

Taxonomy of Interactions and the Design of the Airport Passenger Screening Process

Levi Swann, Queensland University of Technology, Brisbane, Australia,
levi.swann@qut.edu.au

Vesna Popovic, Queensland University of Technology, Brisbane, Australia,
v.popovic@qut.edu.au

William Mason, Queensland University of Technology, Brisbane, Australia,
william.b.mason@gmail.com

Benjamin MacMahon, Queensland University of Technology, Brisbane, Australia,
benpmacmahon@gmail.com

Abstract

This paper presents a case study analysing the interactions of nine security officers during the mandatory passenger screening process at an Australian international Airport. Eye-tracking glasses were used to observe the visual, physical and verbal interactions of security officers while they performed the x-ray task. Stationary video recording devices were used to record physical and verbal interactions performed by security officers during the load, search and metal detector tasks. Six taxonomic groups were developed that define the different types of interactions performed by security officers during each task. Each taxonomic group is comprised of several discrete interactions specific to each of the tasks observed. Through analysing the composition of interactions and the relationships between interactions in different tasks, this paper highlights the prominence of interactions that security officers perform with passengers and their belongings. These interactions play an important role in the first and last stages of the passenger screening process, as well as influence the functioning of the overall passenger screening process. Due to this, they have substantial effect on passenger experience, throughput efficiency and security efficacy. In response to these findings, we draw from emerging security technologies and persuasive design principles to present potential design solutions for optimising the passenger screening process. These are presented in the context of a preliminary framework with which to inform the design of current and future passenger screening processes.

Keywords: Activity-centred design, airport security process, interactions, taxonomy.

Airport security is a complex system comprised of several layers that work concurrently to protect users of the airport and its services. The mode of these layers varies. Some operate in the background, such as intelligence and video surveillance. Others, such as the passenger screening process and customs, are clearly visible (Johnstone, 2015). Perhaps the most conspicuous of these, and the focus of this paper, is the passenger screening process. As a major processing point in the airport, the passenger screening process requires considerable human and financial resources. It is a mandatory process in which passengers must obediently participate in the examination of their person and belongings by trained security officers who operate various screening technologies (Graves et al., 2011). As well as being highly conspicuous, the passenger screening process is considered to be the most scrutinised of the different layers of security in the airport (Johnstone, 2015).

The scrutiny placed on the security screening checkpoint has largely been due to poor test results and significant security breaches. Tests conducted by the Transport Security

Administration (TSA) have shown that an alarmingly high number of threats pass through the security screening checkpoint undetected. The TSA has reported that security screeners at Los Angeles and Chicago airports missed over 60% of fake bombs in 2006 (Johnstone, 2015). This, along with high profile security breaches, such as the December 2009 attempted bombing of Northwest Flight 253, has made the security screening process a continual focus of investigation (Champion, 2012; Johnstone, 2015). Recognising these imperfections, and acknowledging the evolution of what constitutes a threat, airports implement a strategy of additional screening measures and the deployment of increasingly sophisticated technologies (Graves, et al., 2011). While these are seen to be necessary implementations to enhance security, they also add to the complexity of the passenger screening process and the tasks performed by security personnel.

Further to security efficacy, the passenger screening process must also balance other functions. Airports place strict economic pressures on airport security as the airport must demonstrate a certain efficiency and facilitate passenger throughput to remain viable (Salter, 2007). Passenger throughput, of course, must be balanced with adequate security efficacy to ensure the safety of airport passengers and staff, and protect the values of broader society. Failure of either security or economic functions is viewed as unacceptable. Adding to these two functions, the notion of passenger experience in the passenger screening process has gained traction in recent years. This has come in the form of the ‘security as a service model’ which was proposed by the International Air Transportation Association (IATA) and Aviation Council International’s (ACI) vision of ‘Smart Security’ (2016).

While recognising passenger experience as an important aspect of security, Smart Security aims to address equally the functions of security, economic efficiency and passenger experience. It proposes to do this by better organising the technical and human aspects in the design of the passenger screening process. Some key elements of this design strategy are remote x-ray screening, automated baggage transport and tracking, advanced screening technology and the provision of adequate spaces for preparation and repack of belongings (2016). The addition of passenger experience as a key consideration of airport security screening is consistent with the design strategy implemented in other airport services, such as retail, entertainment, and connectivity. In comparison, Airport security is a service that has remained relatively unchanged since the 1970s (Australian Government, 2009).

Given the competing functions of the security checkpoint, this paper analyses the tasks and interactions performed by security officers in the mandatory passenger screening process. In doing so, it contributes to the development of a taxonomy of interactions in the security screening context. It is expected that categorising and quantifying the interactions performed by security officers can provide a better understanding of discrete task functions and their role in the larger process. Short term, this understanding looks to inform design solutions for immediate implementation in the security screening process. Long term, there is the potential to assist planning and implementation of broader scale changes to the design of security processes to best service the functions of the passenger screening process.

Method

Observations were conducted at a security screening checkpoint at an Australian International Airport. The focus of observations were the interactions performed by security officers during the four tasks in the mandatory passenger screening process: (i) X-ray; (ii) Load; (iii) Metal Detector; and, (iv) Search (Figure 1).

