Queensland University of Technology
Brisbane Australia

This may be the author's version of a work that was submitted/accepted for publication in the following source:

Mazhar, Samia, Wu, Paul, & Rosemann, Michael
(2019)
Designing complex socio-technical process systems - the airport example.
Business Process Management Journal, *25*(5), pp. 1101-1125.

This file was downloaded from: https://eprints.qut.edu.au/133760/

© Consult author(s) regarding copyright matters

This work is covered by copyright. Unless the document is being made available under a Creative Commons Licence, you must assume that re-use is limited to personal use and that permission from the copyright owner must be obtained for all other uses. If the document is available under a Creative Commons License (or other specified license) then refer to the Licence for details of permitted re-use. It is a condition of access that users recognise and abide by the legal requirements associated with these rights. If you believe that this work infringes copyright please provide details by email to qut.copyright@qut.edu.au

License: Creative Commons: Attribution-Noncommercial-No Derivative Works 4.0

Notice: *Please note that this document may not be the Version of Record (i.e. published version) of the work. Author manuscript versions (as Submitted for peer review or as Accepted for publication after peer review) can be identified by an absence of publisher branding and/or typeset appearance. If there is any doubt, please refer to the published source.*

https://doi.org/10.1108/BPMJ-09-2017-0241

Designing complex socio-technical process systems – the airport example

Abstract

Purpose: A configurable reference model can be used to assist in the development and management of business processes in complex, multi-stakeholder environments. This paper demonstrates how process design in complex socio-technical environments can be supported via configurable process reference modelling, using airports as an example.

Design/methodology/approach: Existing reference process modelling methods covering model merging and configuration are extended to include contextual and spatial factors using Design Science methodology. The approach is empirically based on a set of BPMN models for international passenger departures, consolidated from five Australian airport case studies via document analysis, interviews and observation.

Findings: The use of contextual factors and operational scenarios, structured using the proposed approach, facilitated an efficient cross-organisational comparison for configuring processes to suit the needs of a target organisation. The resulting configurable model integrates the perspectives of organisational stakeholder groups with those of customers in a transparent and unambiguous graphical representation. The model is reusable and data collection needs are low for each use.

Research limitations/implications: Future research should include: version management; how to keep the model current; configurability via modelling objects *other* than gateways; and cross-discipline application (e.g. as a foundation for quantitative decision-making models).

Originality/value: This is the first reported application of configurable reference modelling to facilitation of passenger flow. Methodological contributions include the addition of space-sensitive process elements and notation to Business Process Management Notation (BPMN); guidelines for systematically deriving contextual factors associated with process variants across similar organisations; and normative guidelines for inductively developing a configurable process reference model.

Acknowledgement

The authors would like to thank the Australian Research Council, as this study was conducted as part of the ARC Linkage program LP0990135: "Airports of the Future".

Keywords

Business process management, configurable reference model, BPMN, space-sensitive process model, process merging, contextual factor, process configuration, airport passenger facilitation, customer-centric process model

Paper type

Research paper

1 Introduction

1.1 Complex socio-technical systems

Modern transportation hubs are large-scale, complex systems with multiple stakeholders and interacting processes. Process design and execution requirements are complex and differ greatly from those of a single organisation in such a *socio-technical system*, which is a “hybrid system that includes technical artefacts as well as humans and the laws, rules, and norms that govern their actions” (Johannesson and Perjons, 2014). In socio-technical systems, core processes can span multiple organisations, resulting in complex interactions among multiple interdependent stakeholders (Bostrom and Heinen, 1977, Rinaldi, Peerenboom and Kelly, 2001). Furthermore, these systems can have multiple, potentially interdependent infrastructures, which are the foundation or basic framework that underlies a system or organization (Rinaldi et al., 2001). Such complexity presents challenges to business managers and decision-makers in terms of process design, management and optimisation of time, cost and quality. Airports are an example of such socio-technical systems, where the challenge of meeting growing customer demand is intensified by an interconnected and often changing economic, regulatory, health, security and technological environment (de Neufville and Odoni, 2013). This paper proposes a new way to deal with the complex process requirements of such systems using a configurable approach towards process modelling.

1.2 Process design using configurable reference models

Business Process Management (BPM) concepts can assist with the design of processes and infrastructure in complex socio-technical systems. Knowledge of business processes is captured in via *process modelling*, which is an “approach for visually depicting how businesses conduct their operations; defining and depicting entities, activities, enablers, events, states and the relationships between them” (Bandara, 2007). It provides visibility and enables coordination across multiple stakeholders and organisations. A *reference model* is a suitably generalised class of conceptual models (Fettke and Loos, 2007), which users may adapt or instantiate according to their application or needs as a source of guidance for improvement. The purpose of a reference model is to (1) provide a framework for identifying, developing and coordinating standards (for reference), (2) create specialised models from this framework for specific scenarios, and ultimately (3) apply relevant information to improve operations (e.g. increase service quality or achieve cost savings) (Mišić and Zhao, 2000).

A process reference model provides a systematic and standardised means for capturing existing processes and consolidating them into a repository across multiple organisational instances, which are referred to as *cases* in this paper (Fettke and Loos, 2006, Rosemann, 2000, Küster, Koehler and Ryndina, 2006). The customisation and application of a process reference model to a target case is known as *process configuration* (Aalst, Dreiling, Gottschalk, Rosemann and Jansen-Vullers, 2006, Fettke, Loos and Zwicker, 2005, Rosemann and Aalst, 2007). Although configuration is challenging – given the variability arising from differing operational contexts – it enables “informed mimicking” of high-performance processes, especially those that operate with lower costs and overheads, faster speed, greater accuracy, improved asset utilisation and enhanced flexibility (Hammer, 2010).

1.3 Reference models for airports

Globally, passenger numbers increased from 1.792 billion in 2002 (IATA, 2011) to a forecasted 4.358 billion in 2018 (IATA, 2018). The ongoing impact on global regulations and processes from health and security concerns (ICAO, 2011) results in pressure on airport operators and airport stakeholders to make costly changes to facilitation, which in turn impacts the process and passengers (Neiderman, 2004). Processes have become complex, and vary across different airports due to the imposition of multiple regulatory and commercial requirements on several aspects such as airport security, border security, and operational efficiency. For instance, Liquids Aerosols and Gels restrictions on international travel increased delays in getting passengers to boarding gates (ICAO, 2007), which affected some flight departures and, consequently, arrivals at destination airports. Thus addition of extra processing steps can produce delays that get compounded into significant undesirable outcomes, including monetary losses in the form of fines faced by airlines (U.S. Department Of Transportation, 2016).

In such a challenging environment, a process reference model can help to identify and manage the impacts of major changes on airports. Its utility is two-fold: as a strategic tool leveraging knowledge about existing practices that demonstrate some degree of success in real world application; and as an operational tool that details contextual activities and related resources, objects and relationships at each airport.

At present, the development and application of configurable reference modelling in practice is limited (Fettke et al., 2005, Kirchmer, 2017, Rehse and Fettke, 2017). This paper presents the first large scale application of configurable reference modelling to the airport domain, focusing on passenger facilitation for international departures. It includes the business-as-usual activities that provide value in typical travel scenarios as prescribed by organisations, and excludes exceptional situations (e.g. emergencies). The facilitation process involves different types of tasks: manual tasks (IT system is not involved), user tasks (user interacts with IT), and service tasks (automated) as represented by the BPMN 1.2 or 2.0.2 specifications (OMG, 2009, OMG, 2013), and any of these can involve actors occupying a physical space or not (e.g. online check-in). Physical activities introduce spatial considerations which are paramount to congested airports (de Neufville and Odoni, 2013, Wu and Mengersen, 2013). While BPMN 1.2 is used in this study, neither specification explicitly incorporates physical spatial considerations such as locations, walking distances and queuing times in its representation of processes.

Reference models have been comprehensively applied in other industries, but none were found to be specifically designed for airports, or directly translatable to the modelling of passenger facilitation and global airport contexts. Some models are prescriptive such as ISO (International Organization for Standardization, 2012) which provides standards across a broad range of industries, services and products. Others are descriptive, such as the APQC Performance Classification Framework (APQC, 2010) which presents a consolidation of practices in different industries, including airlines and aerospace, but not facilitation at airports. Some reference models take the form of guidelines, e.g. ITIL as a reference approach to IT service management (The IT Service Management Forum, 2008), while others are industry-specific such as eTOM Business Process Framework for telecommunication (Telemanagement Forum, 2012) or SCOR for supply chains (Supply-Chain Council, 2008). Reference models also vary in presentation formats (e.g. either diagrammatic or text-based), levels of detail, function, and intuitiveness for correct interpretation and effective application (Ramias and Wilkins, 2012). These frameworks are useful for guidance but not appropriately dynamic, detailed or specific to airport passenger facilitation – a gap that is addressed by novel extensions to existing reference modelling in this work.

The method of producing a configurable process reference model is described in Section 2 and involves process modelling, followed by merging the process models and finally making them configurable. Results of the real-world application are presented in Section 3 as a configurable tool, built by synthesising process models of individual passenger flows at five Australian airports, across multiple stakeholder organisations and roles involved throughout the process at each airport. Findings from analysed results are discussed in Section 4, explaining how new insights may be leveraged from a synthesised model. Section 5 concludes this paper with implications and outlook.

2 Method and knowledge base

The application domain of this study is: airport passenger facilitation processes in Australia. The methodology is firmly based in *design science,* defined by Johannesson and Perjons (2014) as "the scientific study and creation of artefacts as they are developed and used by people with the goal of solving practical problems of general interest". Their method framework has been adapted for developing an airport reference model shown in Figure 1 below:

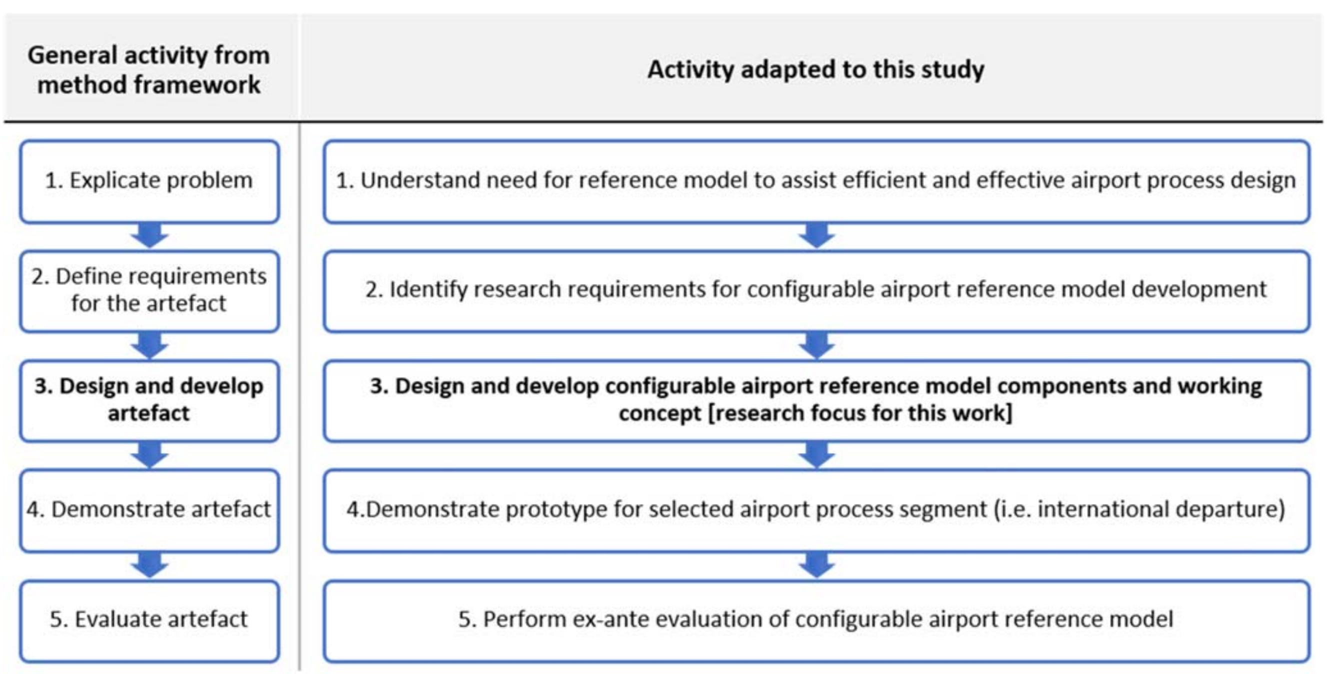

Figure 1. Method framework adapted from Johannesson and Perjons (2014)

