INFO9017: Database for Management

Project : Digital Twin for a cargo airline

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1 Introduction

This report describes the project for the Database for management course. The final goal of this project is to elaborate a digital twin for a freight airline. The airline company represented in this work is *ASL Airlines Belgium* located at Liege airport. Furthermore, the objective is to create a follow-up of the activities of *ASL* for a manager. In a company's context of logistics and air freight transport, this involves the creation of a website with a dashboard, the analysis of KPIs and the design of a map of the airport of Liege with real time information over different assets of *ASL*. This site is intended to be a decision support for a manager at *ASL Airlines Belgium*

First, let's describe the company we are studying.*ASL Airlines Belgium* is established in 2016 following the purchase of *TNT Airways* in Belgium by *ASL Aviation Holdings* (*ASL Airlines Belgium* n.d.). *ASL Aviation Holdings* is a global aviation group in Ireland. Like *ASL Airlines*, the company works with cargo and passengers (*ASL Aviation Holdings* n.d.). The Belgian company is today the largest cargo airline in Belgium with a fleet of 36 aircraft including Boeing 737, Boeing 757 and Boeing 747 (*ASL Airlines Belgium* n.d.). Concerning the information about *ASL Airlines Belgium* during this project, they are mainly based on interviews done at Liege airport whether at *ASL Airlines Belgium* or at its collaborators like *Swissport*. Some information also comes from a thesis done last year by a student of Digital Business at *HEC Liege* and from research in books or on the internet.

To carry out this project, we will first define what a digital twin is. Secondly, the management issues will be specified. These questions allowed us to identify a problematic. Third, the conducted interviews at ASL Airlines will be presented as well as the gathered information about their activities in loading and unloading an aircraft. In this section of the report, there are the different sources studied as well as the business processes. Based on this information, a complete database is established. The entity-relationship and relationship models of this database are present in this section. The sixth part concerns the proposed solution with the implementation of a web site. Finally, considering the size of the project, recommendations and improvements are described.

2 Digital Twin

The goal of this project is to develop a digital twin. This aims at defining and describing what is a digital twin as well as what is its purpose.
Digital twin is quite a new concept and authors still try to develop a general definition of this term. The definition given by *Tonka and Schyns (2021)* define a digital twin as follow:

"A digital twin is a virtual replication of a physical entity (and its environment) which is completely synchronized with its counterpart thanks to the combination of a physical-to-virtual connection (physical metrology[1] *and virtual realisation‡) with a virtual-to-physical one (virtual metrology and physical realisation), and which can be used for various purposes as modelling, decision making, monitoring, optimizing, predicting, or even staff training."*

This definition is the result of a great deal of research and is itself based on a multitude of definitions developed by other researchers. We will therefore use this definition in this project. The definition above is made up of several key concepts. We first understand that we have a physical entity as well as a virtual entity that the second one should be a replication of the first. This implies fidelity between the model and the reality. Synchronization plays a key role in this concept and we see that connection between the two entities are present bidirectionally. Finally, another key aspect is the used of collected data in order to conduct some analysis and, in fine, develop tools such as decision making, optimizing, prediction, etc.

The benefits of a digital twin can be numerous. Indeed, using such a technology can bring many potential advantages. The collection of relevant data can transform this digital twin into a powerful management tool. This is indeed the goal of this project and many advantages will be described once the management question will be developed.

[1] Act of measuring the state of the physical/virtual entity

3 Management Question

The goal of this project is to develop a tool to answer the following managerial question:

Are the vehicles of the company ASL used efficiently ?

First, let's define properly what we mean by vehicles. This term is broad and it includes ground vehicles such as dollies, container loader, cargo tractors,... but also airplanes as well as ULDs. we therefore call vehicles all type of vehicle used for the service of an airplane and the airplanes themselves. In total, we counted more than 60 ground vehicles for Swissport and 300 dollies at Liège airport. Moreover, considering the size of the activities proposed in Liege by ASL Airlines, to carry out our project we decided to concentrate only on the activities concerning the arrival of an aircraft, its unloading as well as its loading and its possible maintenance.

The management question addressed in this project is quite vague and that is why it is accompanied by several sub-questions. To determine if a vehicle is used efficiently and is working properly, we focus on several categories.
The first one is maintenance. A sub-question is therefore "Do some vehicles go in maintenance more often than others?" Maintenance can be either for ground vehicle as well as airplanes. Having a proper tool that transform data into information could provide a good management tool to managers and employees. Indeed, noticing that a new vehicle is quite often in maintenance could point to a manufacturing defect. On the other hand, an old vehicle that also goes to often in maintenance might means that a new one must be bought if maintenance cost is too high.

A second category is time. Where the vehicles are at any time? This question might help a manager to locate a lost vehicle. It could also help him identify the path a vehicle takes quite regularly and determine a more optimal way of working. A problem faced by ASL is that other companies inside the airport take ASL's vehicles as their own. The cost of such practices is high for ASL and knowing exactly the localisation of every vehicles is a necessity. An ASL employee reported another problem. Some employees have to go to the parking place of an aircraft to check if the draining of the aircraft is done well before cleaning it. This is a waste of time for the staff.

The third and final category is operations. Which of the vehicles are used in specific operations such as a plane taking off or arriving? This helps the manager to first define properly all vehicles that will be necessary when a planes arrives or is taking off. The tool might help the employee to determine which of the vehicles it is best to assign based on the location of this vehicle, as well as knowing if this vehicle is already assigned to another flight happening at the same time.