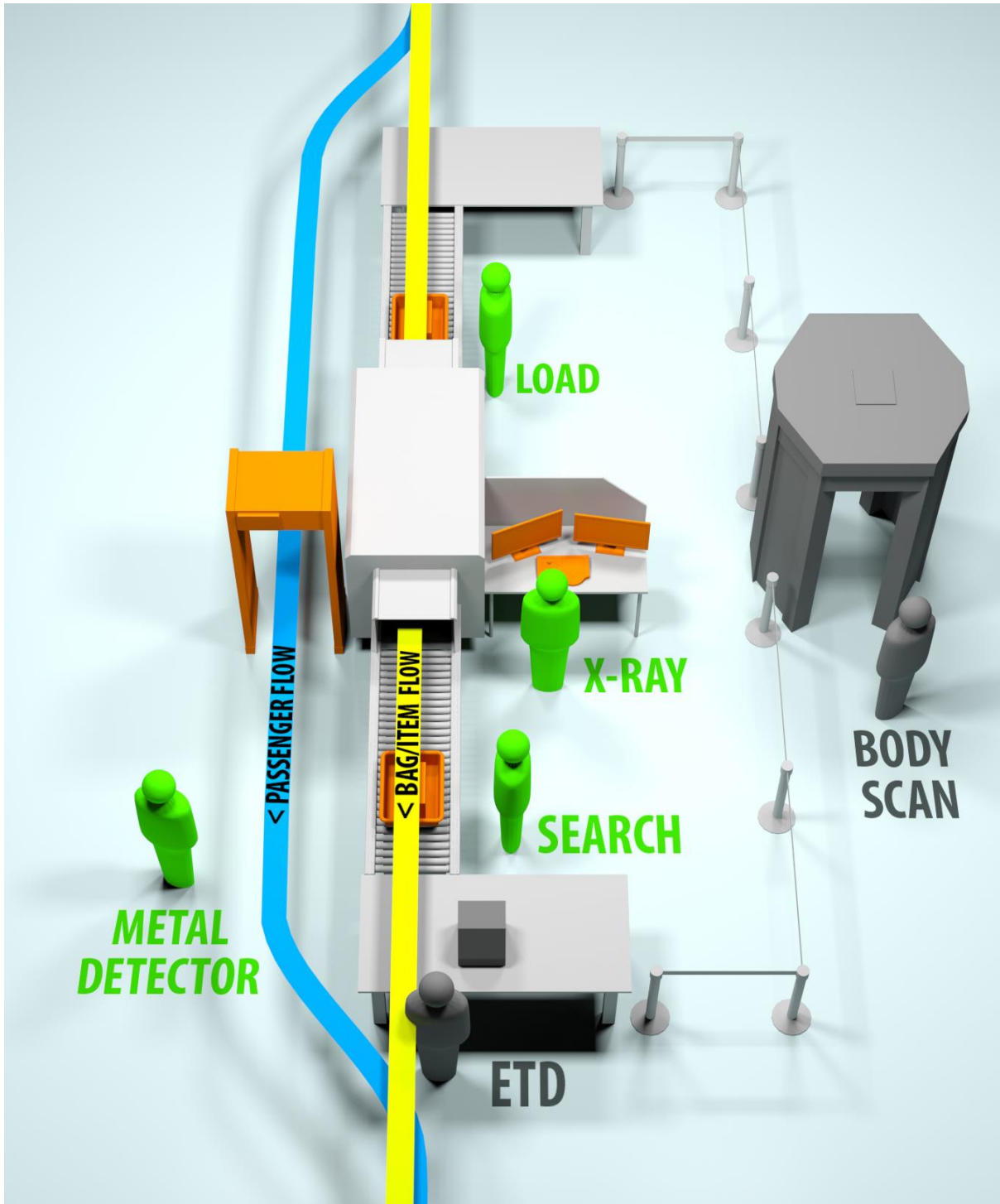


Figure 1. Security screening tasks and locations

Each of these tasks require various interactions to be performed with technology, staff, passengers, and passengers' belongings. To capture detail of these interactions, Tobii eye-tracking glasses and stationary video and audio recording devices were used. In addition to the four mandatory screening tasks reported in this paper, security officers also perform the tasks of explosives trace detection (ETD) and body scan (Figure 1). These tasks were not mandatory for passengers at the airport in which observations were conducted, and due to the scope of this paper, are not reported.

A total of nine security officers were observed while they performed each of the tasks in the mandatory screening process. Eight participants were male and one was female. The age of participants ranged from 20 years to 58 years old. Participants were recruited on the day of observations. They were first approached by the manager on duty, and upon agreeing to participate, were introduced to the researcher. Participants were then briefed on the observation procedure and asked to sign a consent form. Before signing the consent form, participants were informed that they could withdraw at any time and their decision not to participate would not result in any penalty.

Procedure

During normal task operations, security officers rotate through each of the tasks (Figure 1) at 20-minute intervals. Observations of security officers were conducted within this normal rotation policy. The order of tasks observed was (i) X-ray; (ii) Load; (iii) Metal Detector; and, (iv) Search. Prior to commencing an observation, Tobii eye-tracking glasses were calibrated to the participant. This involved a short eye-tracking task (approximately 2-3 minutes) and was conducted in a private location. Calibration is required for pupil tracking rate and tracking accuracy on a 5-point scale. Any participant unable to register a score on either of these scales was not calibrated and not able to participate in the study. All nine participants were successfully calibrated.

Participants were escorted to the security screening lane after being successfully calibrated. Observations of the X-ray task began at the first available rotation. Tobii eye-tracking glasses were fitted to participants and then set to record. Just prior to beginning the X-ray task, participants were reminded to deliver concurrent verbal protocol. This required that participants ‘think-aloud’ (Cooke, 1994; Van Someren, Barnard, & Sandberg, 1994), providing verbal comment on their interactions and processes. This assisted with interpreting the type and purpose of the interactions being performed. While participants were performing the X-ray task, Tobii eye-tracking glasses collected video from their visual field, eye movement data, and audio data of concurrent verbal protocols (Figure 2). At the completion of the 20-minute rotation, Tobii eye-tracking glasses were removed from participants and the recording was stopped. Participants then moved to the Load task.

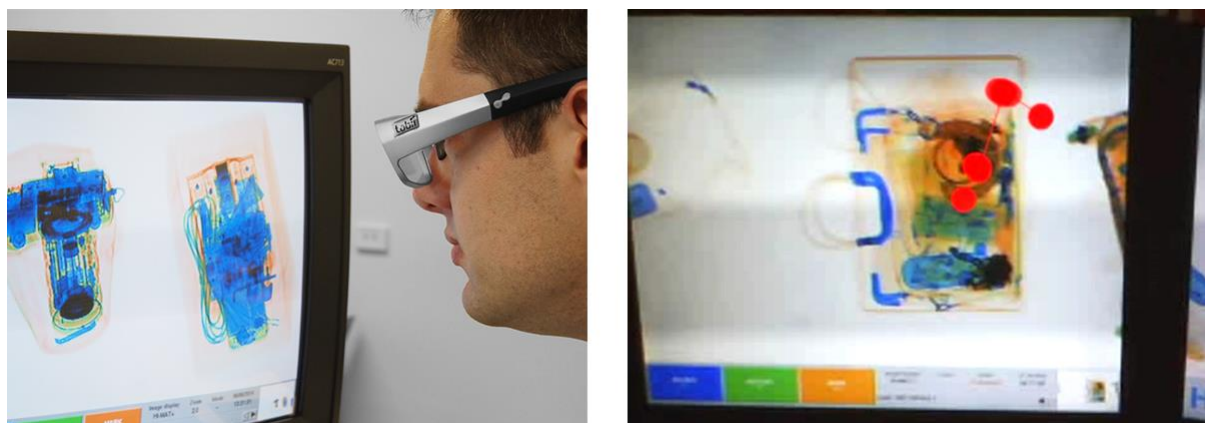


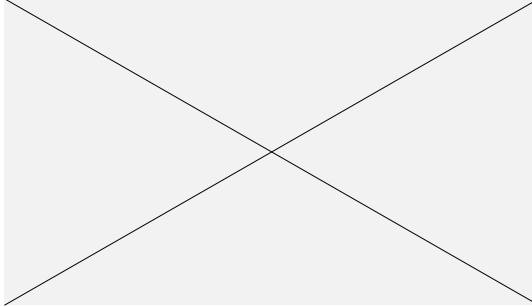




Figure 2. Mock-up of Tobii eye-tracking glasses worn during the x-ray screening task (left), and video and eye movement data captured by Tobii eye-tracking glasses (right)

Load, along with Metal Detector and Search are dynamic tasks. They often require movement between locations in the security checkpoint, and different interactions to be performed at the respective locations. GoPro Session video recorders with suction mounts were used to

capture these interactions. Upon rotating between each of these tasks, the video recorders were positioned at the location and set to record (Table 1).

Table 1. GoPro Session video recorder location and interaction focus

	Video Recorder 1	Video Recorder 2
Load		
Metal Detector		
Search		

Video recorders were positioned to capture the primary interactions that occurred with technology, luggage, passengers and other staff. Depending on the task, either one or two video recorders were used. Two were used during the Search task to capture interactions that occurred between multiple locations. Only one was required for the Metal Detector and Load tasks as the security officers performed interactions from a stationary position. Video recorders were positioned so they did not impede the interactions of the security officer or the passengers and their belongings as they moved through the security checkpoint. When the participant completed a task (20 minutes), the video recorders were moved to the next task location. Data collection was complete when participants performed each of the four tasks within the mandatory passenger screening process.

Data analysis and taxonomic groups

Data collected from observations of each task were coded in The Observer XT 13.0 (Noldus, 2016) behavioural analysis software. Coding schemes were developed using a process of open coding (Benaquisto, 2008). As video data were reviewed, notes of distinct types of interactions were made on Post-its. These were then arranged to form interaction categories and individual interactions (Figure 3).