This study bridges the paradigms of positivism and critical realism, and presents the research contribution as exaptation, where “design knowledge that already exists in one field is extended or refined so that it can be used in some new application area” (Gregor and Hevner, 2013). The conduct and scientific quality of this research is guided by the work by Hevner, March, Park and Ram (2004), Peffers, Tuunanen, Rothenberger and Chatterjee (2008), Baskerville, Pries-Heje and Venable (2009), and Goldkuhl (2012). The research strategy uses descriptive case studies (Orlikowski and Baroudi, 1991, Johannesson and Perjons, 2014) for developing the configurable airport reference model. As advised by Benbasat, Goldstein and Mead (1987) a multi-method approach is used for data collection to ensure the capture of “rich, many-faceted knowledge” via interviews of the domain experts, observation of process execution and document analysis.

The need for reference models and their high level requirements (activities 1 and 2 from Figure 1) were outlined in the Introduction. Model design and development (activity 3) is the core research focus, and involves the following steps explained further later in the corresponding sections:

A. **Modelling processes for individual cases (Section 2.1):** Process models were developed for each case to facilitate reference modelling and establish shared cross-functional understanding across stakeholders. A total of 131 process model diagrams were developed and quality checked for all five airport cases, averaging 26.2 diagrams per airport.
B. **Creating a merged process model (Section 2.2):** The above diagrams from each of the individual airports were compared and consolidated to integrate similar parts while demarcating process differences appropriately. This resulted in a merged model of 26 process diagrams, with the differences captured as 56 “variation points”.
C. **Building process configurability (Section 2.3):** Contextual factors behind process differences were identified to allow model customisation by a business user via a questionnaire interface. Questions and their options - or “facts” - for the questionnaire were mapped to the merged model to enable it to be filtered, showing only the sections relevant to user input. Upon analysis of the variation points, 12 corresponding contextual factors were identified, leading to the articulation of 24 unique questions. Each question was assigned to one or more variation point, and 127 corresponding facts were assigned to relevant model branches. The question sequence and associated dependencies were captured by a “questionnaire model”.

2.1 Modelling processes for individual cases

Process modelling has been widely applied across many organisations to assist in the management of organisational complexities (Bandara, Gable and Rosemann, 2005). BPMN has been adopted for this study as the predominant notational standard (zur Muehlen and Recker, 2008), with attention to cognitive aspects stated by Figl, Mendling, Strembeck and Recker (2010).

Although BPMN is well-suited to this work, the specification does not include modelling objects for spaces or locations. Spatial considerations are recognised as paramount for socio-technical systems such as airports (de Neufville and Odoni, 2013) with their limited space and growing passenger demand. In airports, the widely adopted IATA Levels of Service metric is defined in terms of space (IATA, 1995). In addition, airport planning and design literature emphasises that design of physical areas is as important as the activities performed within them (Dempsey, 2000, Wells and Young, 2004). Functional spaces cater to critical passenger facilitation needs such as access (e.g. entry or modes of transport) and processing (e.g. check-in or immigration checks). The following reference models, tools and enterprise architectures demonstrate the importance of space:

- TOGAF captures locations in terms of where business activities occur (The Open Group, 2012)
- SAP describes functional locations with respect to operational activities (SAP, 2013)
- SCOR refers to suppliers and customers in geographically dispersed locations (Supply-Chain Council, 2008)
- Lean Management advises elimination of non-value-adding spatial elements (Burton and Boeder, 2003)

Other general examples of impacts of spatial design on process are as follows:

- The cluttered design of retail check-outs may allow a customer to remove items without paying
- Long distances in a hospital create delays when moving trauma patients to surgery in time-sensitive cases
- Long complex pathways from airport gates to baggage claim may negatively impact passenger experience

To address the gap, this work extends BPMN by designing location, movement and wait symbols using guidelines from Moody (2009) to capture process-relevant information about the physical environment and its constraints:

- A **location** symbol represents a functional space using the existing BPMN process grouping symbol to avoid construct overload for the reader (Recker et al., 2006). This space is managed by at least one stakeholder as a resource variable, and can be assigned attributes such as unique ID, category, ownership, dimensions, capacity, mode of access (e.g. walking, travelator or escalator), coordinates in building layout or grid, and distance for a passenger to cover to get to other critical functional spaces (e.g. from terminal entry to the check-in counter). The example in **Figure 2** shows some properties:

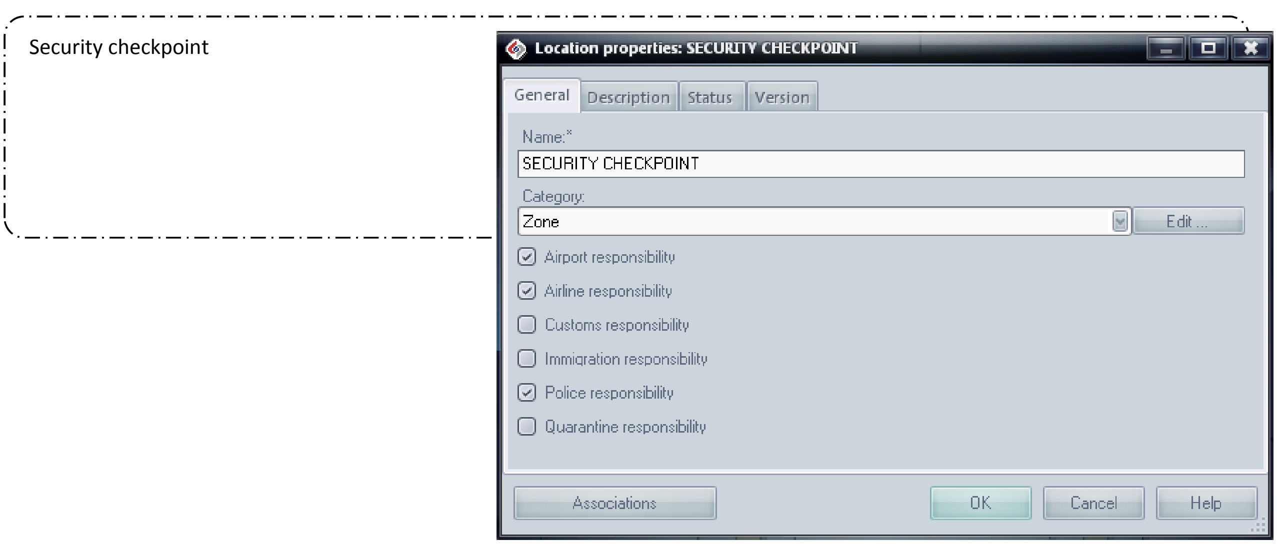

Figure 2. Sample location symbol with properties

- A **movement activity** depicts movements of passengers or physical objects *between* locations (not within). The movement activity extends the activity object in BPMN. The appearance is a boxed arrow pointing in the direction of the control flow, shown in **Figure 3** as an example from a top-down diagram. The gauge on the left hand side represents average time taken to move and the one on the right hand side represents the average displacement (in preferred units), entered according to thresholds determined by the organisation.

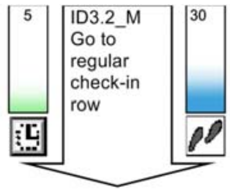

Figure 3. Sample movement activity symbol

- A **wait activity** *within* a location depicts a non-value adding state where time (captured as an attribute) is expended by a waiting passenger or idle organisational resource. This is particularly relevant to the commonly occurring queuing bottlenecks that detract from the passenger experience. The appearance of the wait activity is a red or dark-shaded bi-directional boxed arrow perpendicular to the control flow, shown in **Figure 4** as an example from a top-down diagram. The horizontal gauge underneath shows the minimum, average and maximum time expended in the activity, entered according to thresholds determined by the organisation.

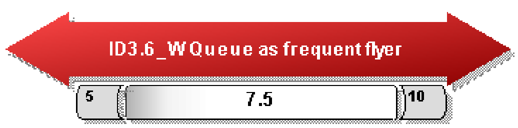

Figure 4. Sample wait activity symbol

Explicitly representing this information helps to accomplish the following:

- Inclusion of spatial information in process guides for operators and passengers alike, by locating actions in space according to physical reference points (e.g. the passenger departure process is considered to start at the entry to the airport terminal building, and end at the boarding gate);
- Measurement and improvement of overall performance and customer experience related to spatial design optimisation, resource utilisation, ergonomics, accessibility, wait time and movement time (e.g. determining which queuing system or kiosks to implement at the airport for more capacity or freedom of movement); and
- Capture and sharing of space-relevant functional process information amongst multiple stakeholders using standardised terminology relevant to ownership/responsibility.

The steps followed for processes modelling are shown in Figure 5.

