Developing a decision-support-tool for an air taxi service

A research proposal to develop a decision support tool to analyze an air taxi service on strategic and operational level

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***Abstract*—this paper is a research proposal to develop a tool to analyze logistic concepts of the air taxi service of Aeolus Aviation in different scenarios. Based on this analysis recommendations can be done for a suitable logistic concept for Aeolus. Based on background analysis of the air taxi service three objectives are formulated; analyzing the air taxi service on strategic level, developing a decision support tool to analyze logistic concepts and finally developing a suitable logistic concept for Aeolus Aviation. Based on these objective research questions are formulated and research methods to answer these questions are given.**

Keywords-component; Air taxi, complexity, Research proposal, decision support tool, simulation

I. INTRODUCTION

Business travelers are more and more concerned of efficient flying. When time and money can be saved when traveling, value is added to their business processes. Recent events in the aviation have not made it easy to gain efficiency. For example the security measures after 9/11 have increased airport congestion. But also the congestion on the road decreases the efficiency of traveling. These developments point to an increase demand for efficient and low cost means of ad hoc point to point transportation.

Aeolus Aviation will provide efficient traveling solutions in Western Europe, adding value to customer processes. Where competitors focus on luxury, Aeolus has a more no-nonsense approach: cost and time efficiency. In this effort Aeolus will continuously attempt to improve efficiency and accurately match capacity with demand. The main goals are to develop an air taxi service, which has the lowest price and travel time and the highest profit. Because many factors are still unknown it is hard to develop an optimal logistic concept of the air taxi service. A logistic concept of an air taxi service is a certain service concept providing transport between selected airports influenced by a certain schedule for the crew, a certain price structure, a certain amount of aircrafts with maintenance schedule and a certain location of a maintenance base. To find a suitable logistic concept for the air taxi service of Aeolus a decision support tool can be built to analyze the logistic concepts. First the air taxi service of Aeolus Aviation will be strategically analyzed. What are the potential customers? Where are those customers? And what are the competitors? Secondly on operational level a tool will be developed to analyze logistic concepts of the air taxi service. When this tool is developed logistic concepts will be developed and tested to come up with a suitable concept for the air taxi service.

In the next chapter the background of the purposed air taxi service of Aeolus Aviation will be analyzed. In the last chapter the research project will be discussed. Based on the background analysis the research objectives will be formulated. Next the main research question and the respective definitions will be described. Based on the research objectives and the main research question a research approach is developed. Finally the research methods and planning will be discussed.

II. BACKGROUND ANALYSIS

This paper is a project proposal of the logistic concepts of the air taxi service of Aeolus Aviation. To get a better view of the background of an air taxi service in paragraph A the air taxi concept in general and the advantages and disadvantages will be discussed. In paragraph B the complexity of operating an air taxi service will be elaborated to get insight into the factors influencing the air taxi service. In paragraph C Aeolus Aviation and their plans will be discussed.

A. The air taxi service concept

To get a better idea of an air taxi service, in this paragraph the air taxi service concept will be discussed. First the concept of the air taxi service will be described; next the strengths,

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weaknesses, opportunities and threats will be analyzed by means of a SWOT analysis.

The demand for air travel is increasing [1]. This larger flow of passengers combined with more strict security measures results in congestions at the major airports, resulting in irritations of business travelers[2]. But on the road an increase of congestion is remarked as well and transport by rail only reaches the bigger cities. A solution for these developments is an air taxi service: on demand point to point business aviation for short distances. This air taxi service results in shorter waiting times at airports, the possibility of choosing the departure time, pick up and deliver at an airport closer to the destination. To achieve this, a large amount of smaller, 10-200, aircrafts will be used to fulfill the demand. Such aircrafts are: the new very light jets, piston and propeller aircrafts. These aircrafts can normally carry 4 to 6 persons, as a shared flight or for a group, can be operated just by one pilot, depending on the type of aircraft, and can land on smaller airports than bigger planes. They are cheap in comparison with current similar jets and have lower operating costs, due to the lower fuel consumption [3]. With significant lower costs than the current unscheduled air service operators, these new air taxi operators promise to provide low fare on-demand personal transportation. The concept of an air taxi is born.