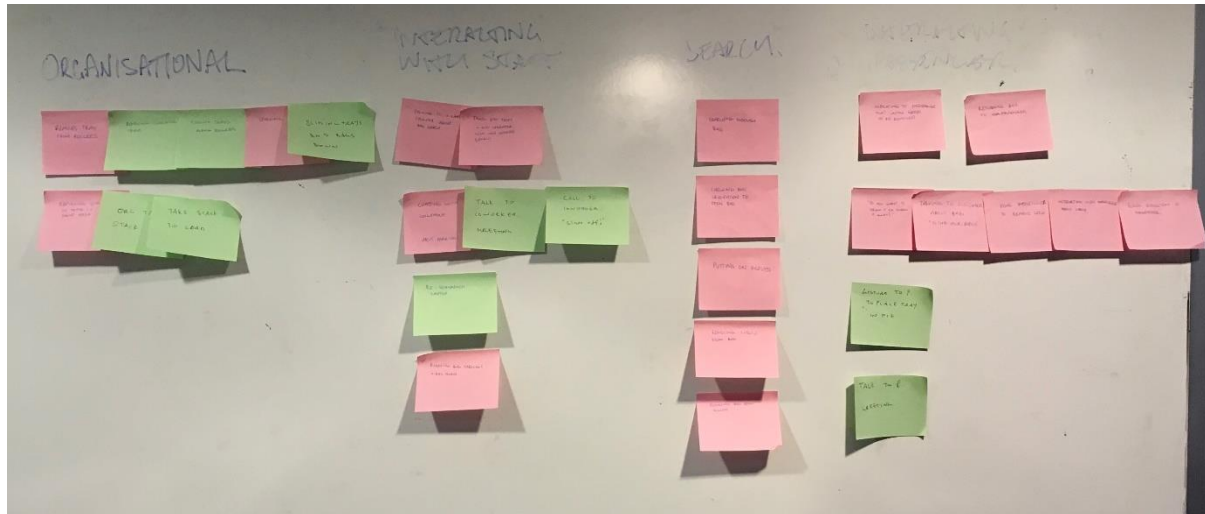


Figure 3. Interaction categories developed for the search task during open coding

Once an initial set of categories and interactions were developed for each of the four tasks observed, they were set-up as coding schemes in The Observer XT (Noldus, 2016). The coding schemes were further developed during early stages of coding within The Observer XT. This involved the addition of new codes to better explain interactions, and the combining of similar codes to reduce the complexity of the coding scheme. Through this process, six taxonomic groups were developed that were applicable to each of the tasks performed by security officers in the mandatory passenger screening process (Table 2).

Table 2. Taxonomic groups and interactions performed during the mandatory passenger screening process

Taxonomic Groups	X-ray	Load	Metal Detector	Search
Visual Interface Interaction	Searching images Examination of item		Watching for alarms	Viewing object location
Physical Interface Interaction	Applying IEF Identifying TIPS			
Bag/item Interaction	Intercepting bag/item Visual inspection Performing manual search Performing re-run	Repositioning bag/items Spacing bags Separating items onto a tray Removing trays		Searching bag Separating items onto a tray Clearing trays
Passenger Interaction	Asking questions about items	Giving instructions Asking questions about items Returning items	Giving instructions Explaining ETD randomiser Informing of result	Explaining process Asking questions about items Assisting gather and repack
Staff Interaction	Requesting manual search Requesting re-run Discussion	Receiving re-run		
Load	Receiving information		Requesting wand	Delivering re-run
X-ray		Informing about items		Discussing an item Receiving search instructions
Metal Detector	Receiving information			
Off-task	Off-task	Off-task	Off-task	Off-task

Airport passenger screening task composition

Results presented in this section analyse the composition of interactions in each task, and the direct relationships that occur between interactions in different tasks within the overall passenger screening process. Total time durations of the interactions performed by each participating security screener were computed using the Observer XT. Mean percentages for interactions were then computed for each individual participant, and then averaged over all participants.

Load

The Load task is primarily comprised of Bag/item Interactions (56%) and Passenger Interactions (28%). Periods of Off-task (11%) and Staff Interactions (5%) were performed to lesser extent (Figure 4).

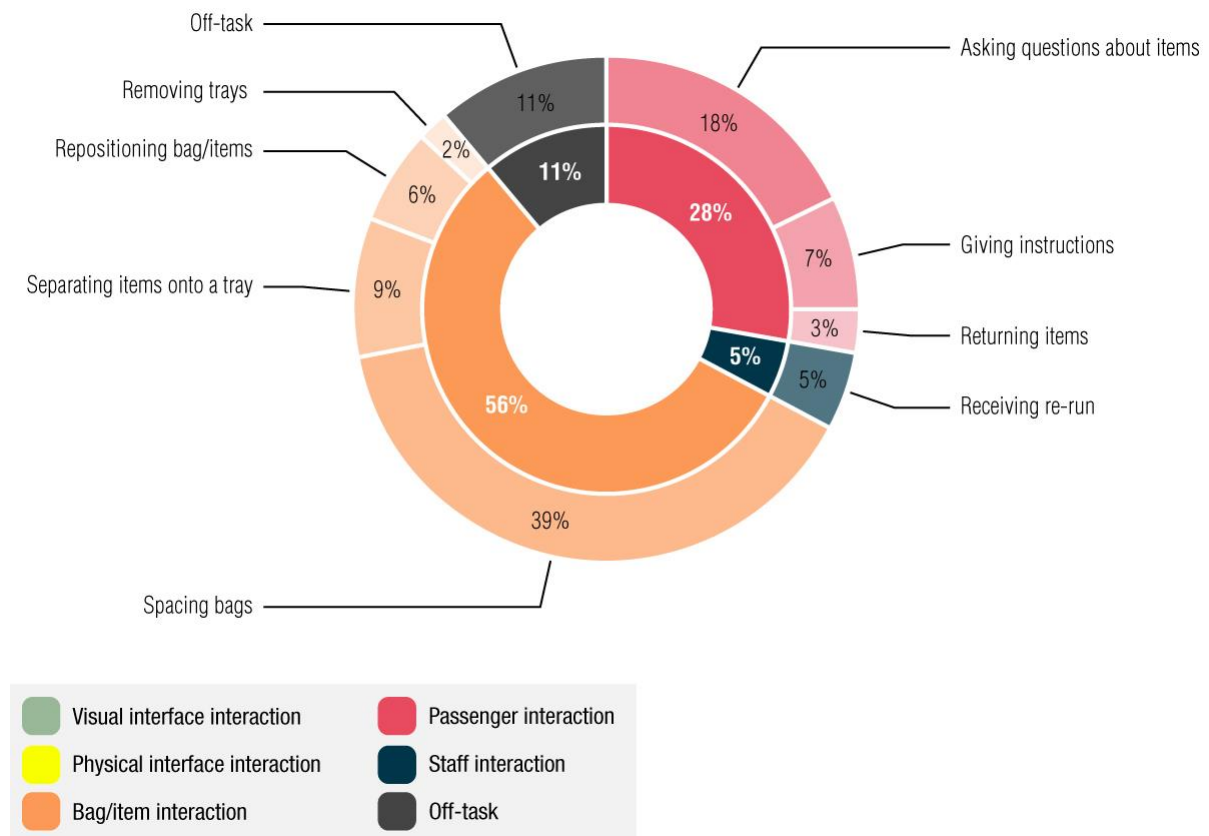


Figure 4. Interaction categories and interactions performed during the load task

The focus of security officers' Bag/item Interactions performed during the Load task was to ensure that passengers' carry-on luggage was inserted into the x-ray machine at appropriately spaced intervals (Spacing Bags 39%). This was followed by separating restricted items (e.g., liquids, aerosols and gels (LAGs); umbrellas; and, laptops) from a bag and placing them on a tray (Separating Items onto a Tray, 9%). Repositioning Bag/items (6%) was performed to reduce any clutter in trays and to ensure that the bag was in the optimal position to be screened by the x-ray. Removing Trays (2%) from the belt was performed to reduce clutter caused by unnecessary trays throughout the screening process.

