A System Dynamics Approach to Airport Modeling

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Airports have their operational focus on the short term, but also need a long term view for their infrastructure planning and development. However, there is a lack of models quantifying the overall long term development of an airport, because current models focus on certain airport elements only. The purpose of this paper is to develop a generic and easy to handle model that covers both operational parameters i.e. the main aircraft movement and passenger flows as well as economic aspects i.e. cash flows of an airport. Thereby this work focus on the methodology used, especially aspects of System Dynamics. It was found, that most of the airport elements can be implemented in a System Dynamics environment with little effort. Nevertheless there are some restrictions, which impede an intuitive modeling.

Nomenclature

A/C	=	*Aircraft*	*RWY*	=	*Runway*
PAX	=	*Passenger*	*SD*	=	*System Dynamics*
MTOM	=	*Maximum Take-off Mass*	*SLF*	=	*Seat Load Factor*

I. Motivation and Objectives

Airports represent the nodes of the air transportation system. Due to still increasing passenger numbers with an annual rate of nearly 5 % over the next 20 years[1,2] and arising capacity shortages, new technologies will likely enter the aviation market in the mid-term. The term "technology" is understood in general sense including also new procedures and processes. For example this can be innovative aircraft designs (e.g. the Blended Wing Body) and new airport concepts (e.g. the Endless Runway[**]), but also environmental activities to achieve a reduction in noise and greenhouse gas emissions[††]. The Airbus A380 is an excellent example for the introduction of such a technology in the recent past. Already within the planning and test phase it became obvious, that it is not possible to operate an A380 adequately on the ground without any changes on airport infrastructures. But not just a change of the Airport's infrastructure but also their business models may be required to adapt to the upcoming developments.

Having a closer look at airports, their operational and business characteristics are quite complex. Depending on the type of airport and the local regulatory framework, the airport operators will vary in the pace of accommodation to trends in air transport demand. This may lead to time lags in adjusting to adequate airport capacity. Therefore a fundamental assessment on investments is necessary to avoid a temporary loss of potential passenger volumes and revenues. This work proposes a system dynamics approach to airport modeling for an assessment of new technological impacts on the airport system, answering the question: Do innovative air transport concepts fail because the infrastructure and business model adaption process is too long and costly or inadequately balanced?

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[**] See hereto: www.endlessrunway-project.eu.
[††] See hereto: www.iata.org/whatwedo/environment/Documents/technology-roadmap-2013.pdf.

II. Theoretical Background

A. System vs. Model

A system consists of elements connected by relationships among each other[3]. Bossel[4] extends this definition by three features an object requires to talk about a "system":

1) *System purpose:* The object pursues a certain aim and the observer recognizes a meaning in its actions.
2) *System structure:* The object consists of elements and relations between them (interactions), determining the object function.
3) *System integrity:* The object is not divisible without losing the system identity. If one system element or relation will be removed, the object cannot fulfill its initial defined system purpose.

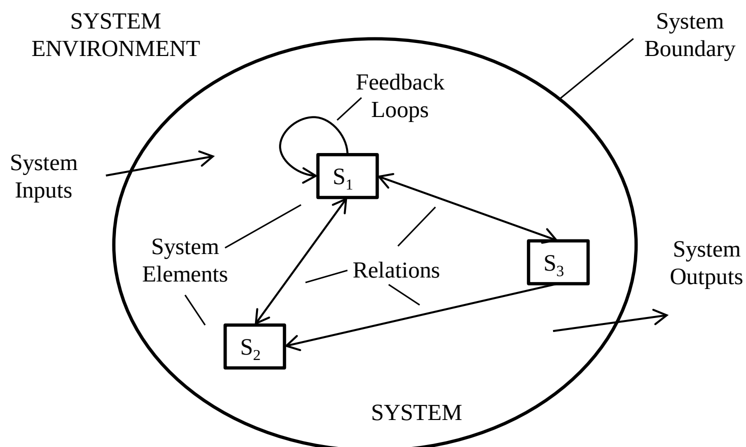

Figure 1. Elements of a system‡‡.

Figure 1 shows some additional system factors. The system boundary isolates the system physically or conceptually from the system environment. Due to a fluent transition it is sometimes difficult to define the system's boundary. The environment influences the system (system inputs) and vice versa (system outputs).

In general systems are dynamic, if they show a time-dependent behavior. Even if they seem to be static, they change their condition over time (e.g. a wooden chair, which is also subject to aging). The most practical way to get reliable results about the behavior of a system is an observation under different conditions. However, in most cases it is impossible due to cost and time constraints or the observation itself disturbs the operational procedures of the system. Therefore models are usually developed, representing a simplified replica of the real existing system. Advantages of a model are cost- and time-saving investigations. Alternative developments can be proofed as well. On the other hand there uncertainty is still existing if the model reflects the reality in all important aspects. A strong validation widely counteracts this disadvantage.[4]

B. The Method of System Dynamics

System Dynamics (SD) is a modeling technique for complex systems developed by Jay W. Forrester during the mid-1950s. Forrester proofed the simulation and modelling possibility of complex, non-linear and dynamic systems within the industry sector[5]. Initially known as "Industrial Dynamics", the term SD obtained more and more validity due to the application in further areas[6]. Therefore SD can be defined as follows:

"System Dynamics is a computer-aided approach to policy analysis and design. It applies to dynamic problems – problems that involve change over time – arising in complex social, managerial, economic, or ecologic systems – literally any dynamic systems characterized by independence, mutual function, information feedback, and circular causality."[6]

‡‡ Referring to Bossel[4].

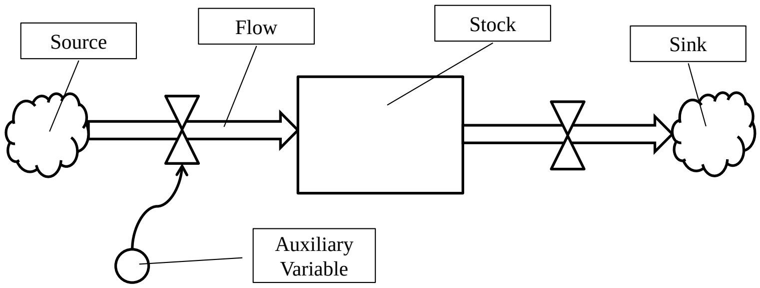

Figure 2. Stock and flow diagram[§§].