To conclude, multiple management tasks might benefit from such a tool. The question "Are the resources well used ?" is a central aspect in a company regardless of its sector and size.

4 BPMN

This section describes the Business Process Model and Notation for the unloading and loading of an *ASL Airlines Belgium* 's aircraft. First, the stakeholders will be described as well as the resources. Then, the different steps of the business process will be covered.

4.1 Resources for the business process

4.1.1 Stakeholders

Concerning the stakeholders, *ASL Airlines Belgium*, located at Liege Airport, works with cargo and passengers' networks with a fleet of 36 aircrafts. In the case studied, the analysis is based on the cargo airline. For the business process, *ASL* load masters study the loading of the aircraft to ensure its balance. The second stakeholder is *Swissport*. *Swissport* prepares the freight and takes care of the ground operations. They provide most of the vehicles used in the process as well as most of the human resources. As for *Liege airport*, it is involved in directing the plane towards its parking place or to provide the truck to fill the plane with fuel. *XL Group* takes care of cleaning and emptying the aircraft. Finally, the daily check of maintenance is provided by *KLM*.

4.1.2 Resources

As far as resources are concerned, a unit load device (ULD) is a term used in air transport to define a unit of cargo to be transported for both passenger and cargo transport. There are two types of ULDs: containers and pallet/net combinations (VRR n.d.). Then, it is important to know that as soon as a ULD has left the *Swissport* warehouse it no longer touches the ground. Indeed, the movement of the ULDs is done thanks to platforms equipped with wheels. The floor of the aircraft is also equipped with wheels. It will be enough to push the ULDs to move them.

The number of motorized vehicles working on the runway and belonging to *Swissport* is 60. They are mainly used for loading and unloading. *Swissport* also has about 300 dollies at *Liege airport*. It is necessary so that each vehicle at *Swissport* has a registration number beginning with *SCS* followed by numbers.

For the vehicles used to move the ULDs, there is the main deck loader, the low deck loader, the belt loader, the speed loader and the dollies. The main deck loader and the low deck loader are similar. They are used to load or unload containers or pallets from the aircraft. According to the definition given by PlanetGSE n.d.(b), the vehicle is built to have two platforms that can go up or down independently. The main deck loader (Appendix A.1) is used for the main desk, as described in its name and the lower deck loader is for narrower parts of the aircraft such as the cargo hold (PlanetGSE n.d.(b)). The belt loader is used to unload or load luggage from the aircraft. Indeed,

with this vehicle, we have a principle of bulk loading. Indeed, the luggage is not in containers (PlanetGSE n.d.(a)). At Swissport, an employee informed us that they use a main deck loader, a lower deck loader and a belt loader for unloading.

Furthermore, there is some speed loaders (Appendix A.2) to move ULDs from deck loaders to dollies and vice versa. For the process of loading and unloading, *Swissport* employees use three speed loaders. As for the dollies, this is trailer on which ULDs are placed. *Swissport* has at least 300 of them, but there is a real problem with these dollies. Indeed, there is still no follow-up of these vehicles and they can end up on paying parking areas or be used by *Swissport*'s competitors. There are two types of dollies used in our case: 10-feet dollies (Appendix A.3) or 20-feet dollies (Appendix A.4) depending on the size and weight of the goods. There will be 40 10ft dollies and some 20ft dollies depending on the weight and size of the cargo. Cargo tractor units (Appendix A.5) can take a maximum of four 10ft dollies and move them. During the process, the *Swissport* operators use two cargo tractor units.

Concerning the fuel, at *Liege airport* on the *Swissport* side (north side of the airport) there are pipelines in the ground and a refueler (Appendix A.6) comes to connect the pipelines and the wings of the plane to fill in fuel. On the south side of the airport, there are no pipelines and it is a tanker truck that comes to refuel the planes.The Liege airport is responsible for this operation.

For the cleaning, the toilet car (Appendix A.7) will come under the aircraft to carry out the draining of the aircraft. After the emptying, the disinfection of the cockpit and the toilets takes place with a *XL Group* van (Appendix A.8).

Finally, there are resources that do not need to be described in detail. To get to the parking place, the plane follows a car of the *Liege airport* called the FOLLOW ME car. The management of this vehicle is done by the airport of Liege. For the process when the plane is stopped, wheel chocks and stairs are used around the plane as well as a ground power unit. And as explained in the description of the stakeholders, the daily maintenance is done by *KLM*. They come with a van to do their maintenance.

4.2 Business process steps

This section describes three Business Process Models. First, the operations performed before the aircraft lands as well as its landing are described. The second BPMN describes the operations done for the unloading of the aircraft. Finally, the third part is dedicated to the loading until the aircraft takes off.