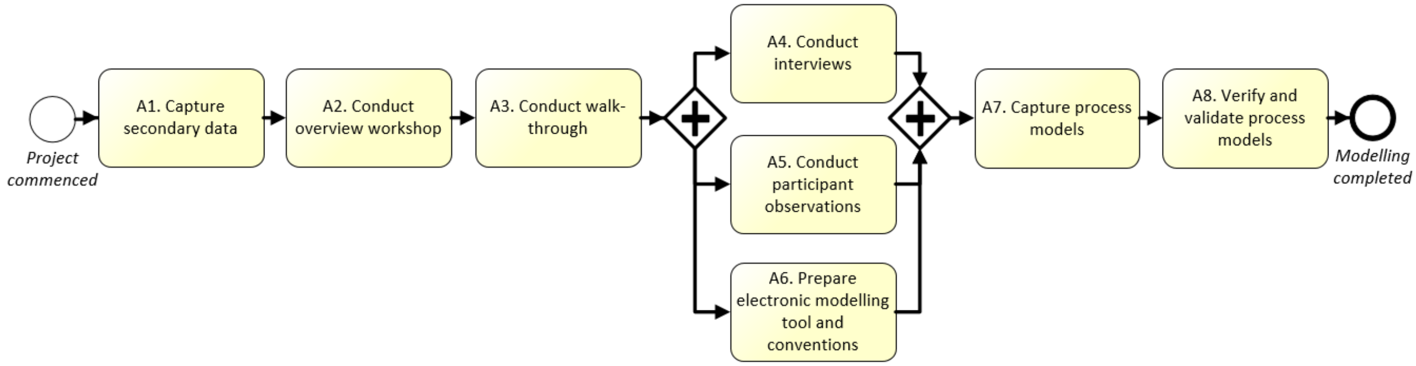

Figure 5. Process modelling process

Before building the knowledge repository of the process models to be developed, an initial background understanding of the selected domain process is acquired from secondary data sources and academic or industry literature. This is followed by an overview (scoping) workshop with senior management to establish buy-in and expectations; identify domain experts to be interviewed; and define the process to be modelled in the form of the value chain steps to determine where the process is considered to start and finish. Once domain experts are engaged, data collection is commenced with either a systematic verbal or physical walkthrough of the typical passenger scenario (Maiden, 1998). This is done through each value chain step, from the start of the selected process till its logical conclusion, to understand the process in its entirety. Process discovery discussions are initiated based on secondary data, to elicit detailed information about the activities sequence, events, roles, resources and documentation from interviews with domain experts. Further insight is derived from document analysis and observing the As-Is process. Capturing the process models is commenced in the modelling tool alongside elicitation, while checking syntactic, semantic, and pragmatic quality (Dumas et al., 2013, Reijers et al., 2010). After the models are completed, they are verified to ensure correctness, and validated with the domain experts.

2.2 Creating a merged process model

Process merging consolidates two or more process models into a single superset model: the reference model. This activity minimises redundancy by unifying similarities and highlighting differences as variants (Dijkman, Dumas, Garcia-Banuelos and Käärik, 2009, Gottschalk, Aalst and Jansen-Vullers, 2008, La Rosa, Dumas, Uba and Dijkman, 2010). Merging is needed for process configuration (La Rosa, Dumas, Uba and Dijkman, 2013, La Rosa et al., 2010, Chen, Reichert and Wombacher, 2008). Methods for merging include algorithms (Gottschalk et al., 2008), tools (Küster, Gerth, Förster and Engels, 2008, Lin, Gray and Jouault, 2007, La Rosa, 2014, Yan, Dijkman and Grefen, 2010); and guidelines (La Rosa et al., 2010, Mendling and Simon, 2006). At the time of this study, an implementation-ready BPMN-capable tool was not available, therefore merging has been guided by the seminal work of Dijkman (2007) and Dijkman, Dumas, van Dongen, Käärik and Mendling (2011). As merging is based on similarity, similar processes are selected across cases for comparison and compared via: *node matching* (labels and attributes, e.g. names of events and activities); *structural matching* (topology, or control flow and branches including conditions or dependencies); and *behavioural matching* (execution semantics or business logic).

The steps used for merging are shown in Figure 6.

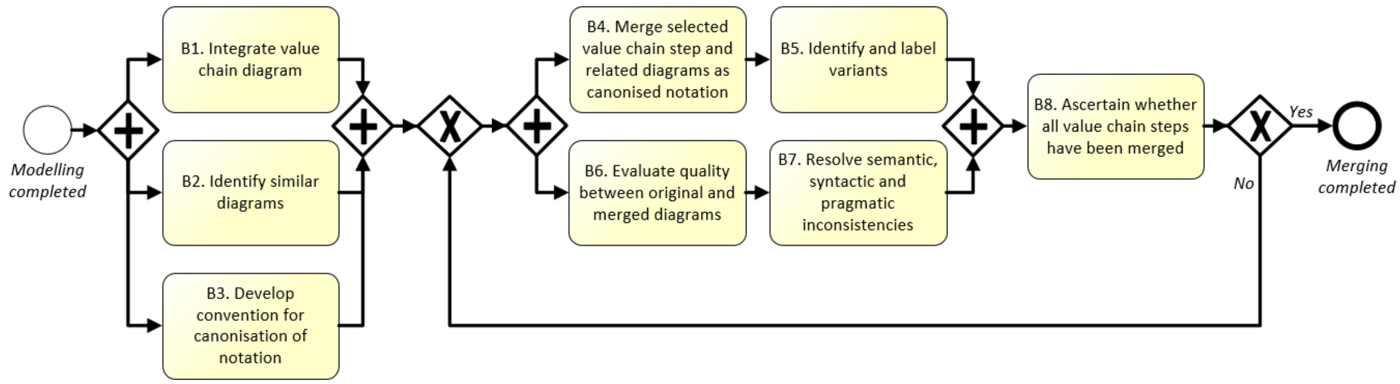

Figure 6. Merging process

The merge is conducted top-down through the hierarchy of process diagrams. All models made in the extended version of BPMN need to be converted into canonical format (La Rosa et al., 2013). *Canonisation* involves converting the models from "native format" into a strict form of BPMN to store in the repository for the required software tools – when available – to process them for configuration (La Rosa et al., 2011). Comparison begins with the value chain diagrams of all case studies. For each common value chain step, similar process models are identified and grouped together into sets. Each set is checked to find semantically identical activities and integrate them into consolidated pathways in the merged model. Syntactic and semantic differences in naming, absence or ordering of activities across the diagrams of the individual case organisations are considered as control flow variants, and are depicted as diverging branches annotated with the name of the corresponding cases.

Inconsistencies in the merged model are resolved by checking records or via further interviews with each domain expert who contributed to the corresponding original model. Differences in objects types other than activities – e.g. pools/swim lanes, data objects, or locations groupings – have been accommodated as control flow variations, as the configuration theory and software used at the time of this study only applied to control flow. In addition to finding similarities and differences, managing homogeneity of terminology maximises consistency across process models (Mendling, 2012, Dijkman et al., 2011). This improves merging efficiency and quality in the following way:

a) Minimisation of ambiguities in object appearance, positioning, representation style, usage, and names
b) Semantic consistency via ongoing validation and logical checks with domain experts
c) Syntactic consistency via modelling conventions and a repeatable approach to drilling down levels of detail

2.3 Building process configurability

Process configurability provides the means of selecting one process variant over the other based on an understanding of the specific deployment context of each variant. This can be done by identifying the influence of underlying *contexts*, or "any information that can be used to characterise the situation of an entity" (Dey, 2001). Leyer (2011) states that contextual factors can be used to operationalise context as indicators of the environment surrounding a business process. A *contextual factor* is therefore taken to be any condition within the context of a business process that may influence execution of the process, thus impacting the flow of activities, relevant events, involved roles, resources or data. Ploesser, Peleg, Soffer, Rosemann and Recker (2009) state the importance of establishing industry-specific context taxonomies for providing a standardised vocabulary as a means to scope and bound these factors. The next step, therefore, requires scoping *and* deriving contextual factors from variants across process models, however literature has not been found on how to do the latter. A number of studies were examined but found inapplicable as they related to other aspects of context, e.g.: effect of context on process performance (Leyer, 2011); context mining (Ploesser et al., 2009); context-awareness of information or technical systems (Dey, 2001; Newman & Sabherwal, 1991); and context-aware process modelling (Ploesser et al., 2009; Saidani & Nurcan, 2007). A study by Rosemann, Recker and Flender (2008), however, found to be applicable for scoping alone, and their "onion model" has been adapted as shown in Figure 7 to "identify, classify, understand and integrate relevant context with business process models".

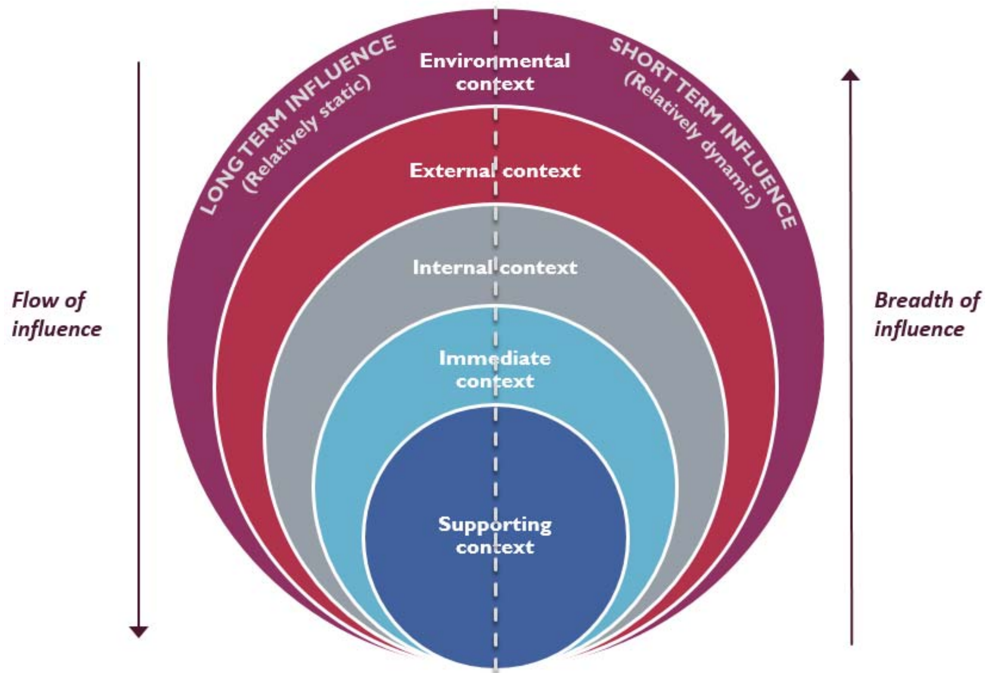

Figure 7. Adapted "onion model" of context scope – based on Rosemann et al. (2008)

The model depicts the scopes of context as concentric circles:

- *Environmental context* is external to the business network or domain (e.g. weather or political situation).
- *External context* is internal to the business network/domain and external to the organisation (e.g. international security related rules set by ICAO).
- *Internal context* is internal to the organisation and external to the business process/business rules (e.g. change in management within the organisation).
- *Immediate context* is internal to the business process/rules and external to supporting socio-technical enablers (e.g. roles or arrangement of activities).
- *Supporting context* includes underlying socio-technical enablers for an executed process (e.g. BPM execution / workflow systems, organisational knowledge applied in process execution, or individual capability).

The innermost layer of "supporting context" is new in this adapted model and is part of the underlying infrastructure of the socio-technical systems discussed earlier, distinguishing it from what is described in the process or "immediate" context. Also new is the distinction between long and short term influence of the contextual factors with respect to configuration. Factors of *short term influence* are intended for "run-time" configuration during process execution, while factors of *long term influence* are intended more for "build-time" configuration during process design. As this work relates to the latter, only contextual factors of long-term influence are identified. This classification model guides the domain expert interviews in investigating contextual factors behind the differences, however it still does not provide techniques to derive them. This gap is addressed by the steps shown in **Figure 8**.