Using SD, an analysis can be subdivided into three steps. First, the generation of a casual loop diagram[***], which will be transferred into a stock and flow diagram in a second step, and finally the formulation of a mathematical system of differential equations. In order to transfer the casual loop diagram into a simulation-capable stock and flow diagram, the elements must be distinguished by their attributes, shown in Fig. 2.

1) *Source (default input):* These are constant system parameters, exogenous environmental influences and initial values of stocks, if there is no input from a system value, because the system has no influence on it.
2) *Stocks:* Indicate the current state of system entirely and cannot be determined from or described by any other system element. Their development is determined by the sum of rates (inflows and outflows),
3) *Flows:* Rates, which are described by a differential equation and influence the stocks in a positve or negativ manner.
4) *Auxiliary Variables:* Calculable by default input values or stock values on the basis of algebraic, logic, or spreadsheet functions. They have at least one input and include rates as well as default input values.
5) *Sink:* Reflects the system output.[4]

C. System Dynamics in Airport Modeling

Using SD in the context of airports is not a complete new approach. SD is used frequently for passenger flow simulations within terminals, e.g. analyzing passenger waiting times at different terminal processors. Manataki[7] assessed the terminal performance using a SD model to support high-level decision-making related to changes in the structure and operation of the airport terminal. But not only passenger flows inside the terminal are addressed. Mühlhausen[8] also evaluated the use of SD for macroscopic simulations of passenger flows between cooperating airports. Due to limited space, especially at agglomeration areas, capacity-limited airports are restriced to expand through runway constructions. The model suggests a cooperation of airports and assesses common suburban train and high-speed train connections between nearby situated airports. Other applications regarding passenger flows are agent based SD simulations[†††], e.g. evacuation scenarios in emergency cases or boarding simulations.

Similar to this paper Stamatopoulos[9] focuses on long term expansion plannings with time horizons of 15-50 years. The implemented, but non-SD set of models estimate the airfield capacity (runway, taxiway, and apron) and associated delays. It should provide quick, reliable examinations of a wide range of different scenarios at a strategic level.

However, the above mentioned investigations has its focus on one special airport part only. The objective of this work is, on the one hand, to develop a generic simulation model of aircraft and passenger flows at the airport airside and landside, taking into account the facility capacities. On the other hand, there is a direct connection to the operational cash flow of the airport as well as its investment planning based on passenger demand forecasts. The model should help to identify capacity shortages in the future, the best point in time for new investments and effects on the cash flow of an airport.

[§§] Referring to Bossel[4].
[***] Extensive statements in Bossel[4], page 70-74.
[†††] See hereto: http://www.anylogic.com/case-studies/simulation-of-the-frankfurt-airport.

III. The Airport Model

A. Covered Elements and Processes of an Airport

The model is divided into two sections. On the one hand it simulates the main operational parameters of an airport. These are the aircraft (A/C) flows on the airport airside and the passenger flows inside the terminal. Cargo processes are implemented, too.

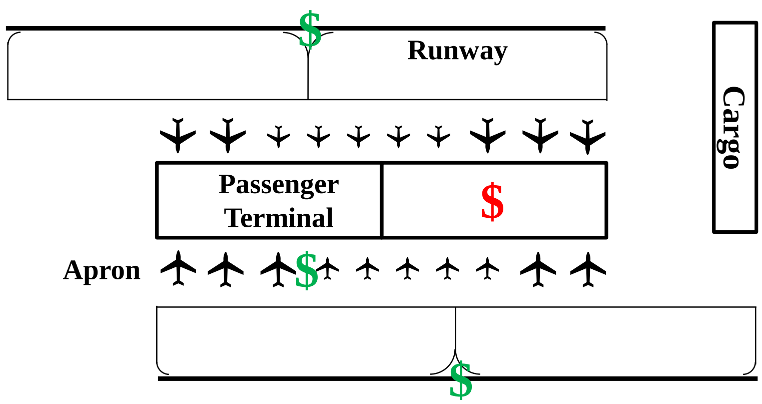

Figure 3. Elements of the airport model.

On the other hand the model considers economic parameters. The airport customers, first of all the airlines, pay charges for A/C handling procedures on the runway (RWY) and apron corresponding to the A/C movements (aviation revenue). But also the passengers generate a substantial amount of so called non-aviation revenues, even more than 50 % at certain airports[10]. Figure 3 gives an overview of the model parts. Details are stated in the following sub-chapters

B. Basic Assumptions and Facts

1. Programming

The model is implemented with the SD software AnyLogic[‡‡‡]. AnyLogic renounces the casual loop diagram and integrate its main principles directly into the stock and flow diagram. At the end of an arrow (link) within the stock and flow diagram, the effect of a system element to the following element is indicated by a "+" or "-" symbol. Thus casual loops and feedback effects can be depicted as well. Table 1 shows the symbols used in AnyLogic.

Beside the common SD variables, AnyLogic provides additional ones that increase the user friendliness. The *spreadsheet function* can be used for the import and export of Excel data. Another helpful variable type is the *shadow*. It is an exact copy of the original, but can be placed somewhere else in the model. Therefore long and confusing links can be avoided. The third listed type is an *event*, which is a single or recurring process, triggered by conditions or time overruns. Mathematical equations are deposited directly at the variable declarations. In total, all equations form a complex equation system.

[‡‡‡] http://www.anylogic.com.

Table 1. AnyLogic Symbols used in the following figures.

