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Depicting Airport Processes: Definitions, Activities and Modelling

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Depicting the Processes of an Airport – Definition of Processes

A process is by definition a "phenomenon marked by gradual changes that lead toward a particular result" or even as a "series of continuous actions or operations conducting to an end" (Merriam-Webster, 2013). This definition has similarities to the ones proposed by the authors. For instance, Davenport (1992, p.5) states that a process is a "structured, measured set of activities designed to produce a specific output for a particular customer or market [and] a specific order of work activities across time and place, with a beginning, an end, and clearly identified business and outputs: a structure for action". For Sharp and McDermott, a process is defined as a "collection of interrelated work tasks, initiated in response to an event that achieves a specific result for the customer of the process" (in Portougal and Sundaram, 2006, p.2). Processes are used to represent the production of a product or service. As Reis (2010, p.76-77) state, "it draws all parties involved, the relationships amongst them, the resources consumed by each one and the tasks allocated to each one. Therefore, the behaviour and evolution of an organisation can be accessed through the monitoring and evaluating of her processes".

A process is herein defined as a set of continuous activities that conduct to an end. An activity is a set of interrelated tasks that perform a specific function and consumes resources: time, human/equipment and financial, through which inputs are transformed in outputs (Figure 1). As such, a task is the basic unit of a process. The passage of outputs from the preceding tasks as input to the subsequent tasks produces flow (information, cost, etc.) which will cross the entire process. The number of tasks and activities depend on each case.

The positioning of tasks is not random. It follows a sequence that is based on their beginning and ending times. Moreover, is possible to have task which run in parallel. As tasks consume resources (time, persons/equipment, financial), different process' configurations will lead to different efficiency levels. It is important to observe multiple configurations for the processes in order to assure its best outcome with minimal resources.

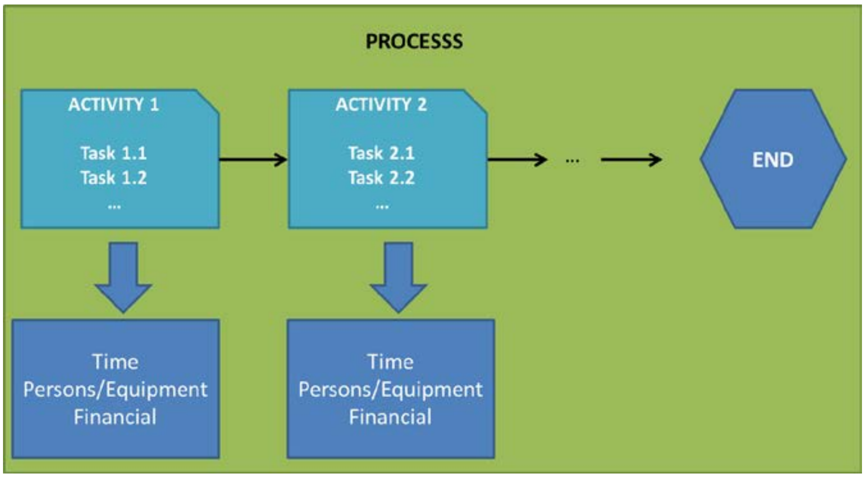

Figure 1 - Process graphical representation

Overall Processes in an Airport

Airports operations involve passengers, luggage, cargo, aircraft movements, ground handling, and crews. All of these operations can be systematised into processes schemes.

Passengers and luggage are processed at airport terminal. Three main types of processes can be established: departing, arrival and transfer. Departure consists in catching a flight to a final or intermediate destination, arrival consists in landing and leaving the airport, and transfer consists in landing at the airport only to catch another flight to a final or an intermediate destination. These processes have two sub-processes: one dedicated to Schengen passengers where no passport control is required and another one for Non-Schengen passengers which requires a passport control. They are explained in detail in sub-chapter 3.3.

Airports also deal with **cargo**. Figure 2 presents the members (parties and organisations) involved in the movement of cargo by air. Cargo flies from the shipper to the consignee through one or more airlines. However, usually there is an intermediate – the freight provider (Ashford et al., 1997). The main reason for this is that, according to Ashford et al. (1997, p.286-287), “air cargo requires rather specialised knowledge, and air cargo might form only a small part of the firm’s normal shipping operation. […] The freight forwarder, being familiar with the necessary procedures permits the airline to concentrate on the provision of air transport and to avoid time-consuming details of the facilitation and landside distribution systems”.

