. Here, the maximum waiting times are as 20 minutes and 2 minutes for a check-in desk and an SSK, respectively (from Table 3). The total number of check-in facilities was catered based on the maximum waiting time while processing the number of passengers based on the arrival pattern (from Table 1). All the check-in desks and SSKs are working as a common check-in facility. The format for queues at check-in desks and SSKs is FIFO, which means passengers are meant to be served based on First In, First Out.

The mix in check-in facilities was varied to see their impact on the waiting time. The results of the simulations in Table 4 show that only case 3 results in a set-up that complies with the IATA's LoS considering the maximum waiting time for the check-in desk and SSK, respectively. As per the collected data, only 24% of passengers are using SSKs, therefore, a lower number of SSKs in comparison to check-in desks are working fine within a tolerable waiting time. Further, it was observed that the introduction of SSKs has not impacted (very much) the waiting time at the check-in desks. Next, if all the check-in desks are replaced with the SSKs then the waiting time at SSK is more than the tolerable waiting time.

When an airport decides to implement a new facility, many questions arise such as whether they really need the new facility, whether they should replace the old facility with a new facility, whether they should add a new facility to the old facility or whether they should do both that and add some and replace some facilities? The analysis in Table 4 can help in answering such questions for the case study at hand. For instance, based on our recent survey we recommend that if an airport wants to add an innovative channel to provide a service for passengers, then they should not completely remove the previously used traditional channel for the same/similar

service for a better passenger experience. Further, the processes at airports are associated with an upstream and a downstream process. Hence, if a passenger is waiting longer at a check-in facility than the tolerable waiting time, it may not only influence (means delay) his/her next process, but it might also impact the waiting time of other passengers standing behind in the queue. Moreover, a delay caused by the long waiting time will further cause passengers distress, fear of missing flight and unsatisfaction.

Processing time interval (minutes)	Check-in desk users (%)	SSK users (%)
0-5	25	67
6-10	17	25
11-15	33	8
16-20	25	0

Table 2. Passenger processing time at check-in facilities

	Area per passenger (m²/passenger)	Waiting time (minutes)
Self-Service kiosk	1.3 – 1.8	0 - 2
Check-in desk	1.3 – 1.8	10 - 20

Table 3. IATAs recommended optimum LoS key-performance indicators (KPIs) for the check-in process

Case	Number of the check-in desk	Number of SSK	Average waiting time at the check-in desk (minutes)	Average waiting time at SSK (minutes)
1	10	0	18.36	N/A
2	8	2	18.72	6.24
3	6	4	19.68	1.08
4	4	6	20.76	0.12
5	2	8	22.08	0
6	0	10	N/A	4.68

Table 4. Check-in facilities vs waiting time

Next, the variation in the number of passengers using the check-in desk and SSK was analysed to see an impact on the waiting time at the service facilities (Table 5). Six check-in desks and four SSKs were chosen as they provide a tolerable waiting time for the given number of passengers. The findings show that the waiting time increased more drastically for SSK users when more than half of the passengers are assumed as using SSKs. However, the waiting time for check-in desk users exceeds the tolerable waiting time only when more than 80% of total passengers are assumed as using the check-in desk.

Passengers prefer to arrive at airports based on their circumstances such as the schedule of the flight (early or late flight), type of travel (domestic or international travel), the number of baggage (carry-on baggage only or baggage to check-in), check-in process (online check- in or check-in at airports), etc. However, passengers need to arrive within a span of 3 hours to 60 minutes before the scheduled departure of the flight. Hence, the variation in the passenger arrival profile with cases 1, 2 and 3 based on the arrival pattern was analysed (see Figure 3). It was found that the waiting time at the SSK remains under the recommended maximum waiting time in all three cases. However, the waiting at the check-in desk slightly exceeds the recommended value with the

passenger arriving pattern as in case 3 (Figure 4). From these results, it can be concluded that the arriving pattern impacts the passenger waiting time at the check-in desk, however, SSK waiting time remains under the recommended waiting time value.

Nowadays, airports all over the world are exploring technological solutions to provide a smooth passenger process, however, regional airports see introducing technology as a complex and slower process (Remencová & Sedlácková, 2021). Most importantly, the security process was seen as a significant area for innovation (Kiliç, Ucler & Martin-Domingo, 2021). Similarly, a wide array of passenger's perspectives can be noticed at different airports. Despite of all these, the common point of focus for every airport is passenger's overall satisfaction. This paper presents a pilot study to analyse and optimise the check-in process using a real case of an Australian airport (based on the collected data). The results achieved in the paper can also be integrated to study different factors affecting the check-in process at any other international or regional airport.

Case	Check-in desk users (%)	SSK users (%)	Average waiting time at the check-in desk (minutes)	Average waiting time at SSK (minutes)
1	100	0	21.36	N/A
2	80	20	19.86	0.54
3	60	40	18.6	4.74
4	40	60	13.8	12.9
5	20	80	3	18.36
6	0	100	N/A	19.56

Table 5. Impact of Self-service kiosk use on the waiting time

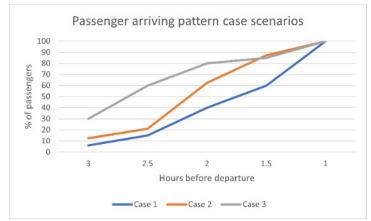


Figure 3. Different passenger arrival patterns: a case scenario

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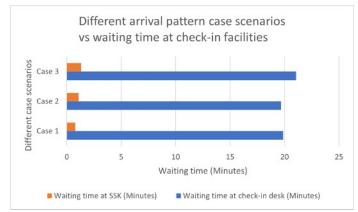


Figure 4. Arrival pattern impact on the waiting time at service facilities

#### 5. Conclusions

This paper presents the results of a study of the impact of technologies on the check-in process flow at an airport using survey results, a simulation model, and an airport dataset. The results show that using at least 6 check-in desks and 4 SSKs at the airport results in a set-up that complies with the IATA's recommended LoS. It was also found that only 24% of passengers were using SSKs, hence, a lower number of SSKs compared to the check-in desks works at SYD airport. Additionally, it was found that it is not possible to completely eliminate all the manned check-in desks even in the future. The achieved results also demonstrate that the passenger's waiting time at a check-in facility impacted the subsequent process time as well as the waiting time of other passengers. It was also found that the waiting time increased drastically for SSK users when more than half of the passengers were assumed using SSKs. Thus, it can be concluded that the variation in the number of passengers using a traditional check-in desk or SSK impacts the waiting time. This study also found that the waiting time varies based on the passenger arriving pattern, however, it remains under the recommended value of waiting time for the SSK users. This leads to the conclusion that the passengers' arrival pattern does impact the passenger waiting time. The study also discussed factors impacting the arrival pattern of passengers, processing time at check-in facilities and why some passengers prefer check-in desk or SSK at airport terminals. The study also helped in identifying factors demonstrating the passenger's perspectives toward the technologies. Overall, the achieved results were found to be helpful for the airport's decision-making towards the innovative technological implementation in the future or redesign of a current process. Furthermore, based on the results achieved in this study, the model developed in this work can be used to model and analyse processes at different airports, designing and planning, and optimisation of an operation in future studies.

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