Symbol in AnyLogic	Meaning
	Stock (variable)
	Rate / flow (variable)
	Auxiliary (variable)
	Link[§§§]
	Parameter
	Spreadsheet function
	Shadow (variable)[****]
	Event

2. Initial Flight Plan

One main default input to the model is a flight plan. It should be on a yearly base and contain the following values for a certain airport:

1) A/C departure and arrival times
2) A/C maximum take-off mass (MTOM)
3) A/C capacity (seats) and the mean seat load factor (SLF)
4) If available: freight volume per A/C (alternatively the yearly freight volume of the airport)

Due to the preferred yearly simulation time, teh values of the flight plan metioned above should be available for each hour and day per year (24 x 365 matrices[††††]). This initial flight plan represents the A/C movements and passenger numbers for the first simulation year and is, thus, the basis for every following simulation year. Therefore only the first simulation year depicts the reality.

3. Aircraft Size

Within the model the aircraft are classified into 4 categories, according to their wake turbulence: *L* (light, MTOM ≤ 7 t), *M* (medium, 7 t < MTOM < 136 t), *H* (heavy, MTOM ≥ 136 t), and *J* (super, Airbus A380 and Boeing B747-8). This classification is used to calculate the charges, which the airlines have to pay for landing on and dispatch at an airport. Furthermore the aircraft category determines the traffic mix. The more heterogenous the traffic mix is distributed, the smaller the airside capacity gets, due to different separation minima of approaching and departing aircraft.

4. Time Unit and Horizon

The model simulates the airport movements and cash flow on the basis of one year, but runs on an hourly base. Thus all variables are depicted on an hourly base. Furthermore the simulation is time-discrete although it seems to be time-continuous. AnyLogic divides the time unit “hour” into thousands of time steps. This means for example, the hourly values of a flow variable run homogeneously distributed over an hour to/from a stock variable, even if it is an integer, e.g. A/C movements. The same holds true for stock variables. Therefore the value of stock variables should be treated with caution within the hourly time step, especially stock variables describing a small number of objects.

In summary a simulation should begin on January 1st and end on December 31st. Displayed numbers during this timeframe are stored wrong or not at all. The simulation time can be selected freely.

[§§§] A link crossed by two parallel lines indicates a delayed effect of the source values on the sink.
[****] Exact copy of the original variable; Symbol in depence on the original variable.
[††††] Leapyears are not considered.

C. Aircraft Movements

This part simulates the basic concept of A/C movements on the airport runway. Figure 4 illustrates the principle for the A/C category *L*. On the left-hand side (first dark red flow *ArrL*) the approaching A/C flow into a stock *WaitingArrL* that represents the waiting line for the apron stands. Afterwards the aircraft taxi to the apron (second red flow *Taxiways ArrL*). The A/C outbound flow is on the right-hand side. Once ready for take-off the A/C queue up the departure line (TaxiwaysDepL) and finally leave the airport (light red flow *DepL*). The overall movements per hour are calculated and stored by the pink flow at the bottom of Fig. 4 for further use.

The waiting line stocks (grey boxes within the flow) are necessary to take into account the capacities of the apron as well as the runway. If the apron is saturated, the inbound A/C queue up and wait for the next available stand. On the outbound flow the runway capacity limits the departing A/C[‡‡‡‡]. The total number of delayed A/C is stored (grey boxes at the bottom edge, e.g. *YearlyDelayedParkedL*) differentiated by the delay reason.

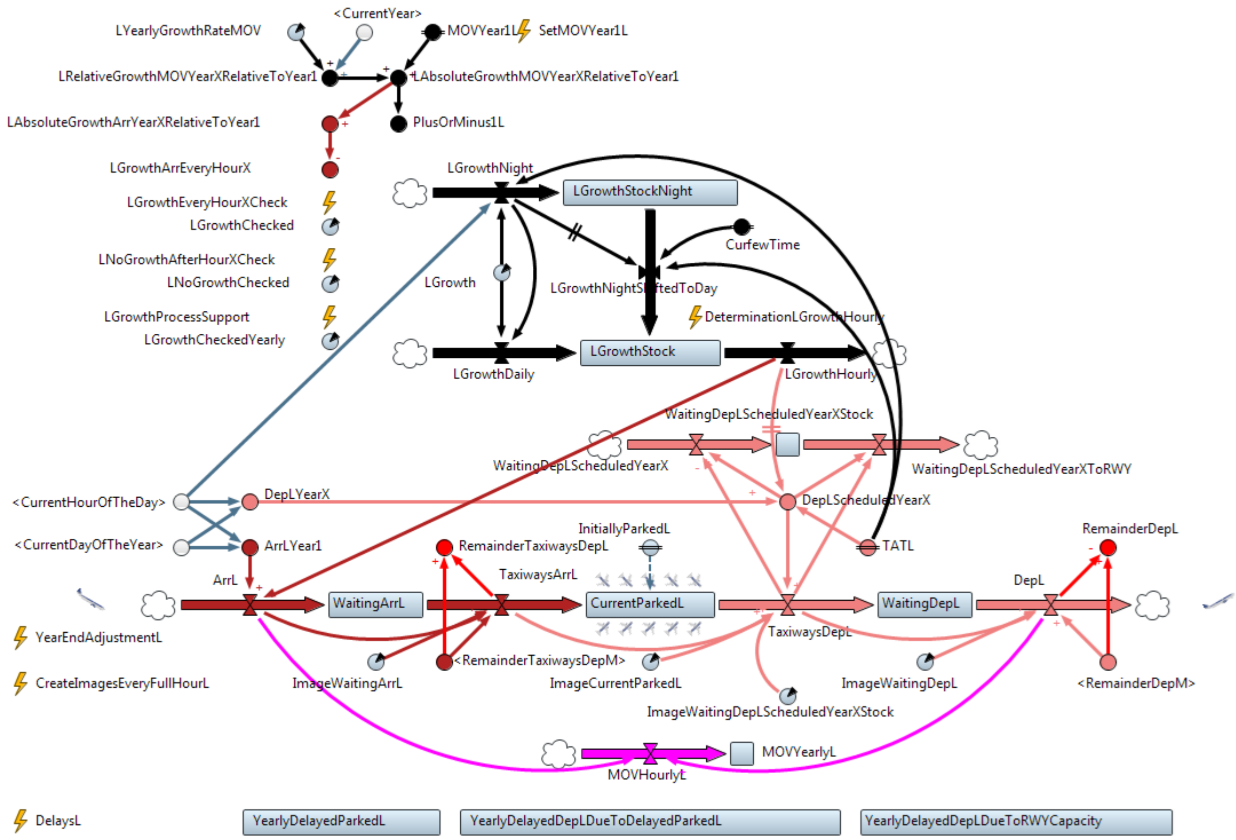

Figure 4. Aircraft movements - category L.