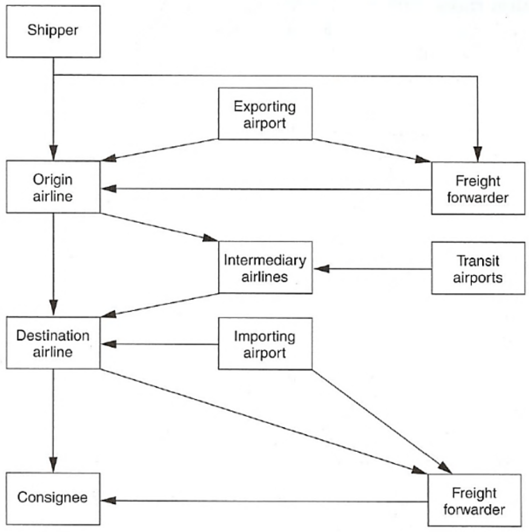

Figure 2 - Activities and actors involved in the air cargo process (Ashford et al. 1997, p. 287)

The **aircraft movements** can be summarised on the following macro activities (Norin, 2008, p.30-34):

- Touch down – landing on the runway;
- Taxi in – aircraft movement between the runway and the gate;
- Index – technical aid showing the pilot where to stop;
- Ground Power Unit – provision of power to the aircraft by the ground handling company;
- Chocks on – placed next to wheel to assure that aircraft does not move;
- Anti-collision light off – shows that the aircraft is not moving (engine shut down);
- Technical checks – external inspection to the aircraft;
- Cleaning and catering – cleaning and catering services to the next flight;
- Chocks and GPU off – removal of the chocks and power supply suppression;
- Anti-collision light on – shows that the aircraft is ready to move;
- Push back – moving the aircraft with the push back vehicle;
- Taxi out – aircraft movement between the gate and the runway;
- Take off – plane departure on the runway.

The services provided by the **ground handling** are crucial to the success and efficiency of the airport operations. These services are usually provided by specialised companies. Briefly, it includes the luggage treatment, passengers carrying from plane to terminal when needed, and aircraft assistance. The processes for these services were already described above.

Focusing on **crew**, there are two major processes: one for departures and the other for arrivals. The crew members also have to pass the security and passport controls; however they have special channels for this. Once they reach the aircraft, the similarities with the passengers' procedure stop. Here, they have to perform a set of activities such as check the aircraft, load sheets, and help passengers to name a few.

The configuration of airport facilities, such as terminals, runways or taxiways, highly influences the processes' efficiency. For instance, as Kazda and Caves (2008, p.107) point out, the configuration of the taxiway system influences the capacity of the runway and therefore, the overall capacity of the airport. One of the most common design approaches to optimise the capacity of the runway system is to build a taxiway parallel to the runway and connect them with exit taxiways with smooth angle (not right angles).

The design of the aprons condition the aircraft manoeuvres. As such, the type of aircrafts that is possible to use at the airport is not trivial. For instance, the satellite concept provides an ample space for aircraft servicing and safe push-back operations. However, this type of design increases the distance from the terminal to the airplane, so it is necessary to provide transport for passengers. It also consumes more space when compared with other designs. Therefore, it is important to find a right balance in order to maximize the airport processes efficiency for passengers and aircrafts as well.

Kauffman said "the distance from the entrance into the terminal building to the airplane is inversely proportionate to how much time you have to catch the plane" (in Kazda and Caves, 2008, p. 241). Despite this feeling, some airport terminals are more efficient than others when it comes to passenger process. The process time and crowding largely depends on the number of stations allocated to each activity and the amount of space provided. Summarising, the design of airport facilities has to consider the efficiency of the airport processes.

Terminal Processes for Passengers and Luggage

Airport terminal operations can be seen as a set of activities of one or more processes. This representation has been used by several authors to model and simulate airport terminals (Jim and Chang, 1998; Guizzi et al. 2009; Curcio et al. 2007; Olaru and Emery, 2007).

A typical flow diagram of the general processes for passengers and luggage at terminals is presented on Figure 3 for departures and Figure 4 for arrivals. The Schengen and Non-Schengen passengers are both considered. It is possible to notice that Schengen process is less complex as immigration service is not necessary. Typically for departures, passengers do the check-in on the airline's area, pass security controls, proceed to the general lounge and lastly to the gate holding area. Arriving passengers are able to immediately go for the luggage claim area, but the Non-Schengen passengers have to pass the passport control at first. After this, passengers have to decide if they need to declare goods or not as the paths are different.