Passenger Interaction types were performed to encourage passengers to divest prohibited items or items such as liquids that are required to be presented on trays for x-ray screening (Asking Questions About Items, 18%). Other types of Passenger Interactions involved Giving Instructions (7%) such as asking passengers to move their belongings down, and Returning Items (3%) that were not required to be screened, such as passports and boarding passes.

Staff Interactions occurred when Receiving Re-runs (5%) from other tasks in the screening process. For example, after a prohibited object had been removed in during the Search task, the bag is required to be re-run through the x-ray to ensure the threat is cleared.

Metal detector

The Metal Detector task had the least diversity of interactions of the four tasks observed (Figure 5). Visual Interface Interactions (86%) with the metal detector unit were the prevailing interaction. Passenger Interactions (13%) were performed occasionally, while Staff Interactions (1%) were rarely performed.

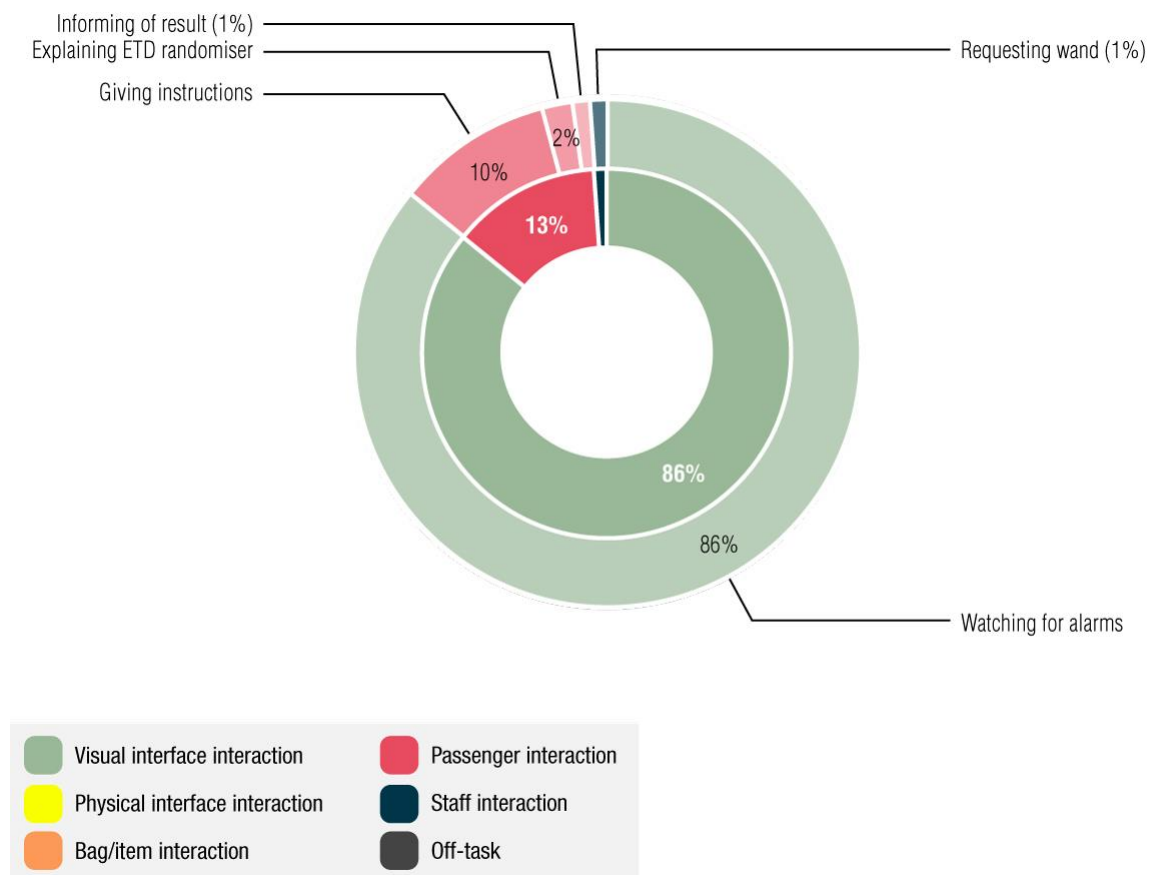


Figure 5. Interaction categories and interactions performed during the metal detector task

Visual Interface Interactions performed during the Metal Detector task involved Watching for Alarms (86%) as passengers walk through the metal detector.

Passenger Interactions performed during the Metal Detector task comprised of Giving Instructions (10%) to passengers, such as when it was clear to proceed, when to wait, and when to stop and go back. Less frequently, security officers were required to explain the explosives trace detection randomiser (Explaining ETD Randomiser, 2%), a visual cue that is

present on the metal detector when a passenger is randomly selected for ETD screening. Security officers were also required to explain to passengers when they had triggered an alarm due to metallic items on their person (Informing of Result, 1%).

Staff Interactions were infrequently performed during the Metal Detector task. They were used to request that another officer check the passenger for metallic items on the body using a hand wand (Requesting Wand, 1%).

X-ray

The X-ray task had the greatest diversity of interactions of the four tasks observed (Figure 6). Visual Interface Interactions (60%) comprised most of the task, followed by Off-task (22%). Bag/item Interactions (7%) and Staff Interactions (7%) each comprised small percentages of interactions. The percentage of Passenger Interactions (2%), and Physical Interface Interactions (1%) performed during the X-ray task were low.

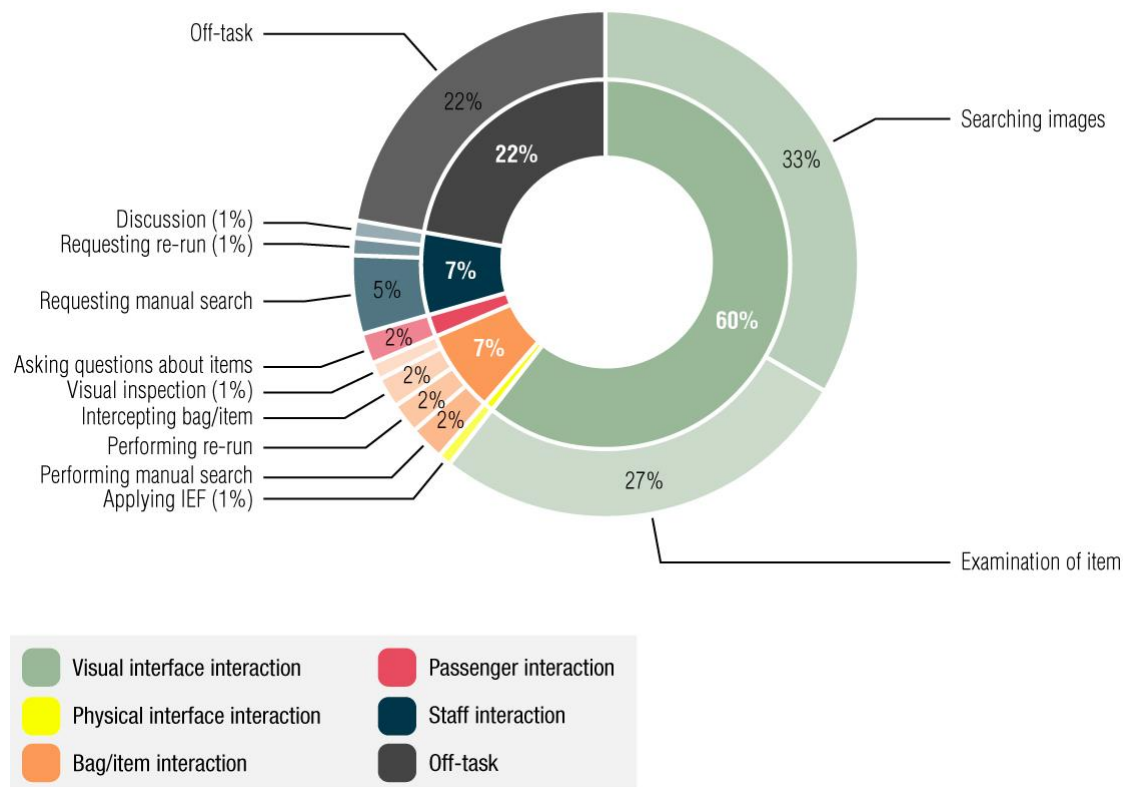


Figure 6. Interaction categories and interactions performed during the x-ray task

Visual Interface Interactions performed during the X-ray task focused on Searching Images (33%) for prohibited items or items of interest, and Examination of Items (27%) for the purposes of identification and evaluation.