4.2.1 Landing

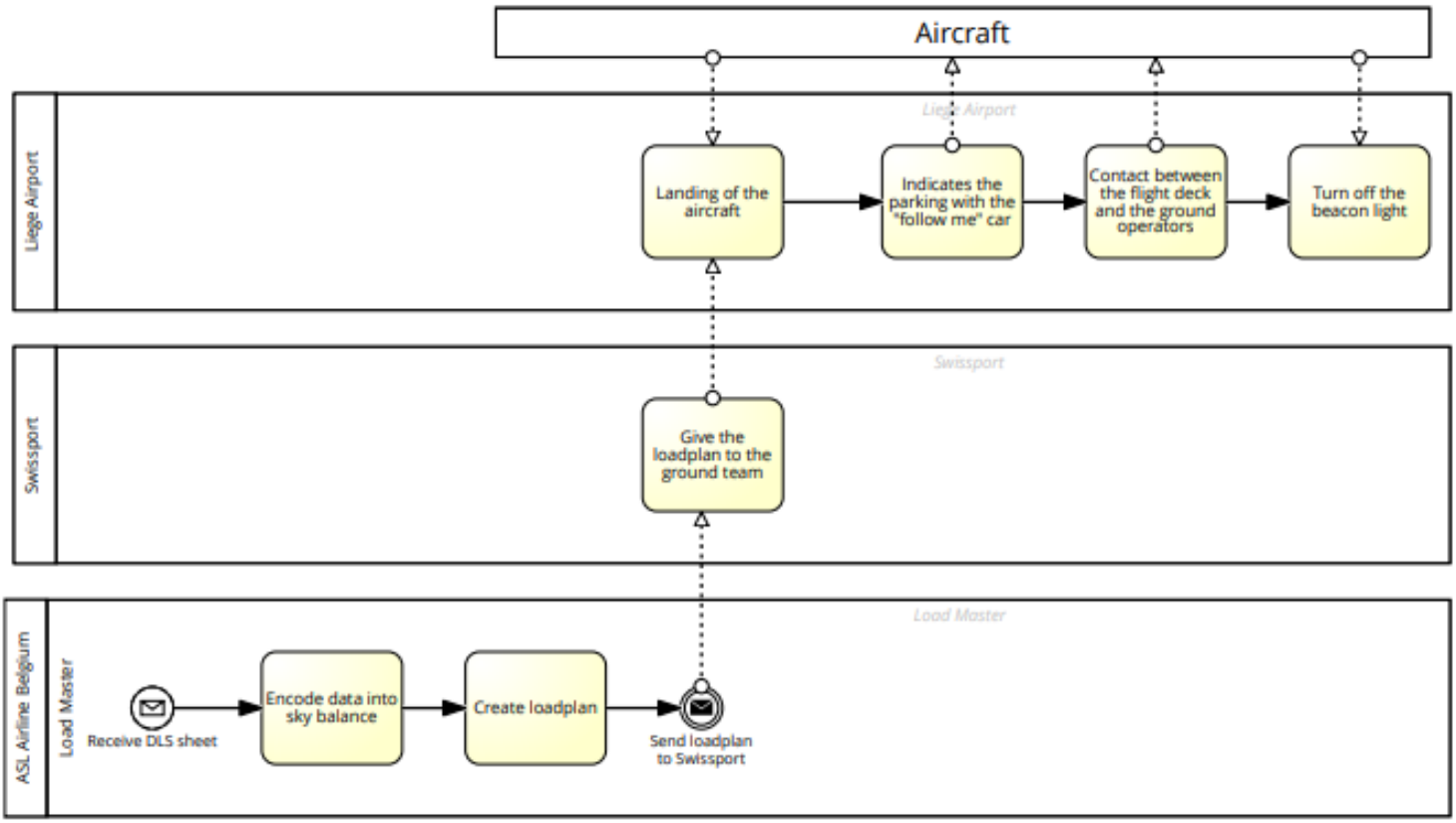


Figure 1: BPMN for landing at Liege Airport

First of all, for the landing three actors are present: *Liege Airport*, *Swissport* and *ASL Airlines Belgium*. The main resource is the landing aircraft. Load masters can work for *Swissport* or for *ASLB*. In this case, the load masters are employees of *ASLB*. As soon as the DLS sheet is received, the business process starts. The DLS sheet lists the freight that will be loaded on the aircraft. It contains information such as the weight of the ULDs, their size and their ID number (*Master Thesis Denef Louise* 2020-2021). From this document, the load masters can enter the data into *Sky Balance*. This system of information allows them to have a visualization of the aircraft and the possible positions for the ULDs. Their goal is to make a load plan from this. The load plan defines the positions of the ULDs in the aircraft according to their weight, the weight of the pilots, and the stops that the aircraft must make while keeping the center of gravity of the aircraft correctly positioned. The load plan is then transmitted to *Swissport* which distributed it to the ground operators. With the load plan, the ground operators know which type and in what quantity of dollies used.

As the plane lands, *Liege Airport* operators guide the plane to its parking spot. In the case studied, there is no difference between a Boeing 737 and a 747, but there are differences in terms of the materials used (different types of dollies or ULDs). Also the amount of freight loaded in the plane is different. The pilot of the aircraft knows his location in advance but there may be last minute changes. That's why the "follow me" car guides him to his parking spot where the vehicles are placed around the parking spot. Finally, the unloading starts as soon as the beacon light of the aircraft is switched off.