Furthermore a yearly growth of A/C movements is implemented, represented by the black flows and stocks at the top. There was the claim to model the A/C movements as an integer, in contrast to passenger or freight volumes. Due to the high passenger volume it is not inaccurate, if there is a decimal number for passenger at the simulation end. But there should not be a half A/C. This procedure counteracts the philosophy of SD and leads to a complex structure to ensure integer A/C movements.

In summary the absolute A/C growth per year is calculated by the absolute A/C movements of the first year multiplied with the relative growth rate. This rate is adjustable separately per A/C type. The additional movements are homogenously distributed to every operational hour, whereby arrivals and departures increase equally. This procedure is also possible for a decrease of A/C movements. The model also considers a turnaround time (steady per A/C category and the whole simulation), initially parked A/C at the apron at the simulation beginning and airport curfews.

[‡‡‡‡] It is assumed, that only departing A/C can be delayed, as approaching A/C are always priortized.

The model comprises one part per aircraft category, similar to the shown image by changing the A/C category index of "L" to the index "M", "H", or "J". These four subparts deliver the input for the total A/C movements' part, shown in Fig. 5. For example the sum over *ArrL*, *ArrM*, *ArrH*, and *ArrJ* (represents the total approaching A/C flow *Arr* (first green flow on the left-hand side). In summary, this part delivers the overall A/C movements (pink flow *MOVHourly*) and examines the capacity load factors for the RWY and the apron. A random allocation of available slots for arriving/departing A/C is not possible in AnyLogic. Therefore the order J, H, M, and L is implemented due to the aim of handling as most as possible passengers in time.

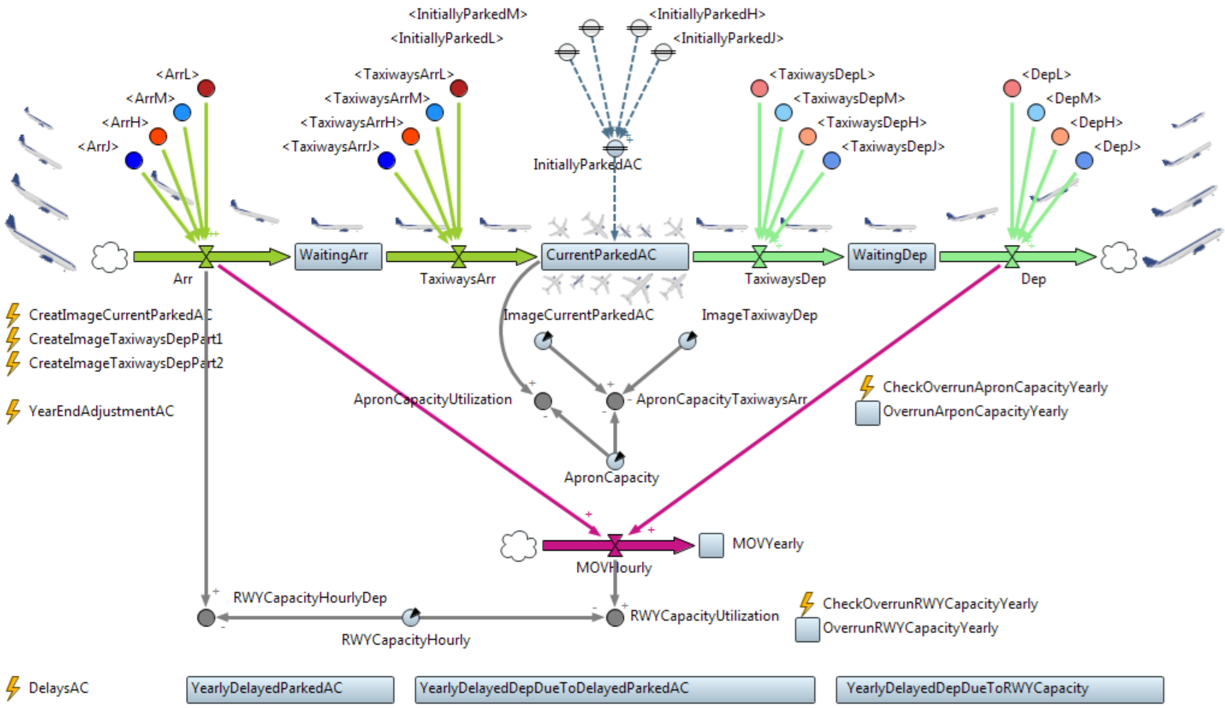

Figure 5. Aircraft movements - Total overview.

D. Aircraft Mass (MTOM)

The MTOM per A/C is essential to calculate the charges an airline has to pay for the A/C handling at an airport, which is addressed in the following. The A/C mass part is similarly structured to the A/C movements' part. There are again subparts for every A/C category (an image is renounced) providing the input for the total A/C MTOM part. These inputs are represented by the colored shadow variables on the left hand side (e.g. *MTOMArrL*), depicted in Fig. 6. The model reads the masses of every single A/C type, which are allocated within the initial flight plan. In comparison to the A/C movements' part, waiting line stocks are not implemented here. Only the currently parked "masses" (*CurrentParkedMTOM*) are stored. Due to the hourly modeling manner and accumulation of the MTOM over an hour, a connection between the movement and the mass cannot be realized. This approach of the model needs to be made in order to preserve the simplicity. Similar to the A/C movements part, the MTOM can increase yearly by a defined growth rate per A/C type. Finally, the total MTOM are stored in the *MTOMMOVYearly* stock.