To get a better view of the positive and negative sides of an air taxi service in table 1 an SWOT analysis is shown. In a SWOT analysis the strengths, weaknesses, opportunities and threats are analyzed. The strengths of air taxi services are the efficient and lower door-to-door travel time, its reliability and its personalized way of transport. The efficient and lower door-to-door travel time is the result of the possibility to use a wider set of airports. When using a wider set of airports it is possible to use uncongested, smaller airports closer to the customer's door. The difference in travel time will even become larger when the capacity crisis at general airports will generate more delays. An air taxi service is more reliable because the amount of delays will be lower.[4] The personalized way of transport by an air taxi is a strength as well. Customers can choose their own trip and are not depended of other customers. Weaknesses are the complexity, which can cause inefficiency for an air taxi service company [5] and the price of a ticket, which is still higher than the price of scheduled flights. The complexity of an air taxi service will be discussed in the next paragraph. Another weakness is the dependency on the weather and daylight. For example, according to JAR OPS 1 a single engine propeller aircraft cannot fly when the visual range is low, for example in bad weather or at night. JAR OPS 1 is the Joint Aviation Requirement for the operation of commercial air transport (aero planes). Any commercial airline within the European Union flying jet or propeller aircraft has to comply with this standard. The opportunities of an air taxi service are the better affordability for customer in comparison to current comparable services. The better affordability, in comparison to the past, is the result of the lower acquisition and operating costs, lower airport landing fees, but also the result of operational efficiencies. Other opportunities for the success of an air taxi service arise when the congestion on the road and at the airport increases and the demand for efficient flying increases as well. Another opportunity is the decreasing of the strictness of regulations in Europe. This will result in lower costs and more possibilities. The threats are congestion in the air. When more airlines will provide in air taxi flight, more aircrafts will be in the air, which can cause delays. Another threat is the possible safety problems. When more aircrafts are in the sky, the sky will become busier and less safe. Another threat is the entrance in the market of large scheduled airlines. Differentiation of those airlines will be a threat because those airlines will have a large budget. Finally ageing of the present pilots and more upcoming airlines can result in a scarcity of pilots in the future.

TABLE I. SWOT ANALYSIS OF AIR TAXI SERVICE

Strengths	**Opportunities**
Efficient and lower travel time	Lower price for customer
Reliable for customer	Increased airport congestion
Personalized transport	Increased road congestion
	Decreasing strictness regulations
Weaknesses	**Threats**
Complexity for Aeolus	Congestion in the air
Higher price than scheduled service	Safety problems
Depending on weather/ daylight	Entrance in market of air taxi services by large scheduled airlines
	Forecasted scarcity of pilots

B. Complexity of an air taxi service

As mentioned in the previous paragraph the air taxi service business is complex, which can cause inefficiencies for the air taxi airlines. In this paragraph the complexity will be elaborated to get a better view of the aspects influencing the air taxi service. This complexity can be divided into three levels: strategic, tactic and operation. Figure 2.2 [6] is based on the flight schedule development process of scheduled airlines of Bootsma and is adapted to the air taxi service of Aeolus. In Figure 2.2 left the general process of planning is shown for each level. As shown on strategic level the market will be analyzed to end up in a plan. In the case of a scheduled flight on tactical level the flight schedule will be developed. On operational level that schedule will be executed. For an air taxi service the tactical level can be combined with operational level because the activities on tactical level of a scheduled service happens during the operational level of an air taxi service, because there is no schedule. In figure 2.2 on the right the process of an air taxi service is presented. On strategic level the service concept, existing out of service between different airports, and fleet planning will be developed and on operational level this service concept of the air taxi will be

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executed. First the complexity on strategic level will be described, second the complexity on operational level will be discussed.