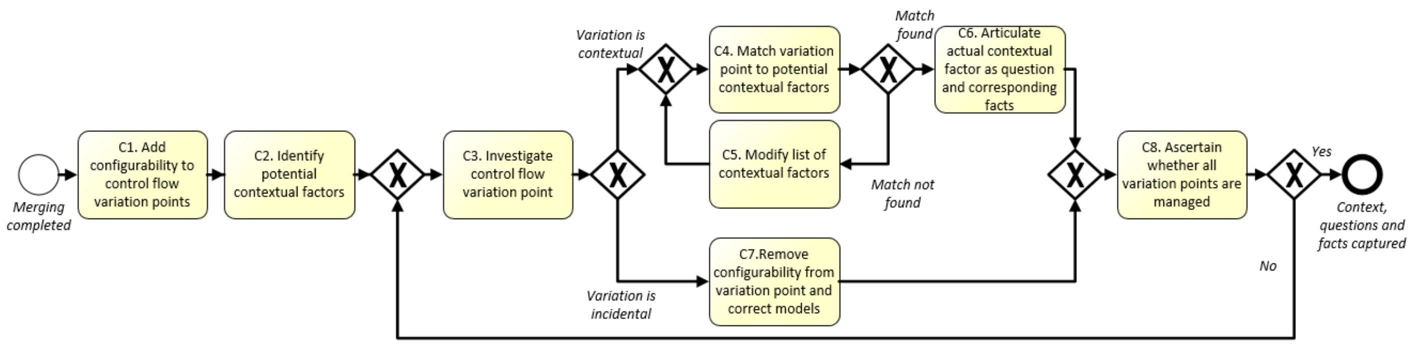

Figure 8. Contextual factor, questions and facts derivation process

Variation points in the merged BPMN model are in the form of gateways. Configurability is added to the gateway object in a modified version of the model editor Signavio with a "Configurable" checkbox attribute. By selecting the checkbox, the modeller marks the gateway as configurable – i.e. a variation point – thus distinguishing it from ordinary gateways. Next, contextual factors are identified for variation points.

The primary method for identifying *potential contextual factors* is the analysis of the variation points, initially inferred by the researcher in conjunction with a study of a broad selection of industry literature and a high level organisational comparison of all the cases in the study. Following this the domain experts are interviewed to ascertain whether differences exist in reality, and its branches are analysed to ascertain whether the difference is contextual or incidental. A *contextual variation* is one that can be assigned a contextual factor, while an *incidental variation* is not associated with a contextual factor, and so can be removed from the list. Potential contextual factors are matched to their variation points with domain experts and confirmed as *actual contextual factors*, each of which is finalised and articulated as a question and assigned two or more "facts" or answer options for the questionnaire model. Every variation point is analysed, verified and validated with domain experts until all unique questions have been articulated. The rationale for this derivation is demonstrated further in Section 3.3.

3 **The tool *Questionnaire Designer* is used to capture the configuration conditions acquired from contextual factors. La Rosa, Lux, Seidel, Dumas and Hofstede et al. (2007) describe how each question has corresponding options or facts (as conditions) from which a selection will be made by the user. Relationships and dependencies between questions and facts are captured by Boolean expressions. Further guidance for designing the questionnaire to prevent mistakes and illogical outcomes has been acquired from La Rosa et al. (2009). This work uses such a questionnaire with brief questions in "plain English" format to be answered via check boxes or radio buttons, as it makes a convenient interface for a user with little or no prior experience, assisted by simple on-screen guidelines (Reichert and Weber, 2012). The merged reference model can now be "configured" by selecting appropriate values or "facts" for the corresponding questions, so that a subset of the merged model, called the *individualised model*, is generated as the output. As facts correspond to variant branches in the model, their selection determines which process variants are included in the resulting filtered subset (La Rosa and Gottschalk, 2009). Results**

Results are discussed here for each reference modelling step from the previous section. Section 3.1 describes the process models for individual cases, Section 3.2 describes the merged process model, and Section 3.3 describes process configurability via contextual factors, questions, and facts. These sections fulfil the third activity of "Design and Development" in the Design Science method framework of Johannesson and Perjons (2014), while Section 3.4 demonstrates the prototype of the reference model, thereby fulfilling the fourth activity.

Data collection at each of the five airport locations involved semi-structured interviews with domain experts, who in this case were team leaders and managers in each of the four *stakeholder groups*, namely: the airport organisation; the security contractor; a federal agency; and the airline or contracted ground handling service. Although individuals cannot be identified due to confidentiality, at least one representative from each of the four stakeholder groups was present for every airport. In total, 65 semi-structured interviews were conducted for the process modelling and contextualisation across 34 interviewees, taking 1-3 hours per interview. During modelling, the interviewees were first directed to the most abstract high level processes then progressively to more detailed activities, with questions such as: "what happens then?"; "who does this?"; "when does this activity occur?"; and "what is required as an input/output?". Other questions elicited events, typical exceptions, locations and any technology that might be used. A basic introduction to BPMN was also provided prior to the interview so that the domain expert could understand what was modelled. During derivation of contextual factors, the most repeated question was "why does this airport do these steps differently", allowing the domain expert to freely express their professional opinion. Document analysis was done to support process modelling using organisational artefacts such as: government reports and brochures; instructional material on business rules; and business objects e.g. Boarding Cards and Outgoing Passenger Cards. Furthermore, over 72 hours of observation were also carried out across all the airport locations, to ensure objectivity, accuracy and comprehensiveness of what was elicited from domain experts and documentation. Data bias and subjectivity was mitigated with cross-airport validation and semantic, syntactic and pragmatic quality checks.

3.1 Process models for individual cases

International departure process models were developed for each of the five different Australian airports in this study using ***Casewise Corporate Modeler***. Each model set provided end-to-end visibility across passenger facilitation from the moment a passenger enters the airport terminal until they go through the boarding gate. A workshop with senior management across all stakeholder groups at the start of the project determined the customer-centric *value chain* for international departure. This value chain, shown in Figure 9, was modified for each subsequent airport, based on their respective operations.

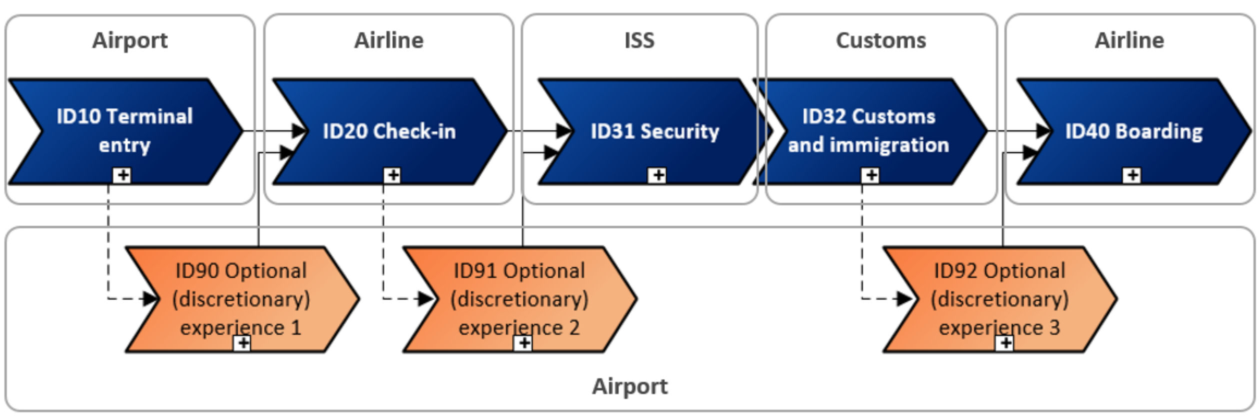

Figure 9. International Departure value chain steps

The dark-shaded value chain steps (ID10-40) represent mandatory parts of the process, while the light-shaded steps (ID90-92) represent the discretionary parts that are not mandated for the passenger (e.g. bag wrapping or shopping). Each step drills down into the next level or two of BPMN process models, as elicited from domain experts using interviews, workshops, and observed and documented evidence (Dumas, La Rosa, Mendling and Reijers, 2013). Processes were modelled from the perspective of the passenger, being the central role common across the steps, thus keeping end-customer experience in focus.

Figure 10**Error! Reference source not found.** shows an extract of the second-level "ID31 Security" BPMN diagram at the security checkpoint. The diagram shows that each passenger arranges their possessions in trays to prepare for checking and puts any Liquids, Aerosols and Gels in to a small transparent bag. They then proceed to the Security Checkpoint via the regular queues or express card-holder pathway. The passenger interacts with security personnel, who perform the needed checks and collect the trays. While only part of the diagram is shown here, the remaining steps show that the passenger may then undergo random pat-down or explosive trace checks as well. If issues are found during any of these checks, then re-inspection occurs. If issues are not resolved then the passenger is not allowed to continue. Once it is determined that issues are not present or have been resolved, the passenger is permitted to continue to the next step of "ID32 Customs and immigration". The sub-processes for preparation activities, security checks and re-inspection drill-down further into the third level of tasks (not shown here).