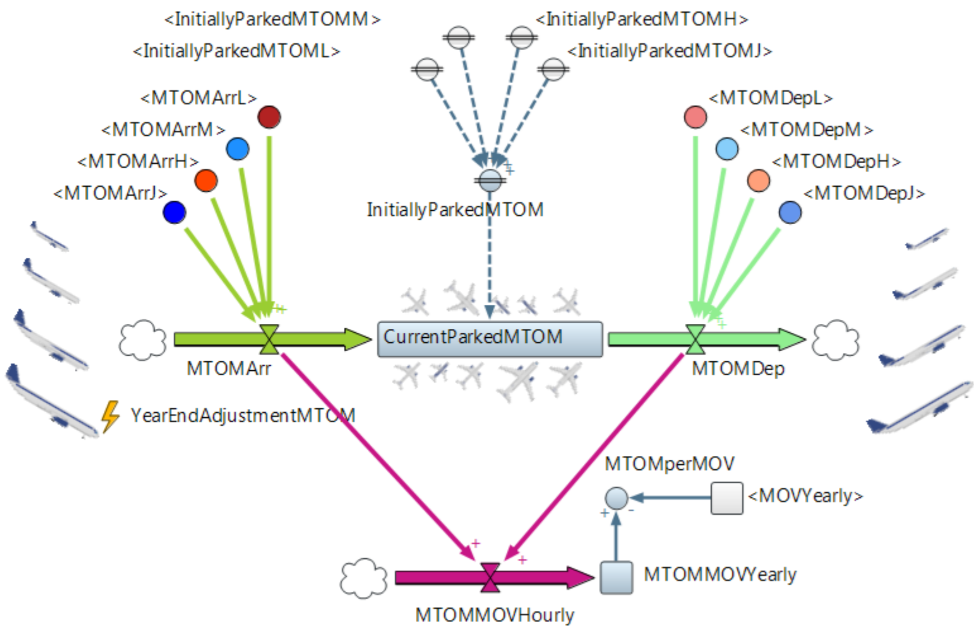

Figure 6. Aircraft MTOM - Total overview.

E. Passenger Terminal

The passenger terminal represents the interface between the airport landside and airside. Within the model a detailed modeling of terminal processes, e.g. check-in, security control etc. is waived. Furthermore, only one passenger terminal is implemented, even if more than one terminal exist in reality. These analyses would require specifications and layouts of every single terminal and would go beyond the constraints of this model. Analyses of processes are addressed extensively by agent based simulations[§§§§].

Figure 7 shows the model structure of the passenger terminal. On the left-hand side three flow variables are depicted: First, landside arriving passengers (dark red flow *ArrivalDepPAX*). Second, transfer passengers, who are arriving by plane and leaving by plane (yellowish green flow *ArrTransferPAX*). Third, airside arriving passengers, who are going to leave the airport by surface means of transportation (dark blue flow *ArrPAX*). The stock in the center represents the current numer of passenger inside the terminal. On the right-hand side there are the outflows of the terminal (*DepPAX*, *DepTransferPAX*, *DepartureArrPAX*), corresponding to the inflows in terms of a lighter color.

The initial flight plan does not contain passenger numbers for every single flight. Thus, the airside arriving passenger number is determined by taking the hourly seat capacity of arriving A/C multiplied with a defined mean SLF[*****]. Thereof, the transfer passengers are subtracted, calculated by a relative share of the airside arriving passengers. The landside arriving passengers are the product of the hourly seat capacity of departing A/C multiplied with the SLF less transfer passengers. These passengers appear at the airport a specific time in advance to departure. This terminal dwell time includes the passenger terminal processing and waiting times as well as the consumption time, i.e. time for shopping, eating etc. Due to interface reasons between the Excel spreadsheets and AnyLogic the terminal processing time can be integer only. According to the terminal dwell time there is a transfer time for transfer passengers. On the right-hand side, a calculation for overnight stays is implemented. If there is not a departure anymore due to night curfew regulations, the transfer passengers have to stay overnight and take the first flight the next morning. The number is stored in a stock and can be analyzed over the simulation time[†††††].

In summary the hourly passenger volume is calculated by the magenta flow, which leads to a yearly passenger volume stock (*PAXVolumeYearly*, at the bottom of Fig. 7). Employees, airport visitors as well as meeters and greeters are not taken into account in the passenger terminal calculations. The hourly passenger volume is compared with the maximum terminal capacity and indicates congestion within the terminal. The capacity parameter does not

[§§§§] For example: Traffic Oriented Microscopic Simulator (TOMICS), see hereto: http://www.dlr.de/fw/desktopdefault.aspx/tabid-5980/9752_read-19750/.

[*****] It is implemented an equal seat load factor for arrivals and departures as well as every A/C category.

[†††††] Due to internal reasons the correct transfer passenger number is not determinable yet.

intervene actively. Thus the passenger volume can exceed the terminal capacity yet. But it is assumed, that this procedure has an impact on the commercial revenues generated by the passengers. The more congested the terminal, the lesser the revenue.