Bag/item Interactions were performed during the X-ray task when a prohibited item or item of interest was identified and further action was required. Performing Manual Search (2%) of a bag was required for the removal of a threat or restricted item, and to investigate items that could not be identified through Visual Interface Interactions. Performing Re-runs (2%) was required when a bag/item had to be scanned through the x-ray a second time. This involved

transporting a bag/item to the officer at the Load position. Visual Inspection of a bag/item (1%) involved short visual check of the bag while it was on the conveyor belt, normally to check a feature on a bag or confirm the identity of an object in a tray. Intercepting Bag/item (1%) occurred prior to Staff Interactions, and involved removing a bag/item from the conveyor belt.

Staff interactions were performed with the security officer in the Search position when a prohibited item or item of interest was identified and further action was required. Requesting Manual Search (5%) was performed when a restricted item or item of interest was required to be removed or evaluated. Requesting Re-run (1%) occurred when the x-ray screener required the bag to be rescreened, for example, to look at the bag from a different angle. A Discussion (1%) between security officers was performed to evaluate and decide on an item of interest shown on the visual display, without requiring further action such as a re-run or manual search.

Passenger Interactions were performed to support Bag/item Interactions, and involved Asking Questions (2%) about a bag/item prior to, and during, a manual search or re-run.

Physical Interface Interactions were performed to support Visual Interface Interactions. Image enhancement functions (Applying IEFs, 1%) were used to alter the appearance of the image on screen to assist identification of an item of interest or to overcome difficult image conditions, such as clutter.

Search

The Search task comprised of a combination of interactions with staff, passengers, and passengers' belongings (Figure 7). Bag/item Interactions were most prominent (30%), followed by Staff Interactions (23%) and then Passenger Interactions (12%). Off-task periods were frequent (35%) in the Search task, as the performance of activity was dependent on search requests from the X-ray task.

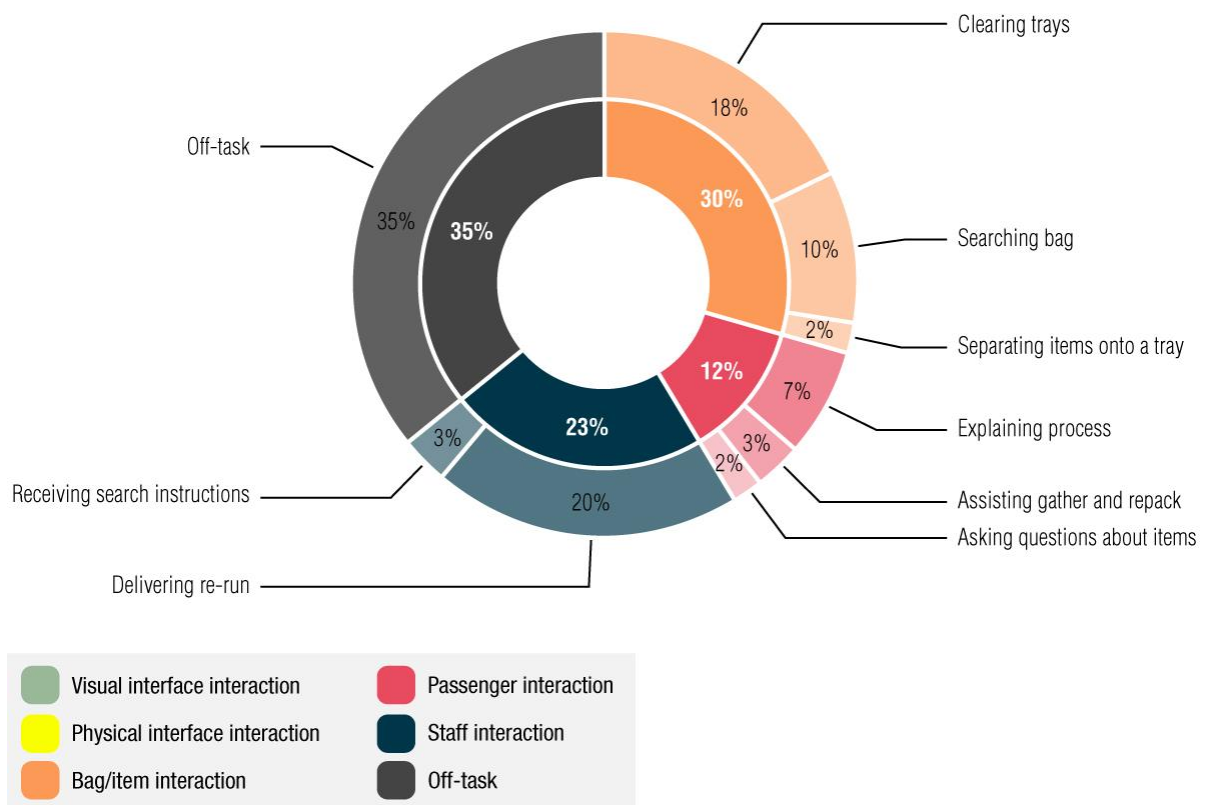


Figure 7. Interaction categories and interactions performed during the search task

Clearing Trays (18%) left behind after passengers had collected their belongings comprised most Bag/item Interactions. The remaining interactions with bags/items were concerned with search actions; Searching Bag (10%) and Separating Items onto a Tray (2%).

Interactions with staff occurred with two positions; Load and X-ray. Delivering bags/items to the load position to be re-run through the x-ray (Delivering Re-run, 20%) accounted for most of these interactions. This action occurred when the security officer in the X-ray position wanted another look at the bag, or following the search of a bag. Receiving Search Instructions (3%) from the security officer in the X-ray position occurred prior performing Bag/item Interactions.

Passenger Interactions were performed to assist search activity. This involved Explaining Process (7%) to passengers, Assisting Gather and Repack (3%) of bag after they had been searched, and Asking Questions (2%) to gain information of an items and its location within the bag.

Relationships between interactions in the overall passenger screening process

The tasks discussed in the previous sub-sections are performed by a single security officer and each serve a specific purpose in the overall passenger screening process. At various points during these tasks, however, interactions performed by security officers share direct relationships with other tasks in the process. They therefore can influence the overall functioning of the passenger screening process. Figure 8 highlights the direct relationships

that occur between interactions within different tasks throughout the passenger screening process.