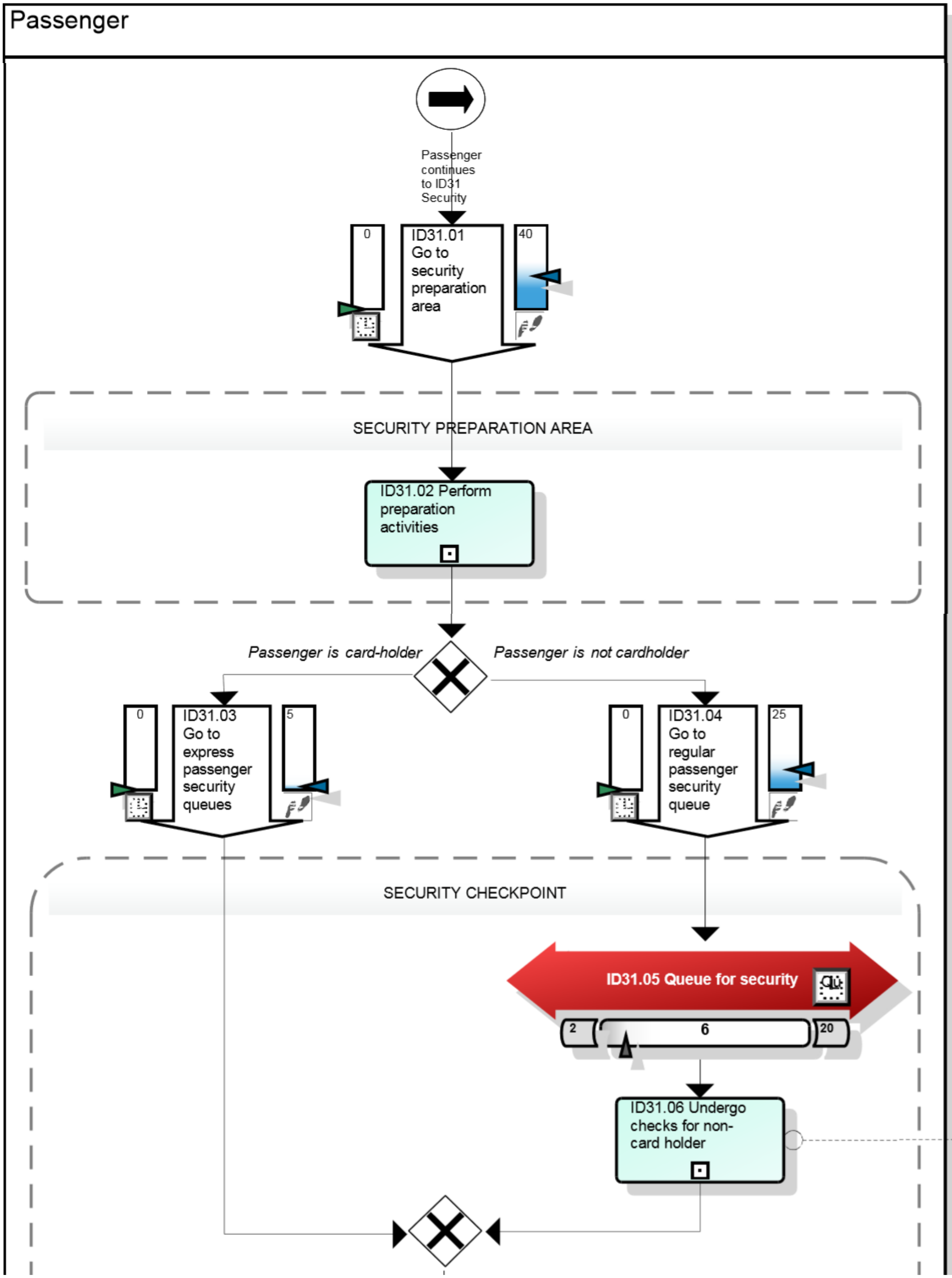

Figure 10. Extract of individual process model

3.2 Merged process model

Figure 11 shows the value chain diagram for the merged airport model, though for configurability the chevrons seen earlier in Figure 9 are replaced with BPMN activities. It can be seen that common steps across similar diagrams have been merged and special BPMN gateways demarcate the *variation points* (shown as a blue/shaded XOR gateway). For the sake of pragmatic quality a decision-making activity was not included to precede each configurable gateway as this is implicit in the questionnaire later. It is important to note that for every value chain step shown below, processes were also merged throughout the lower levels.

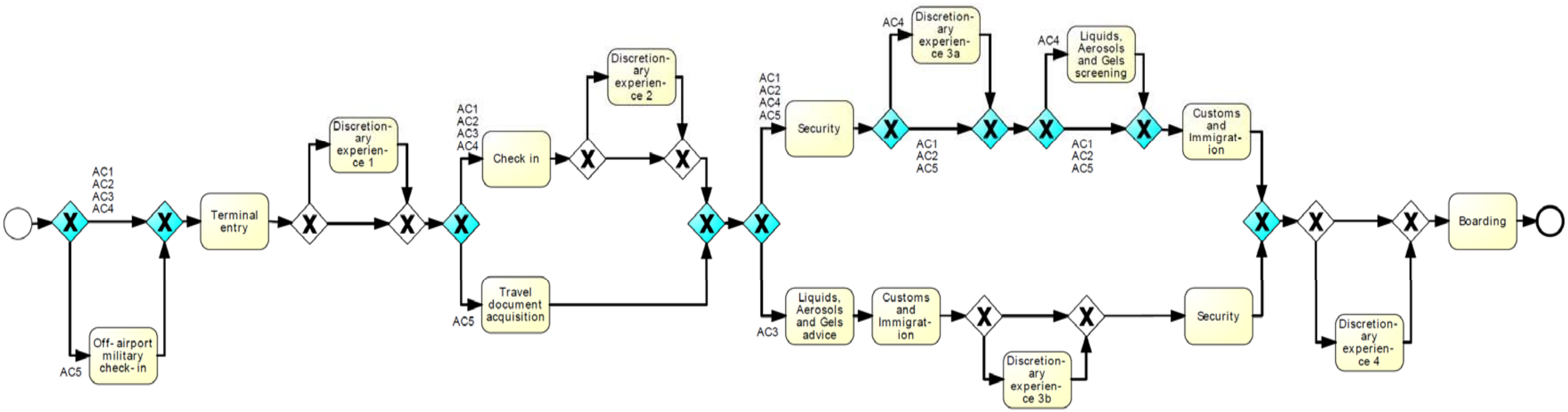

Figure 11. Merged model of value chains

Variant pathways are annotated with the label of the Airport Case (AC) identifier, to show where they apply. The diagram shows that military passengers may be checked-in off-airport prior to terminal entry in one case. Discretionary experiences are available prior to and after check-in, though only prior to acquisition of travel documents, depending on the airport. Next, the passenger may proceed to complete security and Customs activities in a number of different possible sequences. Finally, at all airports, the passenger may undergo one last set of discretionary activities prior to boarding.

3.3 Process configurability via contextual factors, questions and facts

Potential contextual factors were first derived from a high level comparison of the different airports, the analysis of variation points within the merged model, and academic and industry literature on airports. The focus was to identify what could influence differences in process design and performance at airports, whether it be: e.g. technology (IATA, 2012); security and privacy needs (Jain, Ross & Prabhakar, 2004); passenger numbers (Australian Government, 2009); or architecture (Passini, 1992). These influencers were categorised and scoped (see Section 2.3) for further investigation of the variation points in interviews with domain experts by following a line of reasoning to confirm the actual contextual factors, as explained ahead and shown in Figure 12:

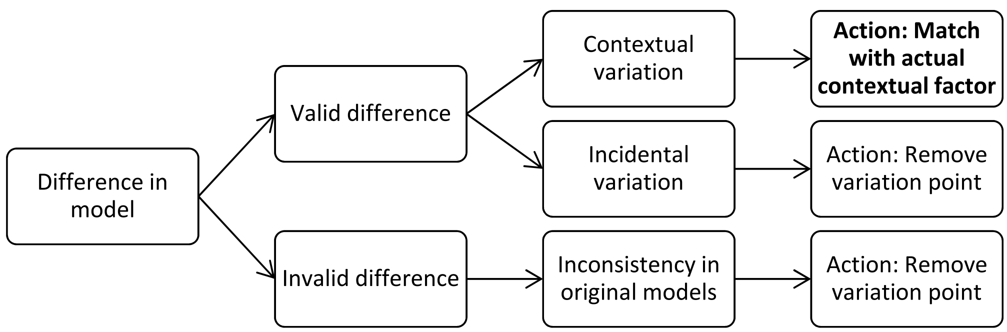

Figure 12. Reasoning out of control flow differences

Focussing on each variation point, the airport domain expert advised whether the identified difference was valid. Invalid differences were rectified to reflect common reality and logically consistent flow, and their variation points removed. It was then determined whether each valid difference was a true contextual variation to be matched to what was then confirmed as an actual contextual factor. Incidental variations and unconfirmed potential contextual factors were removed from consideration. **Table 1** below shows an extract of scoped contextual factors:

Table 1. Sample contextual factors

CATEGORY	SUB-CATEGORY	CONTEXT SCOPE	CONTEXTUAL FACTOR
Passenger	Personal	External context	**Purpose of passenger** Passengers travel for different reasons influencing numerous aspects including whom they are travelling with, types of luggage being carried, and the availability and selection of discretionary activities, services and options.
			Scope of travel The passenger is expected to either fly domestically or internationally. The process is different depending on whether a border crossing is involved. This may also affect other factors, e.g. “usage/configuration of terminal building”.
Organisation	Practice	Immediate context	**Operational policy** Prescribed procedures may be implemented differently at airports where the respective organisational policies are different. In some situations the airport is

			responsible for this difference, in others the airlines. Government agencies, e.g. Customs or Biosecurity, have standard procedures to be implemented in the same way across Australian airports. Organisations such as the security contractor or ground handlers follow practices directed by the organisations that they report to, i.e. airports or airlines.
Resources	Activity space	Internal context	**Usage/configuration of terminal building** There are many qualities related to the spatial orientation of the terminal building that affect process design and execution. The external orientation and positioning of the building affects terminal access from the ground side. Physical placement and orientation of functional spaces will affect the movement of the passenger between those spaces. Design of the activity space itself impacts how effectively an activity is executed by passengers or operators.

This elucidation of variation points, variants and contextual factors enabled the domain experts and researcher to articulate questions and related facts during the interviews. Table 2 shows an example for the variation point VP4, where the explanation of the factors from **Table 1** of "Scope of travel" and "Usage/configuration of terminal building" was applied to articulate "q3. What scope of travel does the usage/configuration of the terminal building cater to?". The facts identified were that the usage is either "f5. Domestic" or "f6. International" or both. Proceeding from VP4, airport cases 1, 2, 3 and 5 involved security preparation activities, and as they all used the terminal exclusively for international travel at a given point in time they were assigned "f6" only. Airport case 4 did not have any activities immediately following VP4, so the empty variant branch corresponded with the combined selection of "f5" and "f6" due to the shared terminal there. The domain experts advised that an exclusively domestic terminal would also follow the empty variant branch, though these were not in scope. This question was also mapped to VP18, VP24, VP28 and VP32 but would be posed only once and the answer reused.

Table 2. Sample mapping of variation point to its question and the respective facts to variants

ID	CONTEXTUAL FACTOR(S)	QUESTION MAPPING TO VARIATION POINT	FACT MAPPING TO VARIANT	VARIANT	Airport Case				
					1	2	3	4	5
VP4	Scope of travel Usage/ configuration of terminal building	**q3.** What scope of travel does the usage / configuration of the terminal building cater to?	***f6*** - International only	Go to security preparation area	✓	✓	✓		✓
			f5 *and* f6 - Domestic and International OR **f5** – Domestic only	Nil				✓	

The ***Questionnaire Designer*** software (La Rosa et al., 2009) was used to design the questionnaire model enabling visualisation of relationships and dependencies between questions and facts. The ***C-Mapper*** software was used to map questions to the corresponding variation points (VPs) and respective facts to their corresponding variant control flow branches in the merged model, and the ***Quaestio*** software was used to generate a user-interface for configuration.

3.4 Application: Process configuration using the airport reference model

This section demonstrates configuration using a Level 2 diagram segment of the merged airport processes, drilling-down from the "Security" step in Figure 11. Figure 13 shows the merged diagram of the passenger preparing for and undergoing security checks, *prior* to configuration, with variation points VP18, VP19 and VP20.