4.2.2 Unloading

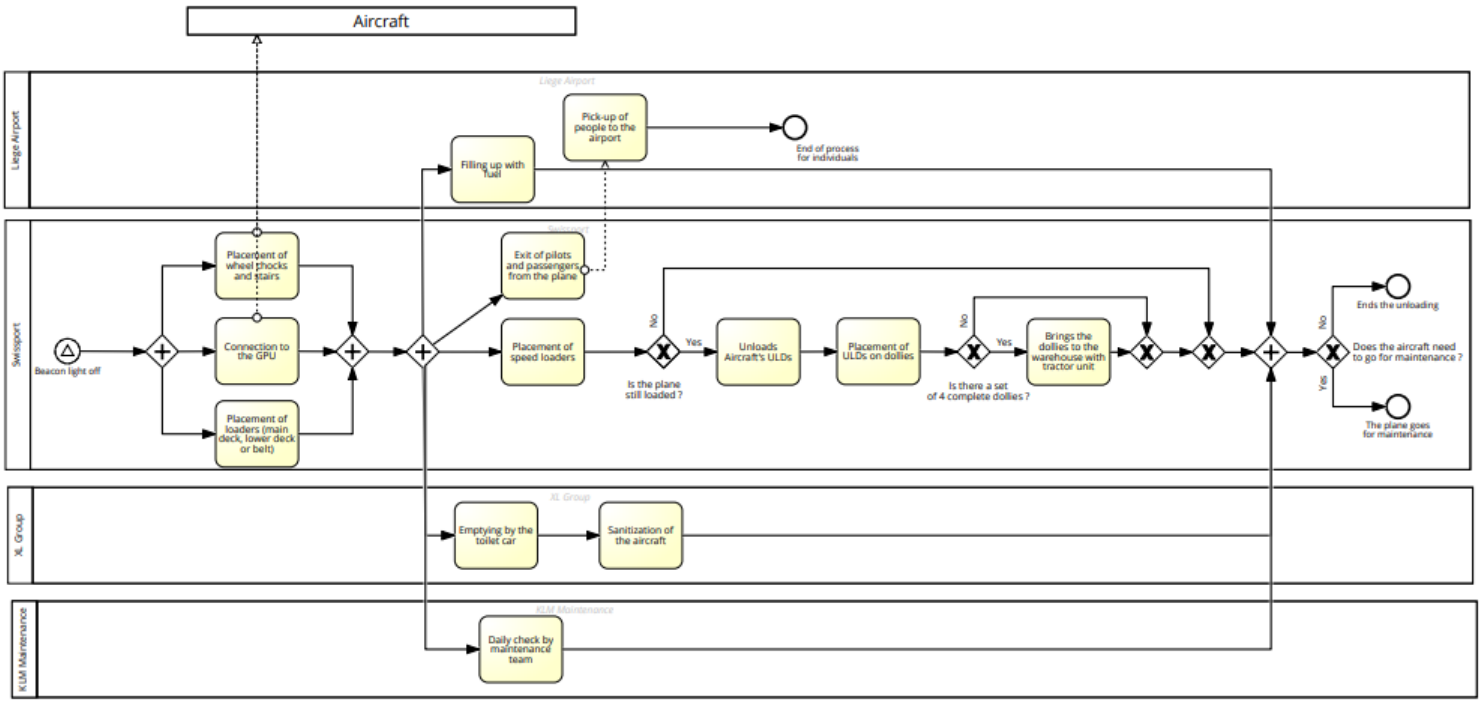


Figure 2: BPMN for unloading the aircraft

During the unloading of the *ASL Airlines Belgium* aircraft, three main actors are present: *Swissport*, *XL Group* and *KLM Maintenance*. Several actions are done at the same time.

First of all, there is the placement of the wheel chocks and stairs, the placement of the different loaders and the connection to the Ground Power Unit.

Then, a truck from *Liege airport* comes to connect the fuel pipelines from the runway to the plane to fill it with fuel. If there are no pipelines, a tanker truck comes to refuel. The pilots and any passengers get off the plane. A airport van picks them up to leave the runway. As for the *XL Group* employees, they have two sequential actions to do: drain

the waste water and clean the inside of the plane (cockpit, toilets, passenger seats). A truck from *KLM Maintenance* also comes to do a daily check-up of the aircraft. The *Swissport* operators push the ULDs from the main deck to the first platform of the high loader. The ULD is then pushed to the second platform of the high loader which acts as an elevator. The speed loaders are placed next to the high loader. They wait for an operator to direct the ULDs onto the speed loaders. Once on it, the speed loaders roll and stand in front of a dolly to move the ULD on it. Once 4 dollies are filled, a dolly tractor transports them to the warehouse.

The fueling, cleaning and maintenance actions are completed as time goes on. It is then time to move on to loading the aircraft unless it is to be moved to maintenance.