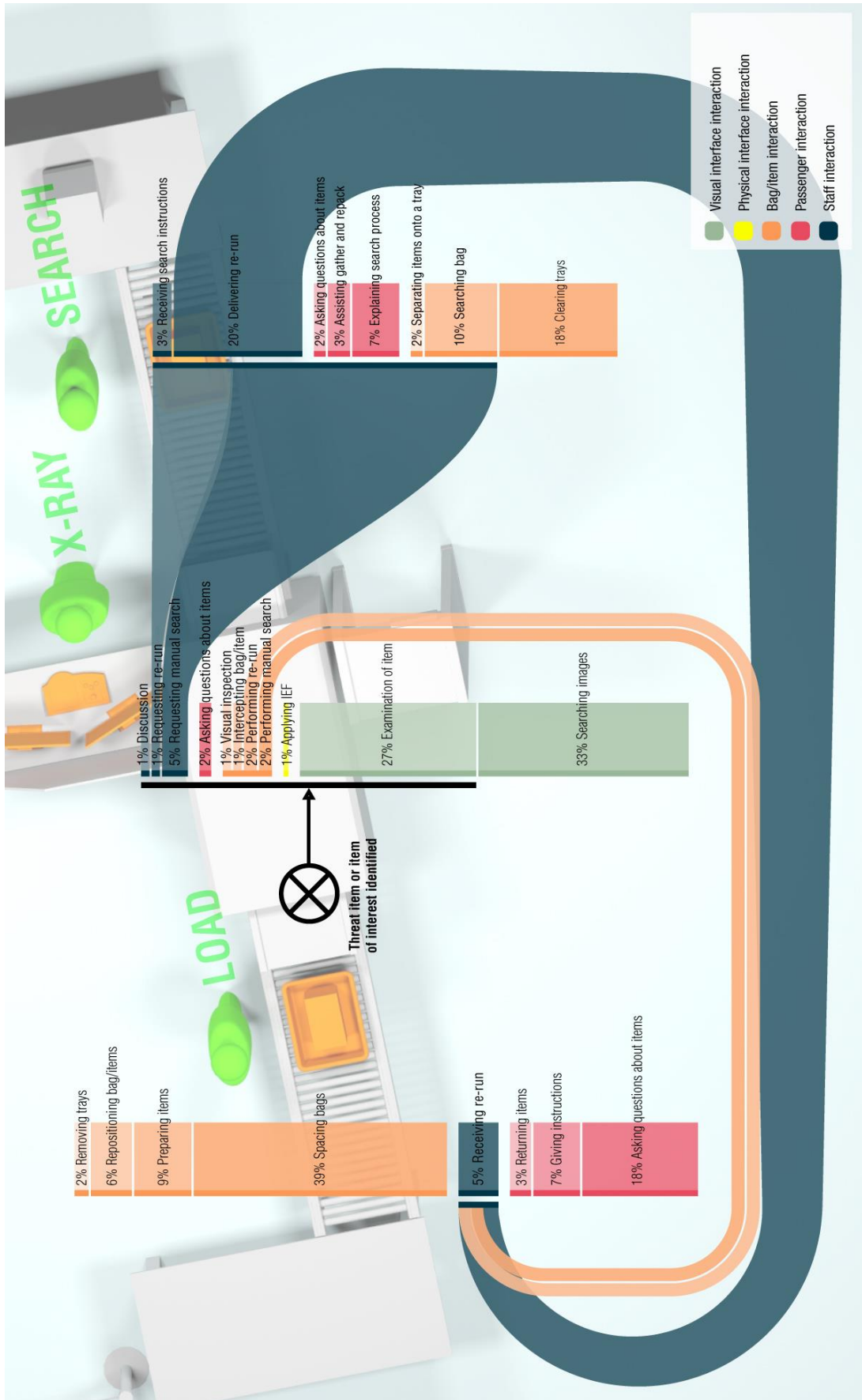


Figure 8. Direct relationships between interactions in the overall passenger screening process

Direct relationships between tasks are initiated by the security officer in the X-ray position when an item is encountered that cannot be resolved by examination or by using physical interactions with the interface. This event is represented by the ⊗ in Figure 8.

To resolve the issue, the security officer performing the X-ray task must first intercept the item (Intercepting Bag/item 1%). There are two types of interaction sequences that follow this: (i) performing a Staff Interaction with the security officer in the Search task; or (ii) performing a Bag/item Interaction themselves.

- (i) In the case of a staff interaction between security officers in the X-ray and Search tasks, the officer in the X-ray task will choose one of three options. If the problem can be resolved easily, a Discussion (1%) will take place. If further action is required, then the officer in the X-ray task will Request Re-run (2%) or Request Manual Search (2%) depending on the type of item. For example, a laptop left in a bag may only require a re-run to make the image clearer, while oversized liquids or sharps must be removed. In either case, the security officer in the Search position will receive Search Instructions (3%) from the officer in the X-ray position. They will then engage the passenger to explain the reason for the search (Explaining Process 7%) and gain information about the item in question (Asking Questions About Items 2%). Alongside these interactions with the passenger, the security officer must search and locate the item (Searching Bag 10%) and prepare the items for a re-run (Separating items onto a tray 2%), before Delivering Re-run (20%) to the officer in the Load position.
- (ii) If the officer in the Search position is not available, then the officer in the X-ray position will perform a Bag/item Interaction themselves. This includes Asking Questions About Items (2%), and then interacting with the bag/item to Perform Manual Search (2%) or Perform Re-run (2%).

In either of these scenarios, the security officer in the X-ray position is required to shift their attention away from the visual interface. Consequently, passengers and their belongings are not being processed for up to 13% of the x-ray task while the officer in this position is interacting with staff, passengers, and bags/items. Subsequently, this has a flow-on effect, accounting for up to 42% of the interactions performed during the Search task, and 5% of the Load task.

Discussion and implications for design

Each of the four tasks in the mandatory passenger screening processes are defined by the interactions that they are comprised of. In this paper, six taxonomic groups were developed to quantify these interactions: (i) Visual Interface Interactions, (ii) Physical Interface Interactions, (iii) Bag/item Interactions, (iv) Passenger Interactions, (v) Staff Interactions, and (vi) Off-task. These groups and the interactions comprising them can be used as a framework with which to inform the design of current and future passenger screening processes. Based on the composition of interactions, the passenger screening process can be divided into two main interaction focuses: (i) Interactions with passengers and their belongings; and, (ii) Interactions with interfaces and technology (Figure 9).

- (i) Interactions with passengers and their belongings

Interactions with passengers and their belongings featured most prominently within in the Load and Search tasks, occurring at the beginning and end of the mandatory screening process. In an environment known for complex and sophisticated technology (Graves, et al.,

2011), the prominence of interactions with passengers and their belongings emphasises the importance of designing for effective passenger engagement. Interactions with passengers at the beginning of the screening process are particularly important for passengers who are uninformed about the process and its requirements. If a passenger is uninformed, it is likely that they will not be prepared properly and thus be subject to further checks and delay. If a prohibited item is left in a passenger's bag, for example, a security officer is required to have the item removed from the bag and then scanned again. This type of delay is inconvenient and frustrating for a passenger, particularly if they do not understand why it happened in the first place (Kirschenbaum, 2013). This can lead to dissatisfaction with the screening process, which has been linked to passengers' lower perception of screening safety. Although airports are likely more interested in actual security efficacy, a passengers perceived safety is also important as it "determines travellers' willingness to take airplanes and pay for the cost of the screening process" (Sakano, Obeng, & Fuller, 2016, p. 129).