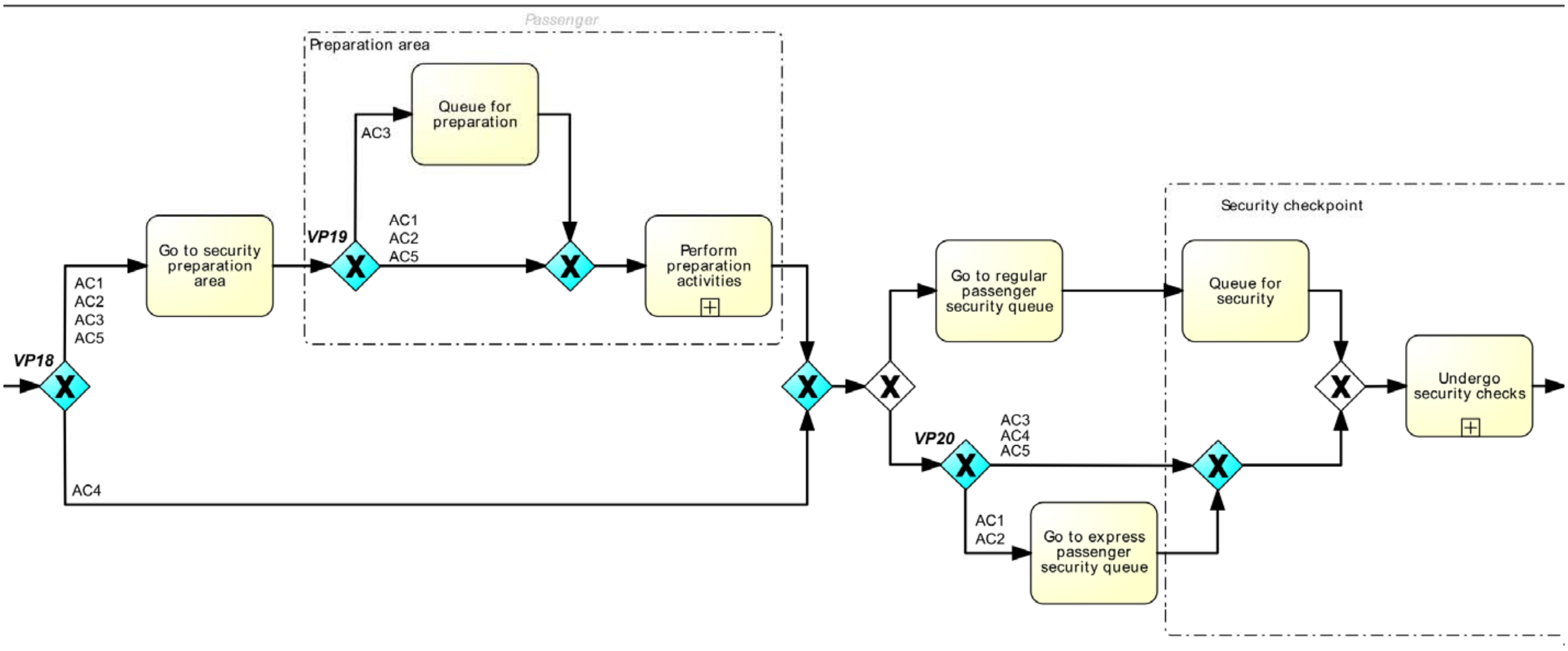

Figure 13. Security process model segment *before* configuration

The questions in the questionnaire related to this example are presented via the interface to the user, who selects one or more answer, as shown below:

Question 3 **What scope of travel does the usage/configuration of the terminal building cater to?**

☑ International

☐ Domestic

(Guide: select either only "International" or "International AND Domestic")

Question 12 **Does airport policy require international passengers to undergo separate security preparation activities?**

⦿ Yes

○ No

Question 13 **Are there enough business travellers to justify an express security pathway?**

○ Yes

⦿ No

Once the questionnaire has been completed by the user, the ***Process Configurator*** and ***Individualizer*** software process the answers to determine which variant branches following the blue/shaded variation points are to be shown, and which hidden. The resulting *configured diagram* can be seen in Figure 14**Error! Reference source not found.** below:

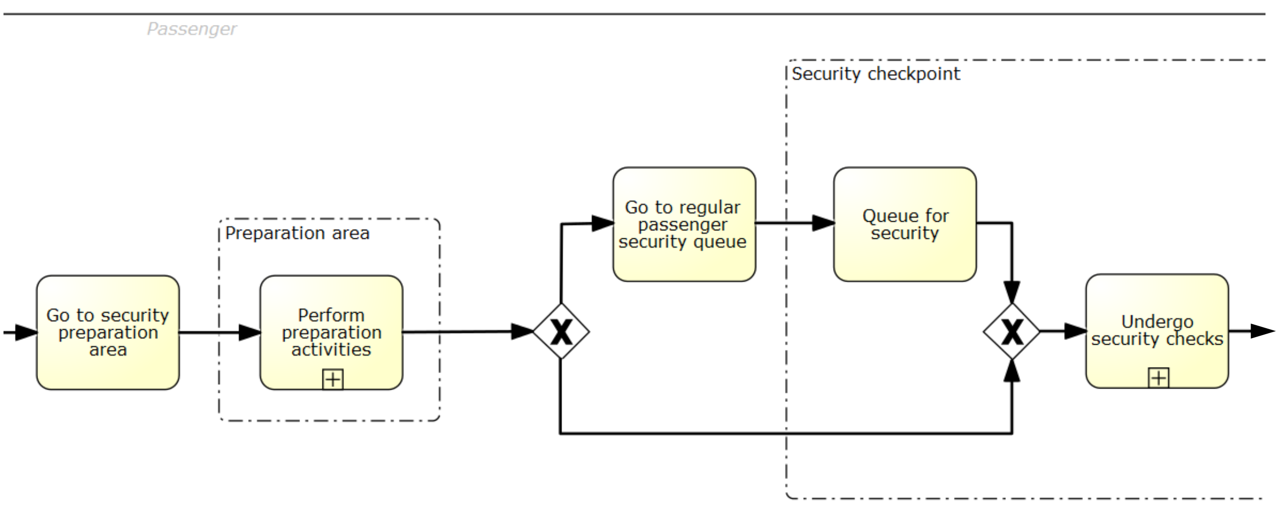

Figure 14. Security process model segment *after* configuration, as shown to user

The final outcome of the research was evaluated as guided by the work of Mišić and Zhao (2000); Indulska, Recker, Rosemann and Green (2009); and Mendling, Reijers and Aalst (2010) among others, thus fulfilling the fifth activity in the Design Science method framework of Johannesson and Perjons (2014) from Figure 1. Syntactic quality was checked according to BPMN specifications, first by the researcher and then by third party process modellers. Semantic correctness and completeness of business logic was ensured through validation by the domain experts that provided the process information. Pragmatic quality related to comprehensibility, utility and ease of use was evaluated using ongoing feedback of domain experts for whom these models were produced.

4 Findings: Using the reference model for airport process design

Development of this reference model with its contextual factors has provided insights into similarities across airports (Section 4.1), differences between them (Section 4.2), and how this knowledge can be leveraged to serve contextual needs (Section 4.3).

4.1 Key similarities

Similarities in the merged reference model in some ways represent the baseline for an Australian international airport, possibly as a reflection of industry-standard practices and regulatory or operational requirements. These similarities are discussed broadly as follows:

- **Terminal Entry:** All airports have a physical space for passengers to organise their luggage, acquire directions, or read rules on carried items prior to check-in.
- **Check in:** Some form of check-in is performed by relevant airline or ground-handler personnel at every airport – confirming identity, flight details and authorisation to fly on that particular flight using passenger documentation such as passports, visas (if applicable) and ticket booking.
- **Security:** The protocol for passenger security screening is the same across all airports for suspicious/dangerous/prohibited items, and for identification and resolution of issues (e.g. weapons in hand-carry). Irresolvable issues result in passengers being offloaded from the plane and not being allowed to fly.
- **Customs and immigration:** Processing of passengers at border control follows the same protocol across all airports for authentication of identity and passport validity, and for identification and resolution of issues (e.g. outstanding warrants or inadequate documentation). Again, irresolvable issues result in passengers being offloaded from the plane and not being allowed to fly.
- **Boarding:** On announcement of the boarding call for their seat numbers, all passengers undergo boarding checks confirming their right to fly and proceed to the boarding gate at each airport.

The common activities in the reference model also represent the minimum set of activities to plan for, which is useful for strategic planning and prediction. Operationally, the detail in the model explains what spaces, personnel and other equipment is required for implementing this plan.

4.2 Key differences

Despite regulatory requirements and a level of standardisation across Australian airports, significant differences were found. Understanding these differences can provide insight into potentially novel approaches to process management. Two prominent contextual differences are discussed in this section.

1. Shared or separate domestic and international terminals

Some airports share one terminal for both international and domestic flights, while others have separate terminals. The related contextual factors linked to this distinction are found to be: *scope of travel* of passengers; and *usage or configuration of the terminal building*. Both of these have been explained in Table 1 earlier. **Airport Case 4** was found to be the only airport to use the same terminal for shared international and domestic traffic at the same time, managed with flexible boundaries. These boundaries take the shape of large room separators pulled across the boarding area to segregate international travellers from domestic ones in the boarding gate area.

Figure 15 shows the value chain for Airport Case 4. International and domestic travellers go through the same steps in the same physical spaces for entry, check in and security. Up to security screening, international and domestic departure passengers are processed in the same physical spaces at the same time, which does not happen in dedicated international terminals. After security, however, international travellers have the opportunity to go through discretionary areas. From this point onwards, domestic and international passengers diverge – domestic passengers are directed to boarding, and international passengers to check Liquids Aerosols and Gels (as these are not screened earlier), immediately followed by customs and immigration checks. The path then leads to the same boarding area as domestic travellers except on the other side of the partition. When there are no international flights scheduled, the partition is removed and the gates previously used by international flights are made available to domestic flights. Typically, airports with smaller international passenger volumes have been found to utilise shared terminals.

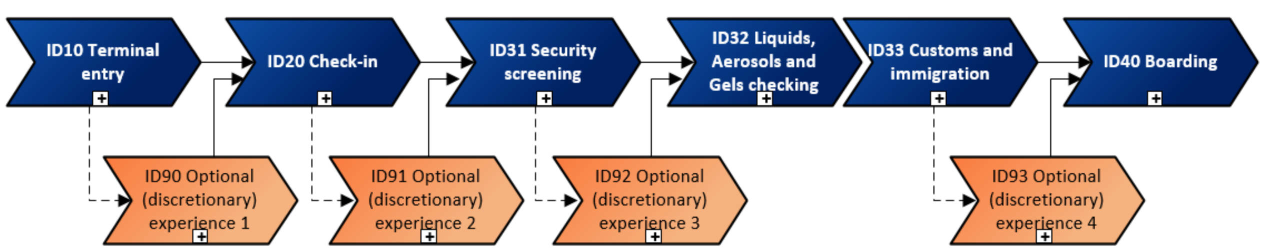

Figure 15. Airport Case 4 value chain

2. Serving military or civilian passengers

Sometimes domestic airports are used for specialised international travel under certain conditions. Contextual factors encountered for this are: the *airport genre* supporting chartered military travel or not; and *passenger type* as military or civilian. **Airport Case 2** runs chartered military flights for short periods of time during the year, while the rest of the time it is dedicated to domestic flights. Thus, there is physical and temporal segregation from civilian passengers. The process for this military travel varies from civilian travel in some ways. The first difference is that check-in occurs in batches prior to the passengers arriving at the airport, and is performed by an airline representative who generates the boarding passes in advance. The military passengers arrive together via trucks or buses, and are sorted into groups by the contracted travel management company. Passengers are then provided with their individual travel document packages, including Outgoing Passenger Cards for filling. The passengers can perform discretionary activities only prior to travel document acquisition and prior to boarding. Figure 16 shows the value chain for Airport Case 2.