4.2.3 Loading and take-off

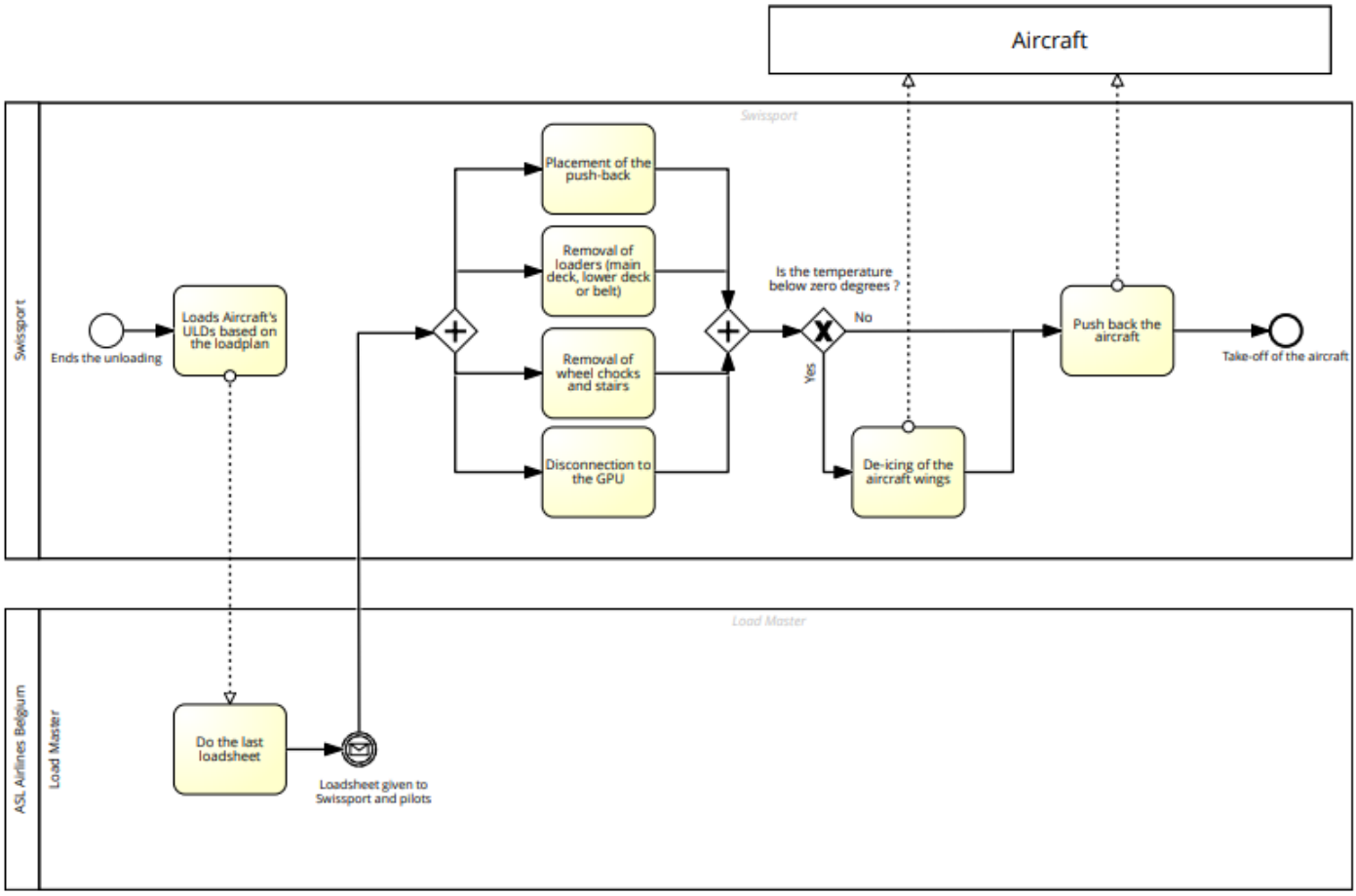


Figure 3: BPMN for loading the aircraft and the take-off

The two actors present during the last business process are *Swissport* for the loading of the aircraft and the *ASLB* load masters for the creation of the last load plan. The operators load the ULDs into the aircraft using vehicles (speed loaders, main deck loader, lower deck loader) according to the plan given at the beginning of the process by the load masters. The ULDs arrive by 4 on dollies pulled by a cargo tractor. Once the aircraft is fully loaded, the load master makes the final checks and distributes the load plan to the *Swissport* employees and the pilots. After that, four operations are done in parallel: removal of stairs and chocks, disconnection to the ground power unit, removal of the main deck loader, lower deck loader and finally the placement of the push-back vehicle. If the temperature is below zero degrees, the aircraft must be de-iced and can only take off after de-icing. The last step is the take-off of the aircraft from *Liege airport*.

5 Creation of the database

To create the database for the parts of the digital twin, we had first to familiarize ourselves over *ASL Airlines Belgium* and its activities. This was done as previously mentioned by researching information about the processes. Therefore, it is time to justify our choices concerning the database used. The purpose of our database is to provide data to our website and thus to answer management questions concerning *ASLB*.

First of all, in relation to the business process, the aircraft are stored in the database. The planes can be defined by a type like Boeing 737 or Boeing 747. The capacity of the aircraft and its maximum fuel level are modified according to the type. It is assumed that the aircraft are tracked in real time. So, the aircraft has a latitude and a longitude at a specified time date in our database. As an activity for the aircraft, we only focus on the maintenance or the flight of the aircraft.

For maintenance, the status of the maintenance, the start and end date must be recorded. The status could be : not yet started, warning, in progress or completed. We did not get more information about the maintenance process of an aircraft at *ASL*. That's why we have so little information about it in the database.

Then, an aircraft can make a flight. A flight is defined by departure and arrival times (scheduled and observed) and a load plan for the placement of ULDs. A flight also has a departure and arrival airport and a gate for *Liege airport*. Furthermore, an airport is defined by IATA code, a name and its geographical coordinates. When a plane arrives at the airport, a number of vehicles are needed. Following our question of material management, we have put an assumption that each vehicle has a GPS tracker with its position updated every 15 minutes. *Swisspport* has a lot of vehicles defined by a matriculation number. The type of vehicle can be: a speed loader, a main deck loader, a lower deck loader, a toilet car, refueling, lavatory service, ...

In the database, the ULDs are defined by a code and have a name related to their size (height x width x length and volume in cubic meter) with their empty weight. These ULDs contain goods and are tracked in real time. The order pickers define the weight of the goods, if it is considered a secured good, the label of the goods and its final destination. The goods will then be linked to a flight. All this specifies the content of our database.

Below are our entity-relationship models and our relationship model.