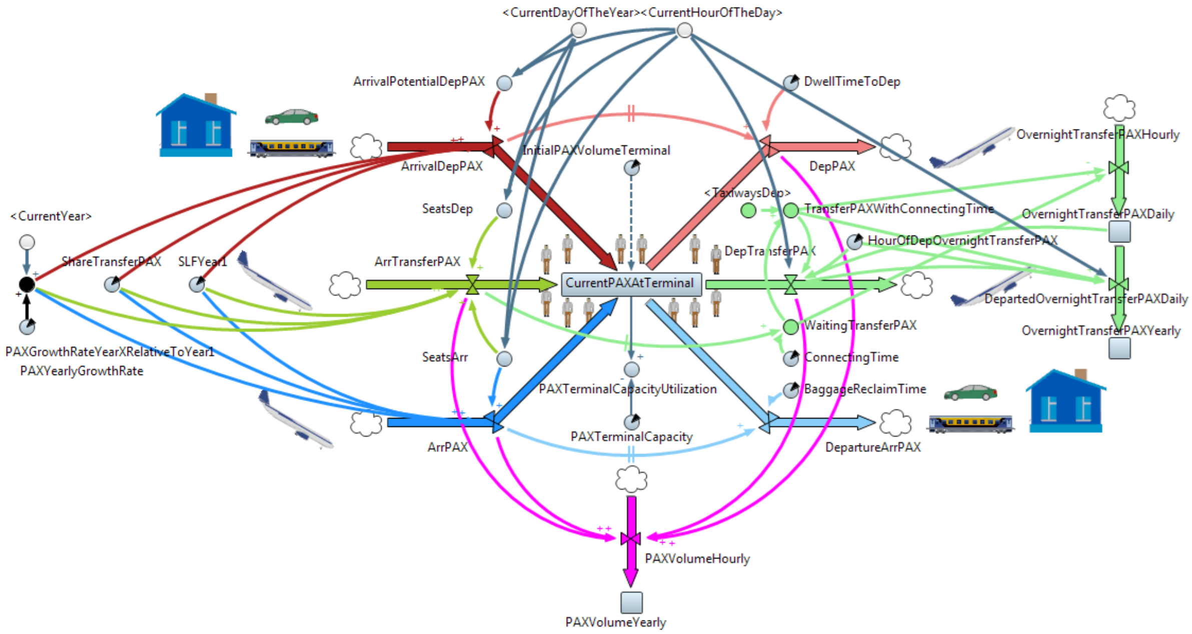

Figure 7. Passenger terminal.

F. Cargo Terminal

Another revenue source of an airport is cargo. The cargo terminal is implemented in two manners in order to cover two different data input structures or calculations of the cargo volume. The first one is quite similar to the passenger terminal part. Due to a lack of freight data per A/C movement, this part is not used yet and therefore not further described. The second freight terminal part bases on yearly freight data per airport as shown in Fig. 8.

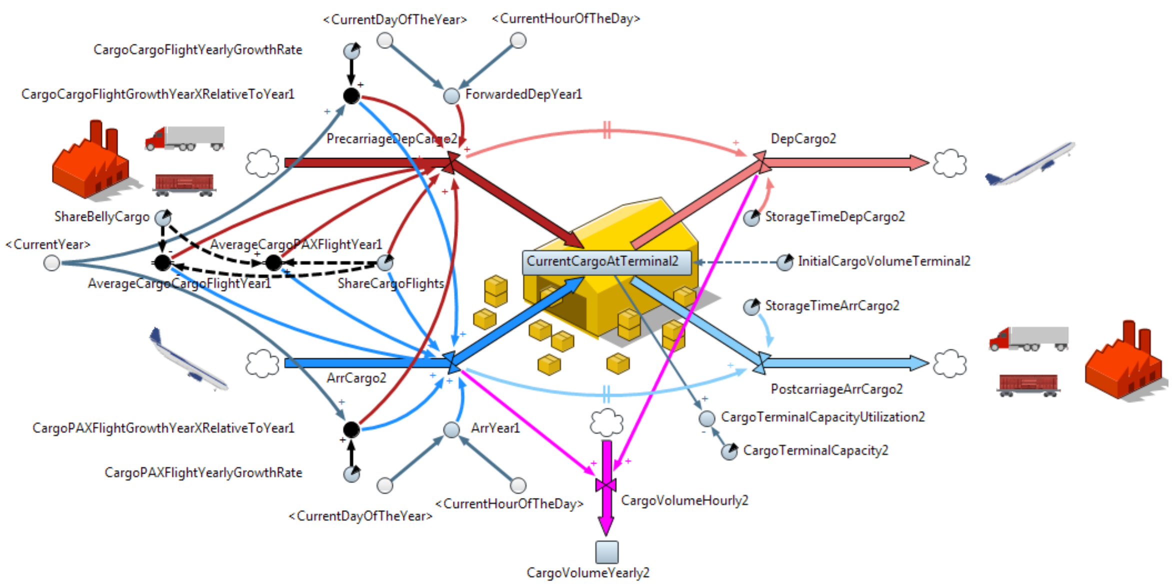

Figure 8. Cargo terminal – version 2.

In general there are again inflows to (dark red *PrecarriageDepCargo2* / dark blue *ArrCargo2*) and outflows from (light red *DepCargo2* / light blue *PostcarriageCargo2*) the cargo terminal. Here the cargo volumes (inflows) are calculated more or less similar to the passengers[‡‡‡‡‡]. They derive from the hourly cargo volume transported by passenger and cargo A/C, estimated by the user. Similar to the above mentioned parts the user can estimate a yearly cargo growth rate. Finally the magenta flow determines the yearly cargo volume and stores it in a stock (*CargoVolumeYearly2*).

G. Aviation and Non-Aviation Cash Flows

The A/C and PAX flows mentioned above are the basis for the following cash flow calculation, which can be separated into an aviation and a non-aviation section. The 1st one is the only model part referring to one special airport[§§§§§]. Worldwide airports have a more or less unique table of charges. Most of them have landing charges, parking charges, handling charges etc.[******]. The huge difference is how these charges are determined.

Figure 9 shows the implemented types of charges (mint green flows). These are passenger handling charges, security charges, parking charges, landing and take-off charges, charges for central ground handling, and other charges. The inputs arise from the aircraft mass part and the passenger terminal part (see above). Every charge/revenue cumulates in a stock separately (e.g. *PAXChargeYearly*) and leads, in summary, to the yearly aviation revenue (dark green flow *AviationRevenueYearly*). Due to the high complexity and uniqueness of the charges a detailed description is waived. Furthermore the model has the possibility to implement discounts on landing and take-off charges as well as parking charges (depicted as red flows and links).