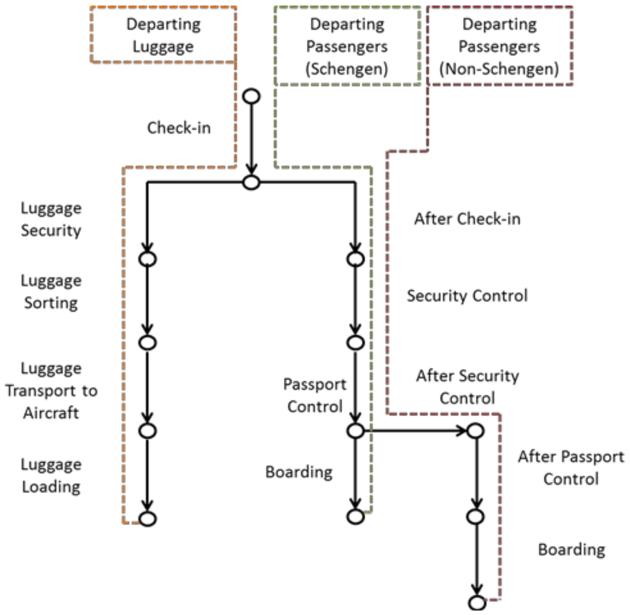

Figure 3 - Departing Process for Passengers and Luggage

Non-Schengen passengers are the ones who provide from Africa, Latin America, North America, Asia, Croatia, Ireland, United Kingdom, Russia, Turkey and Ukraine. The processes of boarding and arrival for passengers and luggage are analysed in this work. Moreover, the transfer process for passengers and luggage is also considered.

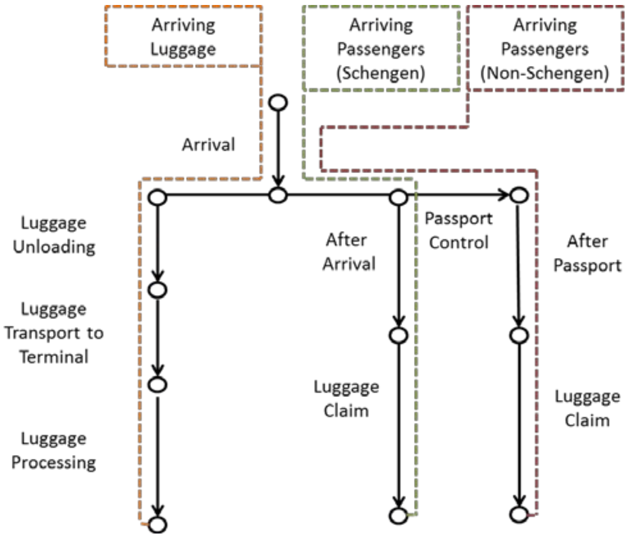

Figure 4 - Arrival Process for Passengers and Luggage

<u>Departure Passengers and Luggage</u>

Check-in: activity through which the passenger chooses his seat on the airplane and delivers (or not) the luggage. The traditional check-in is provided on a counter by an employee who verifies the ticket, passenger's personal information, and receives the passenger's luggage. The luggage receives a bar-code label that assures its appropriate sorting according to the flight. Another possible system to identify and trace the luggage is the RFID (Radio Frequency Identification). It consists on the "use of radio antennas to read individual chips that airlines attach to each bag" (de Neufville and Odoni, 2003, p.731). This activity has been subject to several changes and currently, the alternative is based on the self-service principle that can occur outside or inside the terminal. Outside the terminal, the most common option is the online check-in. Some hotels and transport facilities at the airport surroundings provide this service. Inside the terminal, business and frequent fliers are usually served by special counters. The self-service check-in inside the terminal is provided by kiosks. If the passenger has luggage to deliver, the activity has to be complemented by using the luggage drop-off counter. Figure 5 summarizes the types of check-in described.