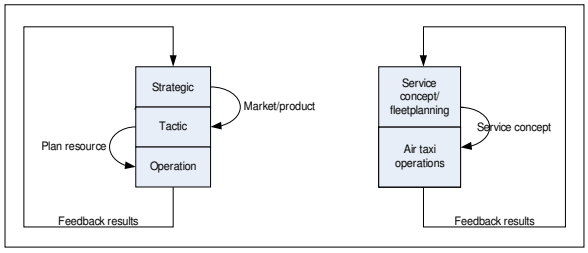

Figure 1. Flight schedule development of scheduled airline

1) Complexity on strategic level

In this sub-paragraph the complexity of an air taxi service on strategic level will be discussed, based on the strategic activities of an air taxi. First the complexity of the demand will be described, next the complexity of the airports will be discussed and finally the complexity of revenue management of an air taxi service airline will be discussed.

a) Complexity of demand

The first factor influencing the complexity is forecasting the demand of on demand air taxi flights. Analyzing the demand for an air taxi service is different than in the case of a scheduled service. First of all the demand for scheduled flight is larger than for air taxi services. Second for scheduled services the fulfillment of travel requests are driven by the supply in terms of the amount of seats on given airline network mostly defines months ago. The demand for air taxi service is driven by individual demand. The passenger can determine the origin, destination and earliest departure time and latest arrival time without being constrained by flight schedules.[7] The individual demand of an airport is hard to determine, because it is very insecure. To make a strategic choice regarding the environment of the air taxi service, the market for air taxi services is based on [8]:

- *Type of potential clients:*
- *Origin and destinations of potential clients*
- *Competitors*

b) Complexity of airports

The complexity of the airports is determined by the constraints of the operated airports. Constraints of airports are:

- *Closing times*
- *Accessibility*
- *Runway length*
- *Fueling possibilities*
- *Landing fees*
- *Other regulations*

Partners are playing a part as well. When developing a door to door service, cooperation with other transport services is needed. Therefore more partners need to be considered when developing an air taxi service.

c) Complexity of service concepts

A service concept of an air taxi service consists of a set of airports with the constraints belonging to those airports and a transport service transporting the passengers by aircraft. The service concept of an air taxi service is complex because an air taxi aircraft flies not often the same route twice consecutively and generates less there and back traffic than scheduled flights: it is a more unbalanced network. It will be unlikely that the arrival airport of a revenue flight corresponds to the departure airport of other revenue flights. Therefore non revenue flights, also called repositioning flights, must exist to connect the destination airport of one revenue flight to the departure airport of the next revenue flight operated by the same aircraft. Because repositioning flights are only generating costs and no revenue and so have influence on the ticket price these repositioning flights needs to be minimized [9]. Several network structures can be developed. Examples of structures are:

- *Shuttles between airports with a high stable demand*
- *Operating a large amount of airports in Western Europe*
- *Operating a limited amount of airports in Western Europe with a high demand*

d) Complexity of ticket pricing

When determine the price of a ticket for an air taxi flight several techniques are possible:[10]

- *Ticket price based on fixed costs per mile*
- *Ticket price based on forecasted demand (revenue management scheduled service))*
- *Ticket price based on true costs per action plus profit margin (revenue management air taxi service)*

Revenue management techniques are techniques to optimize the revenue earned from a fixed, perishable resource. The challenge is to sell the right resources to the right customer at the right time[11]. The demand for scheduled flight is known earlier and can be used easier for pricing of tickets. Revenue management for air taxi flights can be compared with the ticket pricing technique based on true costs per action plus profit margin depends more on the demand at other airports and than for scheduled flights. When implementing revenue management for air taxi service it is important to know the demand on other days and at other airports to minimize repositioning flights. For example when is known that tomorrow the demand at airport b will be large and today it isn't and the customer wants to go from airport a to b, Aeolus can increase the price, because the chance of a repositioning flight is big, or the customer can be advised to

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travel a day later for a cheaper price. These options need to be considered.

2) Complexity on operational level

In this sub-paragraph the complexity of an air taxi service on operational level will be discussed based on the operational activities of the air taxi. First the complexity of crew scheduling will be elaborated and the complexity of the aircrafts and their maintenance will be described. Finally the complexity of the costs will be explained.

a) Complexity of crew scheduling

As mentioned in the previous paragraphs the standards for operating a commercial airline are registered in JAR OPS 1. One example of such a requirement is the scheduling of the crew: A pilot's scheduled duty period cannot exceed 14 hours and may not include more than 8 scheduled hours of flight time when one pilot is present and 10 hours when there are two pilots. Furthermore within 24 hours period a pilot must have a rest of 10 consecutive hours[12]. Crew scheduling of an air taxi service is different than of a scheduled service, because of the unbalanced network. For example it can happen that a pilot reaches a destination of a client, he is not allowed to fly back. A new pilot needs to be mobilized or the pilot has to stay the night and fly back the next day. This will influence the air taxi operations significantly and needs to be considered. To schedule the crew for flights crew rotations can be created. A crew rotation, presented in figure 2 is the path that a single crew performs to execute any number of scheduled flights. Crew rotations are created to minimize the number of crews needed. After crew rotations are created, the rotations can be assigned to specific crews. This process is called rostering. The rostering process has to take the strict regulation on duty periods into account.