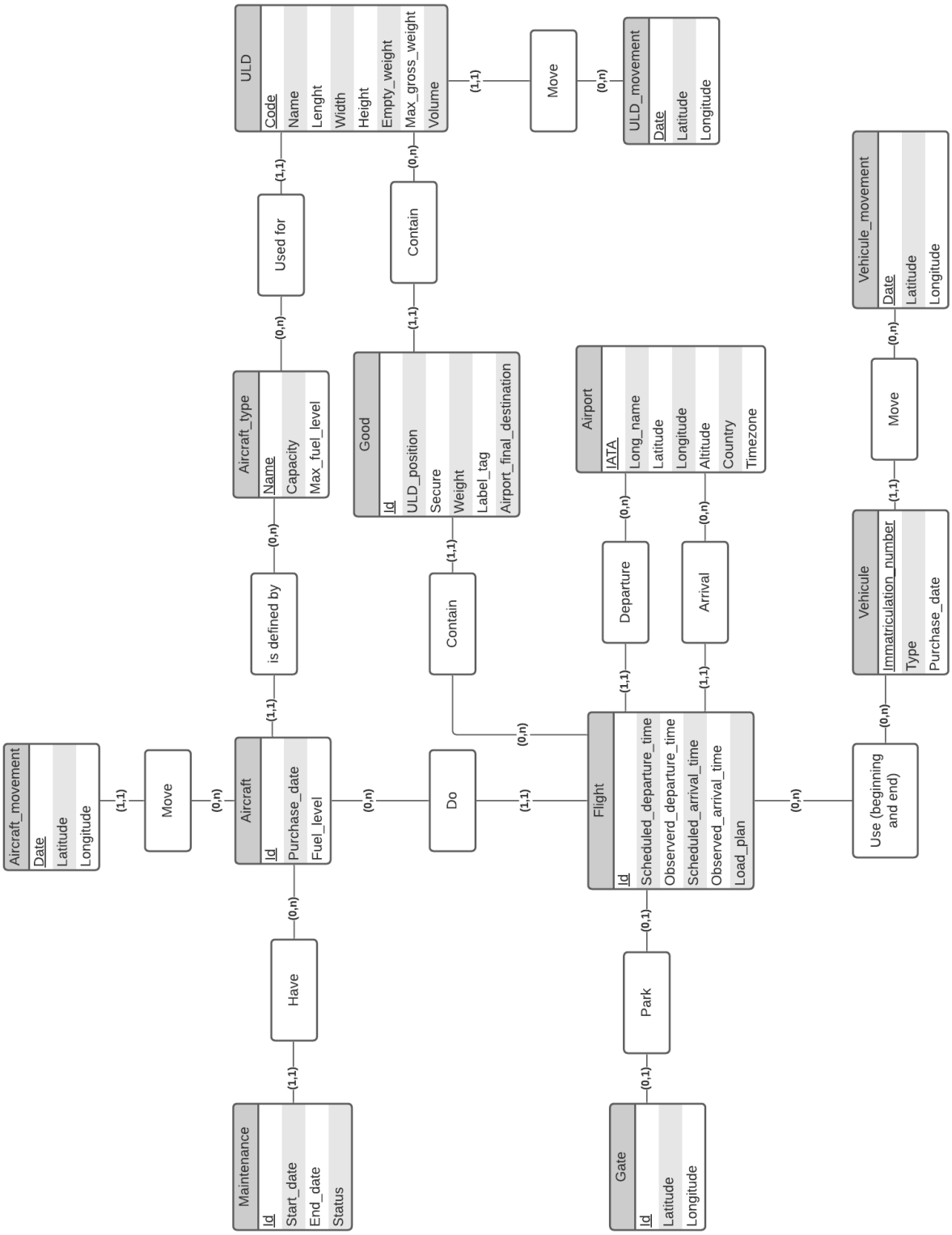


Figure 4: Entity–relationship model

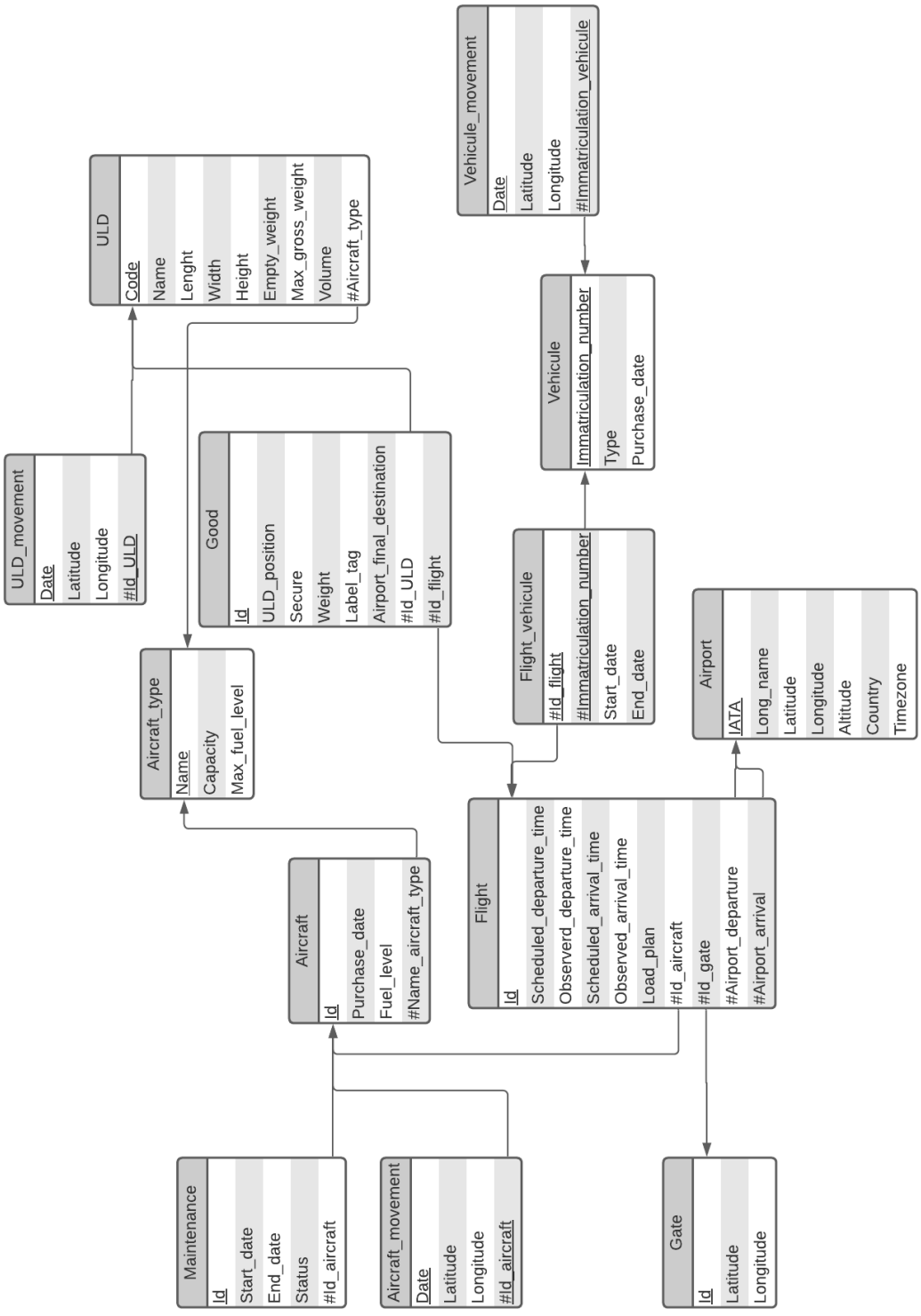


Figure 5: Relationship model

6 Implementation of the site

The management question is well answered through our website interface, its data shown and its KPIs. For instance, to know where our vehicles are located, our website has a map tab in which we are able to see where a specific vehicle is and was at a specified time. We have made an assumption that each vehicle is equipped with a tracker which sends its GPS position to the database every 15 minutes. Thus we are able to see if a vehicle never moves, or on the contrary is always active which can inform us about the use of this vehicle. This helps to answer the management question in a visual representation instead of more conventional numbers. Indeed, we are able to see if a vehicle has not moved for a while, or on the contrary it moves a lot which would mean it used efficiently. Then, we are also able to see which path a vehicle takes when the loading/unloading process of an airplane happens.

Then we also have an activity log tab in which we can see which flights arrived and departed from Liege, and also the maintenance made. Then if you want more information about a flight, there is a table for the flights in which you can not only see all the flights flown but also a flight in detail. This means that you can see which vehicles has worked on a flight, which aircraft was used, what were the scheduled and real departures and arrivals, and its load plan. Moreover, if the flight has not departed yet, you can see if the flight misses vehicles to work properly and which vehicles it misses. Furthermore, in the case a flight misses some vehicles, an option is proposed to see which vehicles could be assigned to the flight. This, moreover, helps to know which aircraft often fly, if it is often in maintenance, if it often delayed, etc. This helps to answer the management question by showing us information about the flights and maintenance. Indeed, we are able to see if a plane flies a lot, if it is always in maintenance and for other vehicles if it is always the same vehicles used to work on flights. This helps us to know which vehicles are often used or planes which often go in maintenance and thus if they are used efficiently.