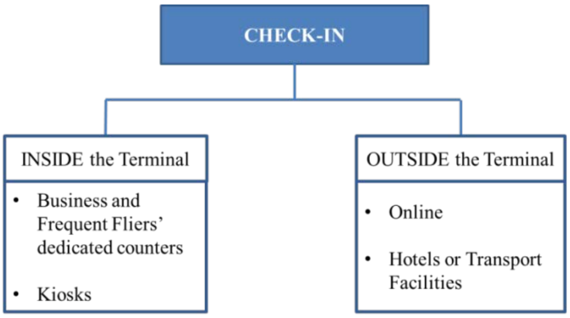

Figure 5 - Types of check-in

After Check-in: after check-in, passengers can proceed to the security control (described below) or spend some time at the shops and restaurants before it. The variety of services provided varies significantly among airports and it is an important source of revenues for the airport manager. However, passengers tend to spend more time at shops and restaurants after the security control to assure that they will not miss the flight.

Luggage Handling System (Security and Sorting): after the check-in, luggage is forward to the luggage handling system for security control and sorted for the respective flight. This is usually done by belts normally located under the floor, especially for large and medium airports. Luggage is checked for explosive devices and then, the bar-codes on the luggage are automatically read and sorted according to the destination for the respective chute. If the system is not able to read the codes or if the security check fails, there is a need for a manual intervention. In small airports, these procedures are typically manual.

Security control: activity through which passengers and hand-luggage are scrutinized by metal detectors, X-Ray boxes and manual search if something unusual is detected. Some airports provide special queues for business passengers to reduce waiting time. Typically, this activity is composed by the following tasks: passengers put all their belongings on the conveyor; conveyor conducts the belongings to an X-ray machine; passengers pass through the metal detector machine; if the machine sounds, passengers are manually inspected by a security employee. The passenger's belongings are processed next to him.

After Security Control: after the security control, passengers can proceed to the board waiting room or spend some time at the shops and restaurants before it. This depends on the available time before the flight and personal preferences. At this point, some business travellers can enjoy their waiting time at special lounges with additional services (refreshments, newspapers, etc.). For Schengen passengers this is the last activity before boarding. Non-Schengen passengers still have to pass through the passport control.

Passport Control (Non-Schengen Passengers): Non-Schengen passengers need to pass the passport control before proceeding to the boarding gate. After this control, passengers are at a specific area of the airport, reserved for Non-Schengen passengers.

After Passport (Non-Schengen Passengers): after the passport control, passengers have retail shops and restaurants available. Depending on the available time, passengers can spend some time at these facilities before proceeding to the boarding gate.

Luggage Transport to Aircraft and Loading: activity through which luggage is carried out from the terminal to the aircraft and loaded, after security and sorting. It is a "time critical activity especially when handling wide-bodied aircraft serving ling-haul routes and on charter flights (Kazda and Caves, 2008, p.184). However, it is possible to reduce the time by using containers to transport and load the luggage.

Boarding: activity through which passengers enter into the plane. This is the last activity at the terminal. An employee verifies the passenger's identification document and, through a machine, verifies the boarding pass and registers that the passenger is boarding. If a passenger who did the check-in does not show up, it is necessary to remove its luggage from the airplane before departure – luggage reconciliation.

Passengers and Luggage Arrival

Arrival: this is the first activity for those who arrive at the airport. At this point, passengers get out of the aircraft and enter into the terminal. Sometimes, to move from the aircraft to the terminal is necessary to use a bus.

Unloading and Luggage Transport to Terminal: at this point, the luggage is unloaded from the aircraft and moved to the terminal.

Passport Control (Non-Schengen Passengers): after arriving at the airport, Non-Schengen passengers need to pass the passport control. Only after this activity, they are allowed to proceed.

After Passport (Non-Schengen Passengers) and After Arrival (Schengen Passengers): after the passport control, Non-Schengen passengers can use the retail shops and restaurants or proceed immediately to the luggage claim room. Schengen passengers can also do the same. The only difference is that they do not need to pass the passport control between this activity and the arrival.

Luggage Processing: Once the luggage arrives at the terminal, it is unloaded from the transporter to a belt by an operator. The belt transports the luggage to the luggage claim room.

Luggage Claim: Passengers who travel only with hand luggage can proceed to the exit without stopping at the luggage claim area. The others have to stop at the luggage claim area to collect their belongings. The luggage enters the room through a belt.