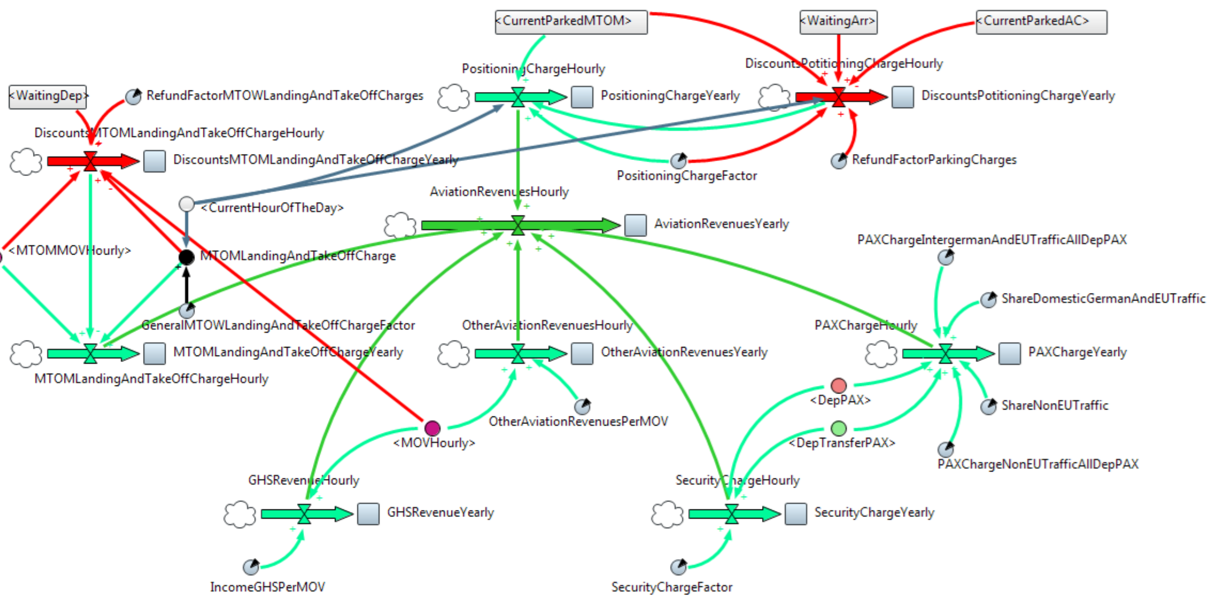

Figure 9. Aviation revenues.

[‡‡‡‡‡] This way was more complicated to implement, although it is more inprecise than a calculation on the basis of freigth volums per A/C.
[§§§§§] Currently, this is Hamburg Airport.
[******] Especially in Europe, there are noise and pollutant emission charges, too.

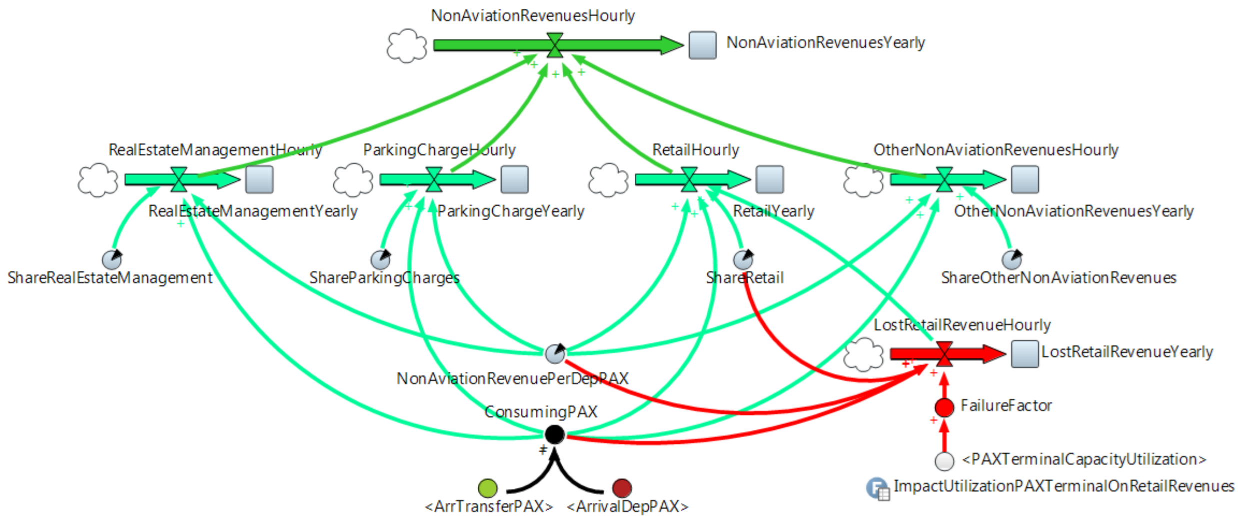

Figure 10. Non-aviation revenues.

In contrast to the aviation revenues, the non-aviation revenues can be modeled in a much easier way. However, there exist no commonly used classification of the type of non-aviation revenue. Therefore it is hard to compare non-aviation revenues of different airports, because every airport makes a secret of that issue.

Visualized as mint green flows in Fig. 10, the model differentiates between real estate revenues (rents and assets), parking charges (by surface vehicles), retail revenues (catering and concessions) and other commercial revenues. Currently the non-aviation charges refers to the departing and transferring passenger demand only, indicated by the green and red circles at the bottom, which is multiplied by a share per charge type[††††††]. Again, these flows are cumulated in stocks (e.g. *ParkingChargeYearly*) and lead in summary to the yearly non-aviation revenues (dark green flow *NonAviationRevenueYearly*). The red flow *LostRetailRevenueYearly* on the right-hand side indicates the above mentioned revenue loss due to a congested terminal, which can be adjusted individually.

IV. First Results

Data from Hamburg Airport were taken to assess the functionality of the model. The (fictional) scenario implemented comprises three infrastructural measures, which influence the operational procedures and revenues during a simulation horizon of 20 years.

First project is the construction of a new parking garage. Therefore the old one closes at the end of 2012 and the new parking garage opens mid of 2014. During the construction phase the parking capacity decreases by 1,450 parking spaces and amounts to 2,800 after the reopening. These capacity changes are implemented to the model by events, represented by yellow lightnings at Fig. 11, e.g. *ReconstructionParkingGarage*, which lead to a loss or profit in parking charges (dark blue flow *ChangeParkingChargesHourly*).