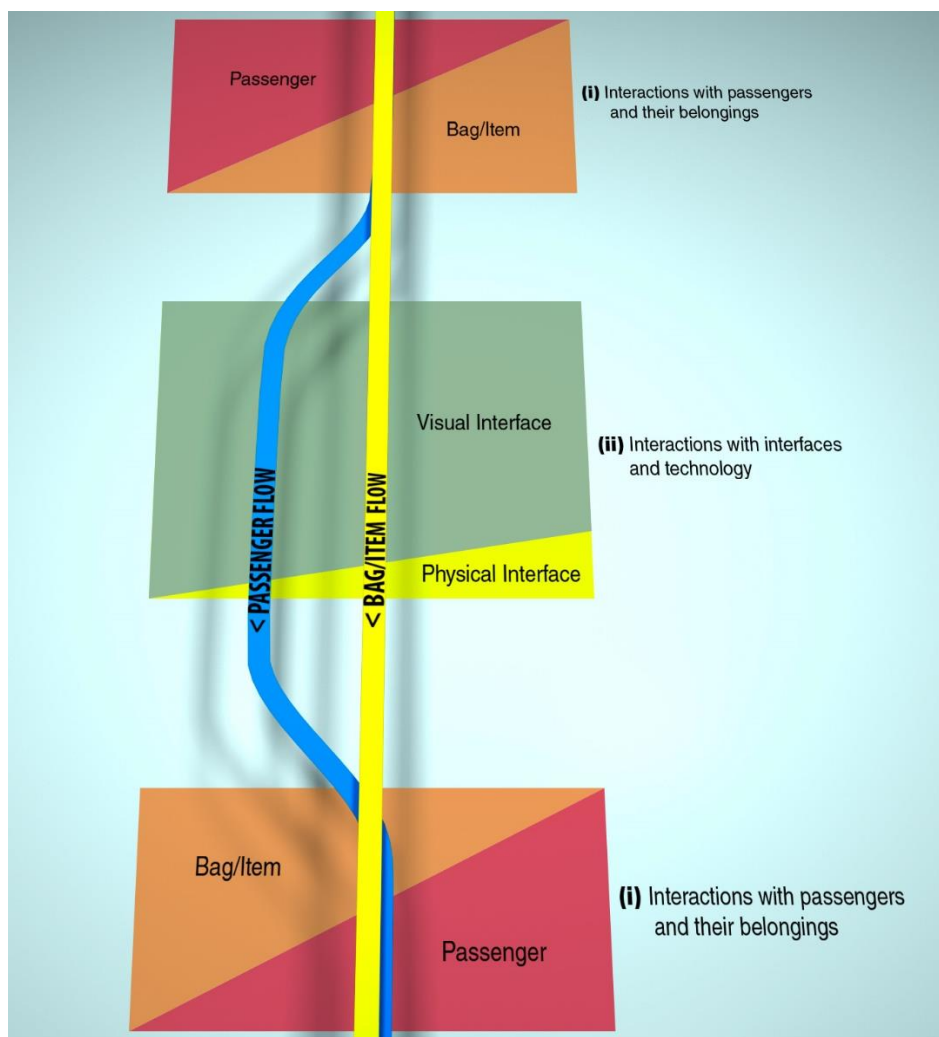


Figure 9. Framework highlighting interactions to be prioritised in the passenger screening process

The effect of delays caused by items and bags that need to be re-run through the x-ray are felt beyond passenger experience, and influence when and how a range of interactions are performed throughout the screening process. Results presented in this paper (see Figure 8) have demonstrated the considerable time and resources required to have bags searched and re-run. Whether security officers request these actions or perform them themselves, it equates to time when they are not processing images of passengers' bags. In effect, this renders the

entire process stationary, and thus decreases total passenger throughput and economic efficiency.

According to Kirschenbaum (2013), a large percentage of the delays that occur due to bag searches and re-runs can be accounted for by uninformed passengers. Kirschenbaum reported that between 85% and 90% of prohibited items that delayed passengers from continuing through the checkpoint were liquids that were either left in bags or that exceeded 100ml. Given this, it stands to reason that a substantial percentage of these delays can be addressed by better designing for passenger preparation and item divestiture. Kirk, Popovic, Kraal, and Livingstone (2012) provide strong support for this, suggesting that passengers' preparation is a critical requirement for airport efficiency as it encourages passengers to proceed through the airport more quickly. Based on their research, it was recommended to their partner international airport that they provide additional preparation space and staff to assist passengers' preparation well before they get to the main queue of the security checkpoint. This resulted in "a reduction in average waiting times from 20 minutes to 3.9 minutes, and an increase from 260 passengers per hour to 340 per hour being processed through security" (Kirk, et al., 2012, p. 10).

As long as passengers are subject to restrictions on common items (e.g. LAGs), and special preparation of others (e.g. laptops) is required, achieving efficient passenger processing is likely to be a challenge for the design of passenger screening processes. Using our taxonomic groups, it is proposed that interactions with passengers and their belongings are prioritised in the first and last stages of the passenger screening process. A first step for this is to implement changes to reduce or eliminate non-passenger focused and repetitive interactions such as spacing bags. While this is an important interaction that reduces visual clutter for the officer performing the X-ray task, it also requires constant attention from the security officer in the Load position. Our results show it comprises 39% of the Load task. This time could be easily freed up by implementing currently available systems that incorporate automatic bag spacing (e.g. Herbert Systems). Removing the need for security officers to perform this task would provide substantial additional time to focus on interaction with passengers and their belongings to encourage divestiture.

Systems that automatically space bags often also feature automatic tray return. Incorporating this technology would remove the need for security officers in the search position to clear trays, which comprised a substantial percentage (18%) of the Search task. Freeing up staff in the Search task means that they are more likely to be available when a search or re-run is required. This means that the officer in the X-ray position would not be required to search or re-run bags themselves, and can focus entirely on processing images of passengers' bags.

In addition to improving interactions during search and load tasks, supporting literature (Kirk, et al., 2012; Kirschenbaum, 2013) highlights the need to ensure that passenger utilised facilities prior to entering the security checkpoint be designed to encourage effective preparation. The current strategy to do this is properly placed signage and the provision of divestiture spaces to encourage preparation (Dallas/Fort Worth International Airport, 2005; Kirk, et al., 2012; Passenger Screening Task Force Architecture and Technology Workgroup, 2006). Despite persistent recommendations, however, the problem of item divestiture remains. Perhaps simply providing divestiture space and instructive signage is insufficient, and greater attention needs to be placed on the contextual design of preparation locations and spaces. There is strong evidence to show that people use contextual features to help them understand what to do and where to go in environments. Carpman, Grant, and Simmons (1984) found that environmental cues, rather than signage, were most important for people

when entering a hospital. Similarly, Cave (2016) has shown that airport passengers often use environmental features to inform them on what to do and where to go.

To enhance the contextual cues available to passengers, persuasive design methods (Lockton, Harrison, & Stanton, 2010a; Torning, 2013) can be employed. In particular, design patterns from visual and cognitive design lenses, which draw ideas from semiotics, product semantics and gestalt principles, are applicable. For example, grouping security preparation activities with similar preparation activities, such as filling out outbound passenger cards, might encourage passengers to perform these activities in a single step before entering security. With passengers likely to spend longer to achieve multiple grouped tasks, there is an additional opportunity to capture their attention with information sources, such as signage. The design of such spaces should also promote visibility between passengers to encourage opportunities for discrete user feedback. Providing discrete opportunities for feedback from people with equal status in the system can provide useful cues for how to behave (Lockton, Harrison, & Stanton, 2010b). This affordance is particularly valuable for uninformed passengers as it allows them to follow cues from others who are familiar with the process.

(ii) Interactions with interfaces and technology

Interactions of greatest priority during the X-ray and Metal Detector tasks are the visual interactions with interfaces to detect prohibited objects and alarms. Eliminating peripheral interactions with passengers, their belongings and staff during these tasks will allow greater focus to be placed on processing images, thus facilitating passenger throughput. Improving passenger preparation and the divestiture of prohibited items will contribute to this. However, security officers must also negotiate a range of image based factors, such as clutter and opaque objects, that can result in error and delay (Schwaninger et al., 2008). Advanced screening technologies will have a significant impact on this, and will facilitate greater focus on visual interactions with interfaces to improve processing capabilities. CT luggage screening systems, for instance, enable the rotation of x-ray images of passengers' bags, leading to better object visibility (Wetter, 2013). Although cost prohibitive at this point, deployment of CT technology will contribute to reducing instances of bag re-runs and manual searches of bags, if not eliminating them all together. Additionally, this technology will be a critical factor in realising remote screening, a key element of 'Smart Security' (2016). The recapture of space previously occupied by screening technology offers enormous potential for overhauling the design of the security checkpoint to maximise security officers' engagement with passengers and to enhance passenger experience.