Transfer Passengers and Luggage

Some passengers land at an airport just to get a connection to other destination – transfer passengers. These passengers and their luggage share some activities with the arrival process: *Arrival, Unloading and Luggage Transport to Terminal*, *Passport Control and After Passport (Non Schengen Passengers) and After Arrival (Schengen Passengers).* After that, according to their origin and destination (Schengen or Non-Schengen) the activities are equal to the ones presented for the departure process, starting at the security control. However, for Schengen passengers there is no need for security control.

The principle is the same for luggage. Luggage from countries that are members of the Schengen Agreement or countries with a cooperation agreement proceeds immediately to a new sorting. Luggage from other countries has to pass the security control before the sorting.

Modelling Processes – Fundamentals of Modelling

A model in mathematics is an interpretation of a theory (Kühne, 2005). Modelling is seen as a way to deal with certain relationships between real systems and models (Zeigler, 1976). A model serves a specific purpose. As such, there is no such thing as a general-purpose model (Sterman, 2000, p.84; Bonabeau, 2002, p.7287) as the same model can hardly be used to test different purposes. This requires that model development is preceded by a careful description of model's specifications.

Moreover, the model should not contain more details than necessary to achieve its purpose (Sterman, 2000, p.84). It is important to be parsimonious when it comes to model complexity in order to have a model that is legible for the others. However, as models represent a complex system (real world) some complexity is necessary to assure a good representation of the environment and its influences. The outcome is supposed to be as accurate as possible. Since there is no rule of thumb to determine the right amount of detail of a model, the modeller has to find the appropriate balance by focusing on the purpose of the model.

As Sterman (2000, p. 87) states, "modelling is a feedback process, not a linear sequence of steps. Models go through constant iteration, continual questioning, testing, and refinement" (Figure 6). It is important to notice that steps can be influenced by other steps. This is represented by the symbol in the centre of the diagram. The author exposes five steps:

1. Problem Articulation – where the model's boundaries and scope are defined. This step is considered the most important one;
2. Dynamic Hypothesis – the theory to explain the problem's mechanisms is developed based on a set of hypothesis;
3. Formulation – where the formal model (fed by the hypothesis) is developed;
4. Testing – moment to subject the model to several tests. The behaviour of the simulated model is compared with the actual behaviour of the system, and also subject of sensitive analysis;

5. Policy Formulation and Evaluation – model is used to design policies of improvement and evaluation of different scenarios.

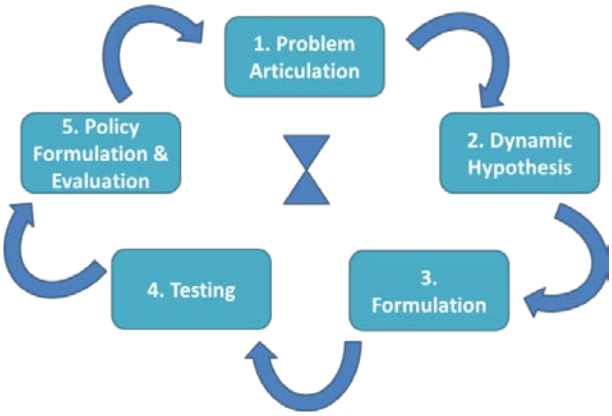

Figure 6 - Model building process (Sterman, 2000, pp. 87)

Since theories are meant to explain the mechanism of real world phenomena, they should be tested in real world conditions to become valid. Sometimes is not possible to use the real world to test theories. One of the alternatives to overcome this drawback is to use models that recreate the conditions of real world by using computational resources. Therefore, the purpose of modelling in this work is to validate the developed theory by testing different flexible scenarios.

The object of study of this research work is the airport terminal. Airport terminals are used twenty four hours a day, seven days a week and are highly sensitive to safety and security issues. Therefore, it is not possible to test different flexible solutions *in locus*. After looking to the alternatives, the decision was to use modelling for validation. Modelling has been commonly applied to airport terminals. Through modelling, it is possible to test flexible options and measure the variations that emerge from the theory.

The operationalization of the model is provided by the simulation. The properties of behaviour of the real system are inferred through simulation. As Maria (1997, p.7) states "in its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest". Simulation can be used to answer questions such as: what is the best design for this network?; how will a traffic load increase affect the system's performance?. Figure 7 is a scheme proposed by the author for simulation studies. Along with modelling, simulation is an iterative process represented by a cycle. Once the simulation model is created, is necessary to test and validate it during the simulation experiment phase. Then, the simulation analysis phase starts and several experimental conditions are run. Lastly, results have to be interpreted – conclusions phase.