In addition to the flight table mentioned just above, there is also an aircraft table which put more the emphasis on the aircraft themselves. In this table, we are able to see all the aircraft of *ASL*, when they were purchased, what was their last maintenance and on which date it was. We can also a view over how many aircraft are in maintenance and in flight. Then, if we look into an aircraft details, we can see which flight it has done and all the information linked to it (departure and arrival times, vehicles used, ...) and also an history all the maintenance it has gone through. Thus it helps answering the management question, especially the sub-question if a vehicle goes too much in maintenance and if it often used for flights and thus if it used efficiently.

After that, we have also added a maintenance table where we are able to see all the maintenance and on which aircraft they will be on, their schedules and what their status is (not yet started, in progress, completed and warning). This table helps especially by answering the first management sub-question. Indeed, this table gives us the ability to

see if there is a vehicle that goes in maintenance too often.

Furthermore, we also added a vehicle table in which we can see all the vehicles *ASL* owns. We can see their matriculation number, type, purchase date and on which aircraft they have worked on and when. This helps us more understand which vehicle did what, on which airplane and when it did it. This tab helps answering the management question because we are able, thanks to it, to know information about a vehicles such as if it goes often into maintenance, if it works often or not thus if it used efficiently and finally on which flights has it been used. In conclusion, if this vehicles is used efficiently or is it sparsely used.

Finally, we found it was interesting to add a table for the ULDs because although it is not a vehicle, it is a core part of the process in *ASL*'s Business. In it we can find all the ULDs *ASL* owns, their identification code, dimensions, how much weight they can hold in and which aircraft they are supposed to go in. Moreover, if we go into detail of one ULD, we can see which flight it has done with what goods it has transported, how heavy it was and all other interesting information. In conclusion, this table gives the same level of details and information as in the vehicle table but for the ULDs which is relevant as an inefficient use of ULDs is also a cost for the company.

6.1 Possible improvements

The tool we designed can be seen as a prototype of a much bigger solution. Indeed, we developed a technical solution that already provides good information and enables better management tasks but multiple features could be added to transform it into the best tool to answer to our management question.