Conclusion

This paper has identified six taxonomic groups to describe the different types of interactions performed during the mandatory passenger screening process at an Australian international airport. Quantification of the interactions within these groups, and analysis of the relationships that occur between interactions in different tasks, have shown the effect that interactions have throughout the passenger screening process. Staff Interactions and Bag/item Interactions performed during the X-ray task are shown to be of particular interest. Not only do these interactions cause delay to the X-ray task but they are directly related to the functioning of the Search and Load tasks. These interactions are also responsible for passenger delay and decreased throughput. The cause of these delays, however, is directly related to passenger preparation and divestiture of prohibited items. While technology is often positioned front and centre in this process, these findings suggest that emphasis also be placed on improving interactions between security officers and passengers.

From our findings, we have proposed a preliminary framework outlining the interactions types to prioritise in different stages of the passenger screening process. The framework emphasises interactions with passengers and bags during the first and last stage of the security process, and visual interactions with interfaces during the middle stage. Emphasis of these interactions can be facilitated by assistive technology that automatically spaces trays in the Load task and returns trays in the Search task. Additionally, advanced screening technologies such as CT systems will assist security officers' visual interactions, thus reducing requirements for bag re-runs and manual searches. It is imperative that the design of passenger screening processes focus on enhancing both technology and human interactions. The significance of this research lays in its potential effect on the three functions of the security screening process: passenger experience; throughput and security. As this research progresses, we expect to further address these functions by extending the taxonomy of interactions to include non-mandatory screening processes.

Acknowledgements

This research forms part of the work undertaken by the project "Monitoring Intuitive Expertise in the Context of Airport Security Screening" (LP140100221) which is funded by the Australian Research Council Linkage Project scheme. The authors also acknowledge the contributions made by the aviation industry partners involved in this project.

References

- Australian Government. (2009). *Review of Aviation Security Screening: Report*. Canberra: Commonwealth of Australia.
- Benaquisto, L. (2008). Codes and Coding. In L. M. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 86-89): SAGE Publications, Inc.
- Carpman, J., Grant, M., & Simmons, D. (1984). *No More Mazes. Research About Design for Wayfinding in Hospitals*. Ann Arbor: University of Michigan Hospitals, Patient and Visitor Participation Project.
- Cave, A. (2016). *Passengers' Intuitive Navigation in Airports* PhD thesis. Queensland University of Technology, Brisbane, Australia.
- Champion, N. (2012). *Aviation Transport Security Amendment (Screening) Bill 2012*.
- Cooke, N. J. (1994). Varieties of Knowledge Elicitation Techniques. *International Journal of Human-Computer Studies*, 41, 801-849.
- Dallas/Fort Worth International Airport. (2005). *Security Checkpoints - Improving Throughput*.
- Graves, I., Batavicius, M., MacLeod, V., Heyer, R., parsons, K., Kuester, N., . . . Johnson, R. (2011). The Role of the Human Operator in Image-Based Airport Security Technologies. *Studies in Computational Intelligence, Volume 338/2011*, PP 147-181.
- IATA. (2016). Smart Security. Retrieved May 27, 2016, from <http://www.iata.org/whatwedo/security/Pages/smart-security.aspx>

- Johnstone, R. W. (2015). 8 - Implementing Aviation Security. In *Protecting Transportation* (pp. 251-288). Boston: Butterworth-Heinemann.
- Kirk, P., Popovic, V., Kraal, B., & Livingstone, A. (2012). *Towards a Taxonomy of Passenger Airport Experience*. Paper presented at DRS 2012: Uncertainty, Contradiction and Value, Department of Industrial Design, Faculty of Architecture, Chulalongkorn University, Bangkok.
- Kirschenbaum, A. (2013). The Cost of Airport Security: The Passenger Dilemma. *Journal of Air Transport Management*, 30, 39-45.
- Lockton, D., Harrison, D., & Stanton, N. A. (2010a). The Design with Intent Method: A Design Tool for Influencing User Behaviour. *Applied Ergonomics*, 41(3), 382-392.
- Lockton, D., Harrison, D., & Stanton, N. A. (2010b). *Design with Intent: 101 Patterns for Influencing Behaviour Through Design*: Equifine.
- Noldus. (2016). *The Observer*. Netherlands.
- Passenger Screening Task Force Architecture and Technology Workgroup. (2006). *Security Checkpoint Layout Design/Reconfiguration Guide*.
- Sakano, R., Obeng, K., & Fuller, K. (2016). Airport Security and Screening Satisfaction: A Case Study of U.S. *Journal of Air Transport Management*, 55, 129-138.
- Salter, M. B. (2007). Governmentalities of an Airport: Heterotopia and Confession. *International Political Sociology*, 1, pp 49-66.
- Schwaninger, A., Bolfig, A., Halbherr, T., Helman, S., Belyavin, A., & Hay, L. (2008). *The Impact of Image Based Factors and Training on Threat Detection Performance in X-Ray Screening*. Paper presented at The Third International Conference on Research in Air transportation, Fairfax, VA.
- Torning, K. (2013). A Review of Four Persuasive Design Models. *International Journal of Conceptual Structures and Smart Applications*, 1(2), 17-27.
- Van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The Think Aloud Method: A Practical Guide to Modelling Cognitive Processes*. London: Academic Press.
- Wetter, O. E. (2013). Imaging in Airport Security: Past, Present, Future, and the Link to Forensic and Clinical Radiology. *Journal of Forensic Radiology and Imaging*, 1(4), 152-160.

Author Biography

Levi Swann

Levi Swann (PhD) is a Research Associate with the People and Systems Lab at Queensland University of Technology. His PhD research investigated the interactions of airport security screeners, focusing on understanding the role of intuitive expertise in complex interactive

systems. Levi's current research expands on this work, and will contribute to the development of automated technologies for monitoring the airport security screening context and the interactions of security screeners. In addition, Levi has collaborated with the CSIRO, and both the Rural Industries and Cotton Research and Development Corporations to conduct feasibility assessments and forecasting of emerging technologies. Levi also has experience as a practicing designer and has worked across the disciplines of Industrial, Graphic, and Strategic Design. This experience positions Levi as an interdisciplinary designer and researcher, with his practice targeted at the nexus of design, science and technology. (levi.swann@qut.edu.au)

Vesna Popovic

Vesna Popovic (PhD) is a Professor in Industrial Design at Queensland University of Technology, Brisbane, Australia. Her research focus is within experience and expertise, intuitive interaction and intuitive navigation domains. She has made an international contribution to design research where she has integrated knowledge from other related areas and applied to the artifact design (e.g. human factors/ergonomics, product usability, design and cognition, expertise and experience) to support and construct design applications. She has been a founder and Director of People and Systems Lab at QUT. The impacts of Vesna's research lies in the cross-fertilisation of knowledge across humanities and technologies to design humanised artifacts/ systems by facilitating the understanding of diverse expertise and experience. Vesna is a Fellow of the Design Research Society (UK) and Design Institute of Australia (DIA). She is the recipient of four Australia Research Council grants. (v.popovic@qut.edu.au)

William Mason

William Mason is an industrial designer, Brisbane, Australia. He graduated Bachelor of Design (Industrial Design) from the Queensland University of Technology (QUT). During his study, he spent a year on exchange to Norway which enhanced his design experience. William has been awarded national Dyson Design Award in 2017. Currently he is working as a designer for a local Brisbane company. (william.b.mason@gmail.com)

Benjamin MacMahon

Benjamin MacMahon is an Industrial designer, Brisbane, Australia. Benjamin graduated Bachelor of Design (Industrial Design) from Queensland University of Technology with a First Class Honours. He has a minor in interactive design and animation as well. Benjamin is working as an industrial designer in a Brisbane-based lighting design company where he is the Head of Research and Development. (benpmacmahon@gmail.com)