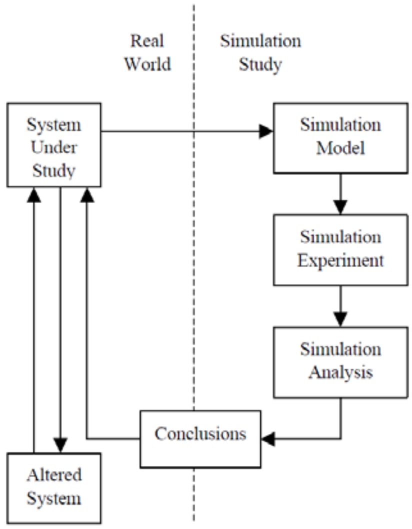

Figure 7 - Simulation Study Scheme (Maria, 1997, p.8)

Modelling and Simulation of Processes

There are several techniques to model processes that underpin decision support tools. The most common ones are herein presented for different fields of research.

Agent-based modelling (ABM) is considered as an emerging approach. It is used to model complex processes and phenomena in social science. Its roots can be traced until the early 1940s but only in 1990s the ABM became a feasible simulation tool (Chen, 2012, p. 167). This technique has been widely used to model processes whenever a social view is required, for example to observe how different types of users interact with a certain dynamic environment (An, 2012, p. 26). The application of this technique is present in the most diverse areas, such as processes, urban design, pedestrian flows, supply chain, consumer behaviour, or traffic congestion to name a few. ABM is formed by two core elements: the agents and the simulation environment. An agent is "a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to meet its design objectives" (Wooldridge, 2002, p.15). The environment is the platform where the agents operate and interact with the environment and/or among each other.

Discrete-event is considered one of the most popular object-oriented modelling and simulation approaches for processes. It is a technique where "events that change the state of an object are modelled to occur at discrete (though unpredictable) time intervals, rather than continuously" (Nidumolu et al., 1998, p.537). As different internal or external events happen, the entities or objects interact and evolve through rules that can be endogenous or exogenous. These entities can be physical, conceptual (information flows) or mathematical. The whole system is characterized by a state that is completely defined once the entity attributes are known. Whenever the system evolves, the state is altered by the value of the entities attributes. The evolution is marked by the relationship (logical or physical) between the entities (Cartenì and Luca, 2012, p.125-127). It is a "network of queues and activities where the state changes occur at discrete points of time" (Tako and Robinson, 2012, p.803). Discrete-event applications can be found on the most diverse fields where processes are present: container terminals (Cartenì and Luca, 2012), supply chains (Tako and Robinson, 2012), business processes (Nidumolu et al., 1998; Windisch et al., 2013). This list is not exhaustive but a representation of the diverse fields of application of discrete-events to model processes.

Another common technique to model processes is system dynamics. Regarding this technique, there is a general belief that it is more suitable to model problems at strategic level. System dynamics is usually used to compare systems' performance under different conditions ad understand how they behave through time. This technique "represents a system as a set of stocks ad flows where the state changes occur continuously over time". Moreover, through this technique, individual entities are not specifically modelled but instead they are represented as a continuous quantity in a stock" (Tako and Robinson, 2012, p.803).

Optimisation is one of the main tools of Operations Research area. It is based on mathematical formulations which differ according with the decisions variables, constraints and objective function. The problems are categorised in linear or non-linear models. The linear problems can be subdivided according to nature of the decision variables, namely: linear problems, integer linear problems, binary linear problems and mixed integer linear problems. There are exact methods, such as branch-an-bound, to solve small problems. However, the complexity rises as the size of the problems increase. To deal with this type of problems, is common to use to methods such as the greedy algorithm, simulated annealing, tabu search, genetic algorithms, or hybrid combinations (Guihaire and Hao, 2008). This technique has been applied in several areas of transport systems, for example network design, facilities location, crew assignment and scheduling.

It is common to observe that some authors use a mix of these applications in the same study. This option could lead the modeller to strong simulation results when compared with the use of just one technique. The model benefits from the mix as it collects the strengths from each technique.

Airport Terminal Modelling and Simulation Methods

Models and simulation are particular useful to analyse passengers handling systems on detail level or for long periods. It is also quite useful to test different scenarios for the same system (Horonjeff and McKelvey, 1994, p.493). Several authors have been studied and evaluating airport terminals operations and performance. The most common used techniques are discrete-events, simulation and decision support systems. Sometimes, authors use a mixture of these techniques, as it is presented below.