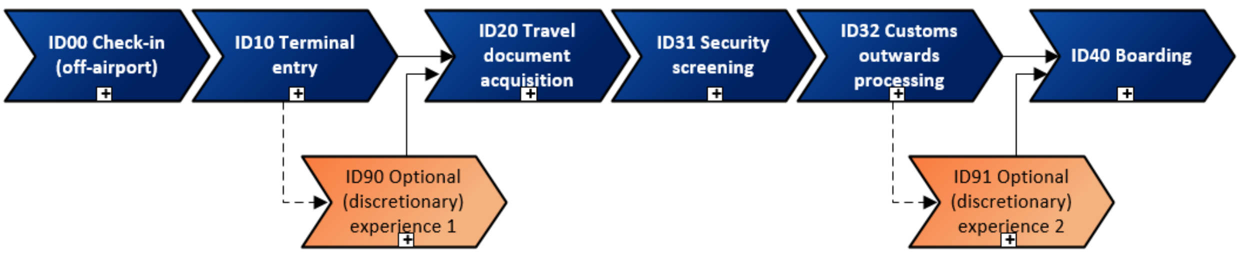

Figure 16. Airport Case 2 value chain

4.3 Utilising the results for adapting practices to specific contextual needs

By leveraging the experiences of other real-world airports, the configurable reference model helps to save time, money and effort in customising process design for a target organisation. Canberra airport is an example that illustrates the potential use of the tool, having recently developed a terminal to commence international flights (Capital Airport Group, 2017). The terminal configuration and process is similar to Airport Case 4 (see Section 4.2) in that it serves international civilian passengers of a relatively smaller number compared to other major Australian airports. The domestic and international passengers are hence in a physically shared terminal, where international passengers take a different path after initial security checks. This tool could provide an airport like Canberra with process design options relevant to its context to inform formulation and implementation of a process design strategy. The configuration example earlier in Section 3.4 could have been an option for Canberra Airport, depending on the operational policy they chose to adopt. In this way, the tool could make design and optimisation of stakeholder management, functional spaces, resource allocation, performance and customer experience considerably more efficient and accurate by eliciting needs and visually supplying the following critical information, as learnt from other airports:

- **Activities**: What are the expected steps and control flow for the process?
- **Roles**: What is the responsibility and accountability of the personnel involved in each step?
- **Stakeholder agreements**: What are the stakeholder organisations involved at a high level, and what policies and agreements need to be in place for their optimum collaboration?
- **Equipment**: What equipment and technology is required for which step and who owns it?
- **Spaces**: What building elements (e.g. functional spaces and pathways) can best accommodate the process and how can they be harmoniously leveraged to maximise process performance?

- **Systems**: What IT systems need to be operational – who owns and uses them, and how?
- **Business objects**: What physical or electronic items must be managed by stakeholders?
- **Knowledge, information and data management**: How is effective stakeholder collaboration ensured by leveraging knowledge and information management and data sharing? Who needs to know what and how can this communication be optimised? What are the data privacy/security requirements?

Comparing context can also enable identification of new requirements and question that have not been considered in existing cases, which may be used to drive innovation. Additionally, the following need to be considered while comparing the corresponding contexts and evaluating process design choices:

- Viability – what expenditure is justified by the specific circumstances and goals?
- Feasibility – what are the constraints, how do they compare to that of other airports?
- Desirability – which practices are best aligned with the values and strategy of the airport?

The airport reference model is the key contribution made by this research to practice, as it is the first of its kind to be developed. It can support process design at various stages of business maturity - e.g. before the airport is established, when a new business need or operating model is being explored, or when existing issues need investigation. This tool provides organisations with a means for performing impact analysis of changes, thanks to the comprehensive and easily traceable control flow, spatial, temporal and stakeholder details in the process model. It enables us to compare and contrast feasible or even exemplary practices at functional airports where they are tested on a daily basis, and gain insights into how to implement and adapt them according airport-specific contextual requirements. The reference model also provides a strong input for improved estimation of accurate baseline costs and timeframes for operations in complex projects.

5 Conclusion and outlook

This work involved the development of a configurable reference model as a tool for informing process design decisions by providing concise and highly relevant insight into existing practices. It has been demonstrated using airport case studies, where configurable reference modelling has not been applied to date. During design and development, a comprehensive set of current practices in airport passenger facilitation was captured, first as process models for five airports individually, and then as a consolidation via process merging. Differences in process between the airports were characterised by contextual requirements to design a questionnaire for filtering relevant process information in this merged model – thus providing configurability. The results revealed insights from the consolidated practices of multiple airports that would not be possible from just one airport, thereby significantly enriching decision-support.

A number of methodological and domain contributions have been made by this research. Firstly, it has bridged two existing research concepts, namely: identifying and using contextual factors in process configuration; and using process configuration in reference modelling. Secondly, it has provided normative guidelines for systematically developing a configurable reference model. Thirdly, these guidelines include novel additions for representation of space, and a systematic framework for identifying contextual factors. The key domain contribution to research is that the reference model bridges research communities through the capture of complex passenger flows across diverse airports in process models. It makes airport facilitation practices visible for communication, investigation and the pursuit of solutions (Oborn & Dawson, 2010; Wenger, 2000) by unlocking the airport domain to multiple disciplines, e.g. the way supply chain management was made accessible via SCOR or telecommunication via eTOM.

There are a number of avenues for future research. Firstly, process design could be extended to include passengers with special needs (especially cognitive) and the tool extended to include more airports (especially positive deviants), thus increasing its value and representativeness. Additionally, for the effectiveness and relevance in long term use of the configurable airport reference model, the following need to be studied: efficient and timely update of content and contextual factors; version management; adaptability; tool adoption; and quality management. The scope needs to be extended for multi-disciplinary application and for configurability beyond gateways alone. Lastly, studies should be carried out to explore their impact and influence of contextual factors on not just how a process is carried out, but *how well* it is carried out. Once the field is mature, the configurable process reference model will assist the evolution of organisations for collective success as a consolidation of “how-to” domain knowledge that systematically evolves into the future.

References

Aalst, W. M. P. v. d., Dreiling, A., Gottschalk, F., Rosemann, M. & Jansen-Vullers, M. H. (2006). "Configurable process models as a basis for reference modeling", Bussler, C. & Haller, A. (eds.), *Business Process Management Workshops*. Springer Berlin Heidelberg, pp. 512-518.

APQC (2010). "Process Classification Framework (PCF)", available at http://www.apqc.org/process-classification-framework (accessed 22 May 2010).

Ashford, N. J., Mumayiz, S. & Wright, P. H. (2011). *Airport engineering: planning, design and development of 21st century airports,* Wiley, Hoboken.

Bandara, W. (2007). *Process modelling success factors and measures* (Doctoral dissertation, Queensland University of Technology, Brisbane, Australia). Retrieved from https://eprints.qut.edu.au/16397/

Bandara, W., Gable, G. G. & Rosemann, M. (2005). "Factors and measures of business process modelling: model building through a multiple case study". *European Journal of Information Systems,* Vol. 14 No. 4, pp. 347-360.

Baskerville, R., Pries-Heje, J., & Venable, J. (2009). Soft design science methodology. In V. Vaishanvi & S. Purao (Eds.), *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*. New York, USA: ACM.

Benbasat, I., Goldstein, D. K. & Mead, M. (1987). "The case research strategy in studies of information systems". *MIS Quarterly,* Vol. 11 No. 3, pp. 369-386.

Bostrom, R. P. & Heinen, J. S. (1977). "MIS Problems and Failures: A Socio-Technical Perspective. Part I: The Causes". *MIS Quarterly,* Vol. 1 No. 3, pp. 17-32.

Burton, T. T. & Boeder, S. M. (2003). *The lean extended enterprise: moving beyond the four walls to value stream excellence,* J. Ross Publishing Inc., Fort Lauderdale, FL.

Capital Airport Group (2017). "The new terminal", available at https://www.canberraairport.com.au/travellers/the-new-terminal/international-2/ (accessed 01 August 2017).

Chen, L., Reichert, M. & Wombacher, A. (2008). "Discovering reference process models by mining process variants", *IEEE International Conference on Web Services, 2008, in*, pp. 45-53.

de Neufville, R. & Odoni, A. R. (2013). *Airport systems planning design and management,* McGraw-Hill.

Dempsey, P. S. (2000). *Airport planning and development handbook: a global survey,* McGraw-Hill, New York.

Dey, A. K. (2001). "Understanding and using context". *Personal and ubiquitous computing,* Vol. 5 No. 1, pp. 4-7.

Dijkman, R. (2007). "A classification of differences between similar business processes", *11th IEEE International Enterprise Distributed Object Computing Conference, 2007, in*, pp. 37-37.

Dijkman, R., Dumas, M., Garcia-Banuelos, L. & Käärik, R. (2009). "Aligning business process models", *13th IEEE International Enterprise Distributed Object Computing Conference, 2009, in*, pp. 45-53.

Dijkman, R., Dumas, M., van Dongen, B., Käärik, R. & Mendling, J. (2011). "Similarity of business process models: Metrics and evaluation". *Information Systems,* Vol. 36 No. 2, pp. 498-516.

Dumas, M., La Rosa, M., Mendling, J. & Reijers, H. A. (2013). "Process discovery", *Fundamentals of business process management*. Springer Berlin Heidelberg, pp. 167-185.

Fettke, P. & Loos, P. (2006). "Using reference models for business engineering - state-of-the-art and future developments", *Innovations in Information Technology, Nov. 2006 2006, in*, pp. 1-5.

Fettke, P. & Loos, P. (2007). "Perspectives on reference modeling", *Reference modeling for business systems analysis*. IGI Global, pp. 1-21.

Fettke, P., Loos, P. & Zwicker, J. (2005). "Business process reference models: survey and classification", in Kindler, E. & Nüttgens, M., eds., *Workshop on Business Process Reference Models - Satellite Workshop of the 3rd International Conference on Business Process Management, 2005, in Nancy, France*.

Figl, K., Mendling, J., Strembeck, M. & Recker, J. (2010). "On the cognitive effectiveness of routing symbols in process modeling languages", Abramowicz, W. & Tolksdorf, R. (eds.), *Business Information Systems*. Springer Berlin Heidelberg, pp. 230-241.

Goldkuhl, G. (2012). "From action research to practice research". *Australasian Journal of Information Systems,* Vol. 17 No. 2, pp. 5.

Gottschalk, F., Aalst, W. M. P. v. d. & Jansen-Vullers, M. H. (2008). "Merging event-driven process chains", Meersman, R. & Tari, Z. (eds.), *On the Move to Meaningful Internet Systems*. Springer Berlin Heidelberg, pp. 418-426.

Gregor, S. & Hevner, A. R. (2013). "Positioning and presenting design science research for maximum impact". *MIS Quarterly,* Vol. 37 No. 2, pp. 337.

Hammer, M. (2010). "What is business process management?", Brocke, J. v. & Rosemann, M. (eds.), *Handbook on business process management 1*. Springer Berlin Heidelberg, pp. 3-16.

Hevner, A. R., March, S. T., Park, J. & Ram, S. (2004). "Design science in information systems research". *MIS Quarterly,* Vol. 28 No. 1, pp. 75-105.

IATA (1995). *Airport Development Reference Manual,* International Air Transport Association, Montreal, Canada.

IATA (2011). "Industry financial forecast - September 2011", available at https://www.iata.org/whatwedo/Documents/economics/Industry-Outlook-September2011.pdf (accessed 01 August 2017).