To begin with, in order to work on this project, we had to make a few assumptions such as not taking into considerations the HR. Indeed, we assume that workers on the airport grounds use the vehicles and are maybe separated in several teams. It could be interesting to add in the future a feature in order to better manage who is in charge of which vehicles or task. A problem that could occur with our current tool is the fact that a vehicle needs to be moved to a certain location to handle a specific operation but no one is available at the time to make this operation. Having knowledge of team's location and other factors might resolve the problem.

Moreover, we also solely focused on the observation and analysis of the activities of the company. For instance, the user of the website could see which vehicles a flight misses and see which vehicles could be used but he cannot add a vehicle to a flight. The ability of write on the database is not currently available for the user and it would certainly be an interesting feature for further development.

An alert system would also be beneficial for this project. Pointing out a vehicle that has not moved since a long time, or a vehicle that has magically moved to the hangar of another company, would be a quite important component of the program. Alerting the company that a late vehicle could lead to a delay for a flight would also be a nice idea with this alert system. The price of a delayed flight is indeed extremely expensive as stated by a load master during one of the interviews at ASL.

Finally, a much bigger program might handle other management question and transform the software into an entire ERP. This would need to be integrated with other programs of the company and would certainly be costly but efficient.

7 Conclusion

To conclude this report of our work, we can say that the activities of *ASL Airlines Belgium* are quite complex as one can imagine. However, it was really interesting to work on a project which is real-life based as we could see the complexity and limitations of real life problems. Having one our team member making an internship in this company provides us real information about the processes and the In the end, as previously mentioned above, we had to make assumptions and limit our scope of work on a particular domain and answer one question of management. At the end of this project, we think we have quite well answered this question with our database and its interface through a website although we are aware that we had to make assumptions. However, if we wanted to be exhaustive, this would require much more time as the problem is really intricate.

Most importantly, we learned an important lesson that for example, a business analyst might definitely need. Indeed, at the beginning of the project, we too quickly went through the management question and directly started to define the structure of the database as well as to start the development of the website. We therefore tried to imagine a technical solution before even properly identifying the management problem to be solved. After weeks of work, we realized during the first discussion with the professor that this central part of defining the management question was not made properly. We almost started again from scratch and it took us several weeks to define, this time, the problem we wanted to address. This important lesson had already been learned theoretically in the innovation course, but the difference this time it is that we experienced it through a real project. Although it was, admittedly, rather unpleasant to start a large part of the project over again, we truly learned the lesson from this experience.

Finally, thanks to this project and the course, we also learned how to define a problem with an associated managerial question, how to design a database which will help us in answering this question, and finally how to make an interface which is not only coherent with the database and the problem but also easy to use. It was really nice and interesting to have the opportunity to work on something which is more concrete and close to reality.

A Appendix

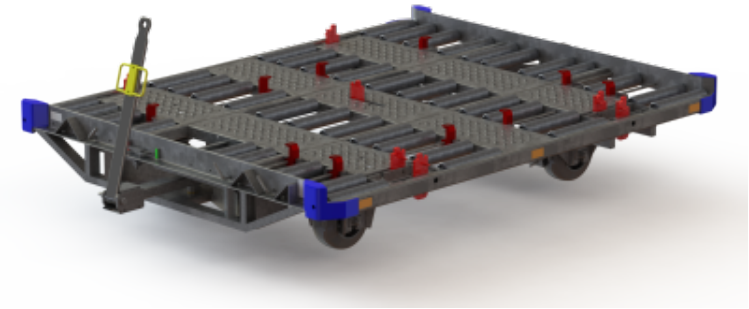
A.1 Main deck loader

Sinfonia. (n.d.). Main Deck Loader. Retrieved December 9, 2021 from Sinfonia: https://www.sinfo-t.jp/eng/product_info/gse/main.htm

A.2 Speed loader

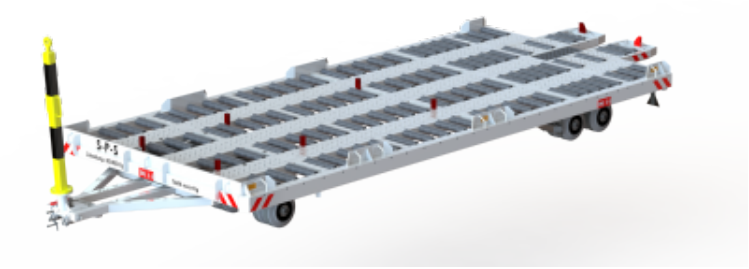
Picture taken at ASL Airlines at Liege Airport by Elisa Etienne. (November 29, 2021)

A.3 Dollies 10ft



S-P-S. (n.d.). S-P-S 10FT Dollies. Retrieved December 9, 2021 from S-P-S: https://www.s-p-s.aero/products/10-ft-dollies/

A.4 Dollies 20ft



S-P-S. (n.d.). S-P-S 20FT Dollies. Retrieved December 9, 2021 from S-P-S: https://www.s-p-s.aero/products/20-ft-dollies/

A.5 Cargo Tractor Unit

eMove 360. (07.2018.).Fully electrical baggage and cargo tow tractor "SHERPA" E. Retrieved December 9, 2021 from eMove360: https://www.emove360.com/fully-electrical-baggage-and-c

A.6 Refueler

Picture taken at ASL Airlines at Liege Airport by Elisa Etienne. (November 29, 2021)

A.7 Toilet Car

Picture taken at ASL Airlines at Liege Airport by Elisa Etienne. (November 29, 2021)

A.8 Sanitizing Truck

Picture taken at ASL Airlines at Liege Airport by Elisa Etienne. (November 29, 2021)

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