Jim and Chang (1998) present a simulation for the design of airport passenger terminals based on SLAM II. SLAM (Simple Landside Aggregate Model) is based on an advanced FORTRAN simulation language. It contains subsystems which support discrete-event that is used by the authors. Moreover, SLAM II possesses a network structure that uses nodes and branches to model elements in a process (queues, servers and decision points). The model analyses the factors which may influence the system's performance, by focusing on the arrival and departure flows. The input data required is: aircraft type, domestic/international passengers and baggage, total passengers, baggage claim facility identification number, passengers' group size, security time distribution, number of services, baggage transport time to claim area, service rate and distribution, facility size.

The SLAM model is also used by Andreatta et al. (2007, p.1533) that characterizes it as an "analytical aggregate model for estimating capacity and delays in airport passenger terminals". Each facility of the terminal is characterized by a module based on mathematical formulas that is incorporated on a network. These modules allow estimating the throughput of the facility (passengers per hour) and the delays of the departing flights generated that facility. According to the authors, the original SLAM did not model luggage handling system delays. So, the authors propose a new aggregate model for airport terminals based on SLAM that includes luggage handling systems. The model is test for Athens International Airport by considering three different scenarios.

Brunetta and Jacur (2007) also developed a discrete-event simulation model focus on the arriving, departure and transfer processes in the airport terminal for passengers and luggage. This model has a special feature: allows the flexible implementation of behavioural models that represent the way passengers make decisions in the terminal and decisions related with the operations in the terminal. More authors developed simulation models using discrete events (Olaru and Emery, 2007; Curcio et al., 2007; James, 2009; Guizzi et al., 2010).

Zografos and Madas (2006) developed a decision support system to evaluate the "total" efficiency of the airport system. An entire spectrum of airport effectiveness measures and associated trade-offs are considered, as well as airport processes and decision-making requirements. The authors use a typical decision support system development lifecycle to build this model. To measure the airport effectiveness, the authors propose different analysis tools such as SLAM.

According to de Neufville and Odoni (2003, p.655) there is "no agreement in the airport industry about standards". As such, there are multiple formulas as standards to determine the best passenger terminal design. They also state that the simulation of passengers and bags flows is the privilege way to explore the building's overall performance.

Software Package for Modelling and Simulation

Once the modelling technique is chosen is necessary to choose the most suitable software package. One of the software packages that can be used in this work is AnyLogic. It is hybrid micro-simulation software that offers a variety of modelling techniques, namely: system dynamics, discrete events, and agent based modelling. It was created and is maintained by XJTek Technologies (AnyLogic, 2013).

The software has extensive libraries covering modelling (movements, scheduling, communication), statistics and plotting, and visualisation (text, drawing tools and interface with the user), which are materialised thorough buttons. Its utilisation can be summarised largely in drag and drop the action buttons towards the model, and programming in Java language particular features.

References

An, L. (2012). Modeling Human Decisions in coupled Human and Natural Systems: Review of Agent-based Models. Ecological Modelling, 229, pp. 25-36.

Andreatta, G.; Brunetta, L.; Righi, L. (2007). Evaluating Terminal Management Performances using SLAM: the Case of Athens International Airport. Computers & Operations Research, 34, pp.1532-1550.

AnyLogic. 2013. AnyLogic Company website. Available at: http://www.anylogic.com/ (last accessed September 9, 2013).

Ashford, N.; Stanton, H.P.; Moore, C. (1997). Airport Operations. Second Edition, McGraw-Hill Books. ISBN-10: 0-07-003077-4.

Bonabeau, E. (2002). Agent-based modelling: methods and techniques for simulating human systems. PNAS, Vol 99, Issue 3, pp 7280-7287.

Brunetta, L.; Jacur, G. (2007). A Flexible Model for the Evaluation of an Airport Terminal. Available at: http://citeseerx.ist.psu.edu/index (last accessed September 14, 2013).

Cartenì, A.; Luca, S. (2012). Tactical and Strategic Planning for a Container Terminal: Modelling Issues within a Discrete Event Simulation Approach. Simulation Modelling Practice and Theory, 21, pp. 123-145.