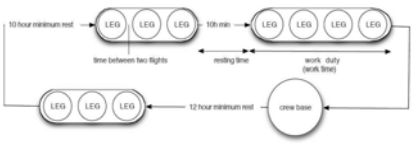

Figure 2. Crew rotation [13]

A schematic representation of a crew rotation is presented in Figure 2. During a single work duty, a crew can perform multiple legs. Between these legs, a crew often spends time on the ground. This ground time is considered resting time if the time spend on the ground is greater or equal to the prescribed resting time. Additionally, the maximum working time is regulated by flight regulations. A series of work duties are separated by a rest after returning to the crew's home base.

b) Complexity of fleet and maintenance scheduling

The complexity of the fleet is determined by the characteristics of the fleet influencing the air taxi service. Each type of aircraft has a different range, speed, weight and minimum altitude. The size of the fleet is important as well. Operating an air taxi service network will be different with 10 aircrafts than with 100 aircrafts.

The maintenance of the aircrafts needs to be considered as well. The maintenance schedule is different for each type of aircraft. The limitations regarding maintenance of aircrafts have three components: number of hours flown, number of cycles and number of days since last maintenance service[14]. Due to this maintenance the fleet will change. This will influence the position of the platform where aircrafts will be maintained as well and is therefore important.

c) Complexity of of costs

The costs of operating an air taxi service can be split into direct and indirect operating costs. Direct costs are costs directly related to an aircraft and its flight operations. Direct costs for an air taxi services are:

- Crew costs, based on flight hours
- Aircraft costs
- Acquisition costs
- Depreciation costs
- Insurance costs
- Fuel costs
- Airport fees
- Third party fees (for door to door service)

Indirect operating costs are costs not directly related to the operation of the air taxi, like food and beverages, advertising, reservation and sales etc

C. Aeolus Aviation

Aeolus Aviation is an air taxi start up, founded in 2006 by Stefaan Ghijs, a former Aerospace Engineering student. The company is in its early stage of development. Aeolus wants to obtain a position in the business aviation, not just as a business charter but also as a business facilitator. Picking up clients from their offices and delivering them at their destination. The main objectives of Aeolus Aviation are to offer the air taxi service for the lowest price and the lowest travel time and to have the highest revenues. On strategic level this means that the demand needs to be maximized by marketing strategies and the price minimized. On operational level it means that the service needs to be cost efficient and non revenue flights needs to be minimized. In this paragraph Aeolus Aviation will be discussed on strategic and operational level.

1) Aeolus Aviation on strategic level

In this paragraph the air taxi service of Aeolus Aviation will be discussed on strategic level. First the market in which Aeolus will operate will be described, next the type of aircraft Aeolus will use and some customer service specification will be elaborated

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a) Market of Aeolus Aviation

As been mentioned the market in which an air taxi service will operate depends on the potential customers, where these clients are and what the competition is. Aeolus will focus on customers more sensitive to higher costs and until now they have not thought of the advantages of business charters. But because of the low price and travel time Aeolus will be remarked. Aeolus wants to attract customers from scheduled flights where time-efficiency is lacking, due to passengers handling and mass transport. And Aeolus wants to attract customers from road transport, where time-efficiency is lacking, due to congestions of the roads. The specific potential customers and their locations and their influence are unknown, so are the competitors. In the near future an extensive market research will be done.

b) Type of aircrafts

To achieve the objectives Aeolus Aviation uses a different type of aircraft than most air taxi services in Europe. Most of the air taxi services are using jets, but Aeolus Aviation is going to use propeller aircrafts. These propeller aircrafts can be especially used for flights of 300-1000 km. In figure 2.3 can be seen that the demand for air taxi flights with a turboprop starts to increase for flights of 100 km and approximately 50 percent of the business flights are flight of less than 500 km. After that the demand is decreasing, but still present till flights of 1000 km. Thus for a propeller aircraft a large amount flight can be executed on a range of 200 to 1000 km. IFR movements are movements according to the instrument flight rules.