IATA (2018). "Fact sheet: industry statistics - June 2018", available at http://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-industry-facts.pdf (accessed 07 June 2018).

IBM (2008). "Align IT with business goals using the IBM process reference model for IT", available at ftp://public.dhe.ibm.com/common/ssi/sa/wh/n/gmw10425usen/GMW10425USEN.PDF (accessed 25 September 2011).

ICAO (2007). "A history of LAGs and STEBs", available at http://www.icao.int/Security/SFP/LAGS_STEBS/Documents/A%20history%20of%20LAGs%20and%20STEBs.ppt (accessed 20 November 2014).

ICAO (2011). "Ten years after 9/11, ICAO meeting considers new options for countering terrorism and trans-border crime", available at http://www2.icao.int/en/NewsRoom/Lists/News/DispForm.aspx?ID=54 (accessed 21 September 2011).

Indulska, M., Recker, J., Rosemann, M. & Green, P. (2009). "Business process modeling: current issues and future challenges", Eck, P., Gordijn, J. & Wieringa, R. (eds.), *Advanced Information Systems Engineering*. Springer Berlin Heidelberg, pp. 501-514.

International Organization for Standardization (2012). "About ISO", available at http://www.iso.org/iso/home/about.htm (accessed 24 October 2012).

Johannesson, P. & Perjons, E. (2014). *An introduction to design science,* Springer International Publishing.

Kazda, A. & Caves, R. E. (2007). *Airport design and operation,* Elsevier Science & Technology, Amsterdam, Oxford.

Kirchmer, M. (2017). "Reference Models: Accelerators and More", *High Performance Through Business Process Management: Strategy Execution in a Digital World*. Springer International Publishing, Cham, pp. 103-118.

Küster, J. M., Gerth, C., Förster, A. & Engels, G. (2008). "A tool for process merging in business-driven development", *20th International Conference on Advanced Information Systems Engineering, 2008, in*, CEUR WS.org, pp. 89-92.

Küster, J. M., Koehler, J. & Ryndina, K. (2006). "Improving business process models with reference models in business-driven development", Eder, J. & Dustdar, S. (eds.), *Business Process Management Workshops*. Springer Berlin Heidelberg, pp. 35-44.

La Rosa, M. (2014). "ProcessConfiguration.com", available at http://www.processconfiguration.com/ (accessed 11 November 2014).

La Rosa, M., Aalst, W. M. P. v. d., Dumas, M. & ter Hofstede, A. H. M. (2009). "Questionnaire-based variability modeling for system configuration". *Software and Systems Modeling,* Vol. 8 No. 2, pp. 251-274.

La Rosa, M., Dumas, M., Uba, R. & Dijkman, R. (2010). "Merging business process models", Meersman, R., Dillon, T. & Herrero, P. (eds.), *On the Move to Meaningful Internet Systems*. Springer Berlin Heidelberg, pp. 96-113.

La Rosa, M., Dumas, M., Uba, R. & Dijkman, R. M. (2013). "Business process model merging : an approach to business process consolidation". *ACM Transactions on Software Engineering and Methodology,* Vol. 22 No. 2.

La Rosa, M. & Gottschalk, F. (2009). "Synergia - comprehensive tool support for configurable process models", *Demo Track of the 7th International Conference on Business Process Management, 2009, in Ulm, Germany*.

La Rosa, M., Lux, J., Seidel, S., Dumas, M. & ter Hofstede, A. H. M. (2007). "Questionnaire-driven configuration of reference process models", in Meersman, R. & Tari, Z., eds., *19th International Conference on Advanced Information Systems Engineering, 2007, in Trondheim, Norway*, Springer, pp. 424–438.

La Rosa, M., Reijers, H. A., Van Der Aalst, W. M., Dijkman, R. M., Mendling, J., Dumas, M. & García-Bañuelos, L. (2011). "APROMORE: An advanced process model repository". *Expert Systems with Applications,* Vol. 38 No. 6, pp. 7029-7040.

Leyer, M. (2011). "Towards a context-aware analysis of business process performance", *Proceedings of the 15th Pacific Asia Conference of Information Systems, 2011, in Brisbane, Australia*.

Lin, Y., Gray, J. & Jouault, F. (2007). "DSMDiff: a differentiation tool for domain-specific models". *European Journal of Information Systems,* No. 16, pp. 349-361.

Maiden, N. A. M. (1998). "CREWS-SAVRE: Scenarios for acquiring and validating requirements". *Automated Software Engineering,* Vol. 5 No. 4, pp. 419-446.

Mazhar, S. (2015). *A configurable airport reference model for passenger facilitation* (Doctoral dissertation, Queensland University of Technology, Brisbane, Australia). Retrieved from https://eprints.qut.edu.au/87436/

Mendling, J. (2012). "Three challenges for process model reuse", Daniel, F., Barkaoui, K. & Dustdar, S. (eds.), *Business Process Management Workshops*. Springer Berlin Heidelberg, pp. 285-288.

Mendling, J., Reijers, H. A. & Aalst, W. M. P. v. d. (2010). "Seven process modelling guidelines (7PMG)". *Information and Software Technology,* Vol. 52 No. 2, pp. 127-136.

Mendling, J. & Simon, C. (2006). "Business process design by view integration", Eder, J. & Dustdar, S. (eds.), *Business Process Management Workshops*. Springer Berlin Heidelberg, pp. 55-64.

Mišić, V. B. & Zhao, L. J. (2000). "Evaluating the quality of reference models", in Laender, A., Liddle, S. & Storey, V., eds., *Proceedings of the 19th International Conference on Conceptual Modeling, 2000, in Salt Lake City, Utah*, Springer, pp. 484-498.

Moody, D. L. (2009). "The "physics" of notations: toward a scientific basis for constructing visual notations in software engineering". *IEEE Transactions on Software Engineering,* Vol. 35 No. 6, pp. 756-778.

Neiderman, E. (2004). "The human factors of civil aviation and transportation security". *Gateway,* Vol. 13 No. 4.

Oborn, E., & Dawson, S. (2010). Learning across communities of practice: an examination of multidisciplinary work. British Journal of Management, 21(4), 843-858.

OMG (2009). *Business Process Modeling Notation (BPMN) Version 1.2,* Object Management Group.

OMG (2013). *Business Process Modeling Notation (BPMN) Version 2.0.2,* Object Management Group.

Orlikowski, W. J. & Baroudi, J. J. (1991). "Studying information technology in organizations: research approaches and assumptions". *Information Systems Research,* Vol. 2 No. 1, pp. 1-28.

Peffers, K., Tuunanen, T., Rothenberger, M., & Chatterjee, S. (2008). A design science research methodology for information systems research. *Journal of Management Information Systems, 24*(3), 45-77.Ramias, A. & Wilkins, C. (2012). "Reference models: the long, long shortcut", available at http://www.bptrends.com/performance-improvement-reference-models-the-long-long-shortcut/ (accessed 20 November 2013).

Ploesser, K., Peleg, M., Soffer, P., Rosemann, M., & Recker, J. (2009). Learning from context to improve business processes, available at http://www.bptrends.com/learning-from-context-to-improve-business-process/ (accessed 5 January 2012)

Recker, J., Indulska, M., Rosemann, M. & Green, P. (2006). "How good is BPMN really? Insights from theory and practice", *14th European Conference on Information Systems, 2006, in Gothenburg, Sweden*.

Rehse, J.-R. & Fettke, P. (2017). "Mining Reference Process Models from Large Instance Data", Dumas, M. & Fantinato, M. (eds.), *Business Process Management Workshops: BPM 2016 International Workshops, Rio de Janeiro, Brazil, September 19, 2016, Revised Papers*. Springer International Publishing, Cham, pp. 11-22.

Reichert, M. & Weber, B. (2012). "Constraint-based process models", *Enabling flexibility in process-aware information systems*. Springer Berlin Heidelberg, pp. 341-374.

Reijers, H. A., Mendling, J. & Recker, J. (2010). "Business process quality management", Brocke, J. & Rosemann, M. (eds.), *Handbook on business process management 1*. Springer Berlin Heidelberg, pp. 167-185.

Rinaldi, S. M., Peerenboom, J. P. & Kelly, T. K. (2001). "Identifying, understanding, and analyzing critical infrastructure interdependencies". *Control Systems, IEEE,* Vol. 21 No. 6, pp. 11-25.

Rosemann, M. (2000). "Using reference models within the enterprise resource planning lifecycle". *Australian Accounting Review,* Vol. 10 No. 3, pp. 19-30.

Rosemann, M. & Aalst, W. M. P. v. d. (2007). "A configurable reference modeling language". *Information Systems,* Vol. 32 No. 1, pp. 1-23.

Rosemann, M., Recker, J. & Flender, C. (2008). "Contextualization of business processes". *International Journal of Business Process Integration and Management,* Vol. 3 No. 1, pp. 47-60.

SAP (2013). "SAP help portal - functional location", available at http://help.sap.com/saphelp_470/helpdata/en/01/d5438b4ab311d189740000e8322d00/content.htm (accessed 28 November 2013).

Standards Australia/Standards New Zealand (2008). "AS/NZS ISO 9001:2008 Australian/New Zealand Standard Quality Management System - Requirements".

Supply-Chain Council (2008). "Supply-Chain Operations Reference-Model SCOR® Overview Version 9.0". Supply-Chain Council.

Telemanagement Forum (2012). "Business process framework overview", available at http://www.tmforum.org/Overview/13763/home.html (accessed 24 October 2012).

The IT Service Management Forum (2008). "An Introductory Overview of ITIL® V3". The IT Service Management Forum.

The Open Group (2012). "TOGAF®, an Open Group standard", available at http://www.opengroup.org/subjectareas/enterprise/togaf (accessed 24 October 2012).

Tošić, V. (1992). "A review of airport passenger terminal operations analysis and modelling". *Transportation Research,* Vol. 26 No. 1, pp. 3-26.
Transportation Research Board (2014). "Airport Cooperative Research Program", available at http://www.trb.org/ACRP/ACRP.aspx (accessed 21 September 2014).
U.S. Department Of Transportation (2016). "American airlines fined $1.6 million for violating tarmac delay rule", available at https://www.transportation.gov/briefing-room/american-airlines-fined-16-million-violating-tarmac-delay-rule (accessed 01 August 2017).
Wells, A. T. & Young, S. (2004). *Airport planning & management,* McGraw-Hill Professional.
Wu, P. P.-Y. & Mengersen, K. (2013). "A review of models and model usage scenarios for an airport complex system". *Transportation Research Part A: Policy and Practice,* Vol. 47, pp. 124-140.
Yan, Z., Dijkman, R. & Grefen, P. (2010). "Fast Business Process Similarity Search with Feature-Based Similarity Estimation", Meersman, R., Dillon, T. & Herrero, P. (eds.), *On the Move to Meaningful Internet Systems*. Springer Berlin Heidelberg, pp. 60-77.
zur Muehlen, M. & Recker, J. (2008). "How much language is enough? Theoretical and practical use of the business process modeling notation", Bellahsène, Z. & Léonard, M. (eds.), *Advanced Information Systems Engineering*. Springer Berlin Heidelberg, pp. 465-479.