Chen, L. (2012). Agent-based Modelling in Urban and Architectural Research: a brief literature review. Frontiers of Architectural Research, 1, pp. 166-177.

Curcio, D.; Longo, F.; Mirabelli, G.; Pappoff, E. (2007). Passengers' Flow Analysis and Security Issues in Airport Terminals using Modeling & Simulation. Proceedings 21st European Conference on Modelling and Simulation, ISBN 978-0-9553018-2-7.

Davenport, T. (1992). Process Innovation - Reengineering Work through Information Technology. Harvard Business School Press, Boston (United States), ISBN: 0875843662.

de Neufville, R.; Odoni, A. (2003). Airport Systems: Planning, Design and Management. The McGraw-Hill Companies, ISBN 0-07-138477-4.

Guihaire, V.; Hao, J. (2008). Transit network design and scheduling: A global review. Transportation Research Part A - Policy and Practice, Vol. 42, No. 10, pp. 1251-73.

Guizzi, G.; Murino, T.; Romano, E. (2009). A Discrete Event Simulation to Model Passenger Flow in the Airport Terminal. Proceedings of the Applied Computing Conference 2009 (ACC '09), VolumeII, Mathematical Methods and Applied Computing, ISBN: 978-960-474-124-3.

Horonjeff, R.; McKelvey, F. (1994). Planning & Design of Airports. Fourth Edition, McGraw-Hill, ISBN 0-07-045345-4.

James, K.C. (2009). Performance Improvement Studies of an Airport Terminal using Discrete-Event Simulation. Computer Modelling and New Technologies, Vol. 13, No. 3, 58-64.

Jim, H.; Chang, Z. (1998). An Airport Passenger Terminal Simulator: a Planning and Design Tool. Simulation Practice and Theory, Vol.6, 387-396.

Kazda, A.; Caves, R. (2007). Airport Design and Operation. Second Edition, Emerald Group Publishing Limited, ISBN 978-0-08-045104-6.

Kühne, T. (2005). What is a Model?. Dagstuhl Seminar, 04101, March.

Maria, A. (1997). Introduction to Modelling and Simulation. Winter Simulation Conference Proceedings, Ed. S. Andradóttir, K.J. Healy, D.H. Withers, B.L. Nelson, pp.7-13.

Merriam-Webster. (2013). Online Dictionary. Available at: http://www.merriam-webster.com/ (last accessed July 8, 2013).

Nidumolu, S.; Menon, N.; Zeigler, B. (1998). Object-oriented Business Process Modeling and Simulation: a Discrete-event System Specification Framework. Simulation Practice and Theory, 6, pp.533-571.

Norin, A. (2008). Airport Logistics – Modelling and Optimizing the Turn-Around Process. Licenciate Thesis No. 1388, Linköping University, Department of Science and Technology, Sweden.

Olaru, D.; Emery, S. (2007). Simulation and GA-optimisation for Modeling the Operation of Airport Passenger Terminals. 29th Conference of Australian Institutes of Transport Research (CAITR), Adelaide, Australia.

Portougal, V.; Sundaram, D. (2006). Business Processes: operational solution for SAP implementation. IRM Press, London, ISBN: 1591406153.

Reis, V. (2010). Development of Cargo Business in Combination Airlines: Strategy and Instrument. (Doctoral Thesis), Universidade Técnica de Lisboa, Instituto Superior Técnico, Lisboa.

Sterman, J. (2000). Business Dynamics: Systems thinking and modelling for a complex world. Irwin McGraw-Hill, Boston (United States), ISBN: 978-0072389159.

Tako, A.; Robinson, S. (2012). The Application of Discrete Event Simulation and System Dynamics in the Logistics and Supply Chain Context. Decision Support Systems, 52, pp.802-815.

Windisch, J.; Röser, D.; Mola-Yudego, B.; Sikanen, L.; Asikainen, A. (2013). Business Process Mapping and Discrete-Event Simulation of Two Forest Biomass Supply Chains. Biomass and Bioenergy, 56, pp.370-381.

Wooldridge, M. (2002). Introduction to MultiAgent Systems. John Wiley & Sons.

Zeigler, B. (1976). Theory of Modelling and Simulation. John Wiley & Sons, ISBN 0-471-98152-4.

Zografos, K.; Madas, M. (2006). Development and Demonstration of an Integrated Decision Support System for Airport Performance Analysis. Transportation Research Part C, 14, 1-17.