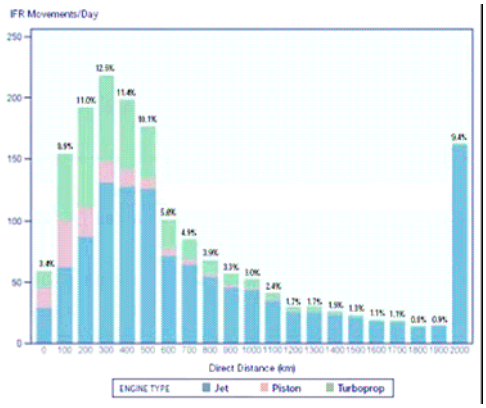

Figure 3. : IFR Movements/day[15]

Especially for these distances the turboprop aircrafts have advantages. The advantages are that propeller aircrafts:

- *have cheaper types to purchase*
- *are economic*
- *have a shorter runway length*

The disadvantages are that propeller aircrafts:

- *less comfortable*
- *slower[16]*
- *have stricter regulations*

But the lower price for flights will compete with these disadvantages, because the customer's top priority is the lowest price[17].

The amount of aircrafts is not yet determined. It will be likely that the amount of aircrafts will increase throughout the years, so that needs to be considered in the trade off of the different logistic concepts.

c) Pricing of tickets

Another difference between Aeolus and other air taxi services is the fact that passengers pay for the aircraft and not for a seat. Seat sharing will therefore not be possible. This will influence the pricing of tickets of the air taxi service of Aeolus Aviation. Which pricing technique Aeolus will use is not yet determined.

Other customer service specifications of Aeolus Aviation are[18]:

- *Door to door air service*
- *Within 6 hours airplane is ready to take-off everywhere in Western Europe*
- *Flexible route planning*
- *Capacity for 6 passengers*
- *Hotel arrangements when necessary*

2) Aeolus Aviation on operational level

Operations are needed to fulfill the strategy of Aeolus. Off course providing transport for customers is the main operation of an air taxi service. But the transport of these customers is influenced by many factors. In paragraph 2.2.2 the most important factors influencing the air taxi service on operational level are described. These are:

- *Crew scheduling*
- *Aircraft characteristics*
- *Maintenance scheduling*
- *Location of the maintenance base*

All these aspects, together with the service concepts between airports, can be combined into logistic concepts of the air taxi service of Aeolus Aviation.

Thus a logistic concept of an air taxi service is a certain service concept providing transport between selected airports influenced by a certain schedule for the crew, a certain price structure, a certain amount of aircrafts with maintenance schedule and a certain location of a maintenance base. Several logistic concepts can be developed, so it is not easy to develop an optimal logistic concept of the air taxi service network of Aeolus Aviation with the lowest costs and the highest revenues. A tool needs to be developed to analyze logistic concepts to eventually come up with a suitable logistic concept.

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D. Conclusions

Aeolus Aviation is starting up an air taxi service. Operating an air taxi service is complex on strategic and on operational level. The complexity on strategic level is caused by insecurity of the demand, constraints of airports, minimization of the repositioning flights and pricing techniques. The complexity on operational level is caused by the scheduling of the crew and maintenance and the location of a platform. So many factors are influencing the logistic concept of an air taxi service network.

The main goals of Aeolus Aviation are to develop an air taxi service, which has the lowest price and travel time for flights and the highest profit. Because many factors are still unknown, it is hard to develop an optimal logistic concept with the lowest costs and highest revenues. A tool is needed to model logistic concepts and to analyze the factors influencing the air taxi service of Aeolus Aviation

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III. RESEARCH PROJECT

As mentioned in the previous chapter many factors influencing the air taxi service of Aeolus Aviation are still unknown and it is hard to find an optimal logistic concept. Therefore in this research the discussed issues will be further investigated to eventually find a feasible solution for a logistic concept of the air taxi service of Aeolus Aviation.

In this chapter the research project will be discussed. First the main objectives of the research will be mentioned. Next the main research questions and definitions are formulated and finally the research approach with sub questions will be discussed.