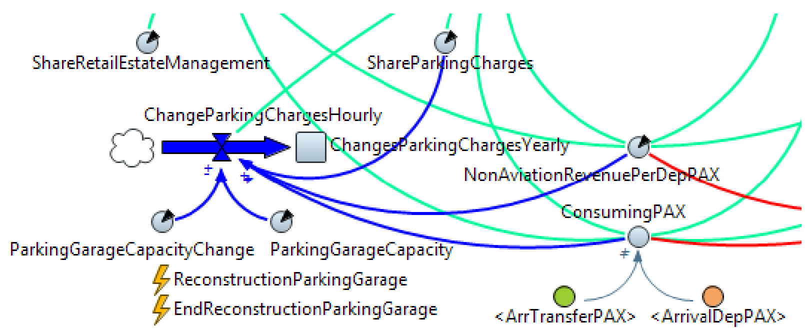

Figure 11. Scenario changes within the non-aviation revenues part.

[††††††] This share can be adjusted individually for any airport. If more detailed information is available, a restructuring would be possible.

Finally a change of the non-aviation revenue development per year is visible. Figure 12 shows the total non-avitaion revenues from the base year 2010 until 2029. The share of the parking charges (purple bars) decrease in 2013 by approximately EUR 1.4 million to EUR 13.4 million per year. After the reopening in 2015 the parking charges increase to EUR 17.7 million. The costs of the project, both investment and operating costs, are also considered. These cannot directly implemented in the model and, therefore, calculated separately by a profit and loss statement.

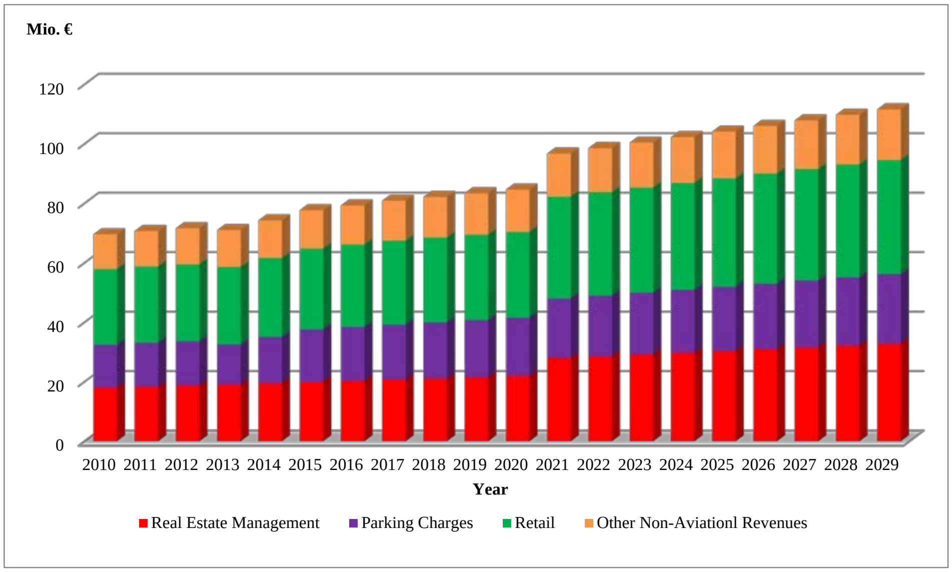

Figure 12. Non-aviation revenues - simulation results.

Due to a forecasted growth of passenger demand, the old terminals reach its capacity limit. Thus, the second project implemented in this szenario is a construction of a new terminal building, opening at the end of 2020. The new terminal has three more aircraft stands equipped with jet bridges and can handle 1,370 additional passengers per hour. Some effects can be seen in Fig. 12, too. The retail revenues (green bars) rise from EUR 28.8 million in 2020 to EUR 32.2 in 2021 due to the higher passenger volume per hour (mint green flow *RetailHourly* at Fig. 10). But also the passenger charges (mint green flow *PAXChargeHourly* at Fig. 9) will increase due to this project.

In summary, the model calculates for this scenario a non-aviation revenue increase from approx. EUR 70 million in 2010 to EUR 110 million in 2029 distinguished in four categories.

V. Conclusions

The paper's objective was to implement a generic airport model, which can be adjusted to different airports easily. The model covers the main activities at an airport. On the airside the A/C movements and restrictive capacities and on the landside the passenger/freight volumes are modeled. These "flows" are mainly responsible for the airport aviation revenues. Additionally the non-aviation revenues are estimated according to the yearly passenger volume. However, some elements of an airport are not considered yet. One of these elements is the connection to the landside transport system (intermodal transport). Within the model all passengers arrives a constant time before departure, although this varies very much[11]. Furthermore a direct connection between A/C movements and passenger numbers is not implemented yet due to a lack of data. If passenger numbers per A/C are available within the flight plan, the accuracy of the model can be increased.

In contrast to the revenues, the airport expenses cannot be assigned to individual "objects" like A/C or passengers in most cases. For example, the electricity expenses do not correlate with the current passenger volume inside the terminal. An assignment of personnel expenses is by far more difficult. Moreover these expenses change erratically or on a monthly/yearly basis (particularly balance items). Therefore the balance as well as profit and loss calculation is not accounted in the model at this point.

Regarding the modeling technique used, the biggest advantage of SD (AnyLogic) is the easy to handle graphic interface in most cases. The user does not necessarily need any detailed programming knowledge. Moreover SD is very useful to model passenger flows especially within an agent-based environment. On the other side, modelling an airport within a SD environment occur some difficulties, too. It is very complicated to implement integers. As mentioned before, this counteracts the philosophy of SD, which often leads to a complex and diverse variable structure. Furthermore there are difficulties to implement a “stop” of flows for a certain time span, which is absolutely needed for night curfews, overnight stays of passengers or waiting lines. The implementation so far, was not always practical. The model is not finalized yet and still some adjustments are needed.

In summary the implemented model is a useful tool to show the dynamics of A/C movements, number of passengers, capacities, infrastructure development and cash flows as well as forecasted growth factors. Thus, high-level long term decision-making can be supported.

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