A. Research objectives

The analyses of the previous chapter result in three objectives:

- *Analyzing the air taxi service of Aeolus Aviation on strategic level*
- *Developing a tool to analyze logistic concepts of the air taxi service*
- *Developing a suitable logistic concept for the air taxi service of Aeolus Aviation*

B. Main research question and definitions

In order to reach the objectives, mentioned in the previous paragraph, the following main research question need to be answered:

How to analyze logistic concepts of the air taxi service of Aeolus Aviation on strategic and operational level using a decision support tool and what logistic concept would be suitable for Aeolus Aviation?

The strategic level of the air taxi service of Aeolus Aviation can be analyzed by answering the following sub questions.

- *What are the requirements, assumptions and criteria influencing the logistic concept of the air taxi service network of Aeolus Aviation?*
- *What are the potential clients for air taxi flights of Aeolus Aviation and what are the most important regions in Europe to operate from to be able to reach them?*
- *What are the most important competitors in the network and what is their influence on the service concepts of Aeolus Aviation?*
- *Which airports in those regions are most suitable to operate from, regarding Accessibility, regulations, costs, future developments of those airports and cooperation with other parties?*

To be able to develop a tool to analyze logistic concepts of the air taxi service the following sub questions need to be answered.

- *What are the requirements for the tool to model the logistic concepts?*
- *How can the network of airports be modeled?*
- *How can the demand for air taxi flights be modeled?*
- *How can the crew schedules be modeled?*
- *How can the maintenance schedules be modeled?*
- *How can the expected costs and revenues be modeled?*

To be able to develop a logistic concept suitable for Aeolus Aviation the following sub questions need to be answered.

- *What logistic concepts of the air taxi service can be developed, regarding the strategy of Aeolus Aviation?*
- *What logistic concept fulfills the requirements and scores best on the criteria?*
- *What recommendations can be done, regarding a suitable logistic concept of the air taxi service of Aeolus Aviation*
- *What would be the implementation trajectory for this logistic design of the air taxi service network?*

C. Research methods

In this paragraph the methods to answer all sub questions will be described. For each part of the research the research methods will be described.

1) Methods to analyze the strategic level of the air taxi service

To analyze the requirements, assumptions and criteria influencing the air taxi service of Aeolus Aviation the environment of Aeolus will be analyzed in detail. Several requirements, assumptions and criteria are already mentioned in the background analysis. Existing air taxi services or researches about it, in Europe, but in the USA as well, can

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provide more information about the requirements, assumptions and criteria.

When analyzing the strategic level of the air taxi service, the first step is to determine the type of potential customers and competitors for the air taxi service of Aeolus and the location where those customers are. The market of the air taxi service of Aeolus Aviation will be analyzed by means of interview with mr. Ghijs. Mr. Ghijs has the knowledge of his potential customers and competitors. Based on that interview the customers and competitors will be analyzed in detail by means of a literature research

Based on the market analysis the most important regions can be determined by means of a research on data of demographic factors. An example for such a data base is Eurostat and interviews with professionals in the business.

Within these regions airports needs to be chosen. Data for this choice will be gathered by interviews with pilots and an analysis of the airport as well on the internet or by phone. The pilots will have knowledge about airports in West Europe. To eventually make a choice between airports this data is used in multi criteria analysis.

2) Methods to develop a tool to analyze logistic concepts

To be able to indicate the requirements to model logistic concepts all variables influencing the air taxi operations, which have to be modeled, will be identified. Based on these requirements the decision support tool can be built.

To develop a tool to analyze the logistic concepts simulation software will be used. With the ARENA, simulation software of Rockwell Software, the network of airports and the factors influencing this network can be simulated. The choice for a simulation model is made because in this way the current situation can be analyzed and experiments can be done to distinct the best alternative transport manner. ARENA is developed based on flow oriented simulation. This means that a real situation can be presented as a chain of delays and operations an entity needs to go through[19].

3) Methods to develop a suitable logistic concept

To be able to generate logistic concepts the strategic analysis of the air taxi service will be used and interviews with professionals in the business will be done. This will finally end up in several logistic concepts.

These logistic concepts will be modeled to compare them to each other. The output of these models will be analyzed.

This will end up in recommendations for Aeolus Aviation. A part of these recommendations is the implementation trajectory. The implementation trajectory will be determined by means of a literature research and interviews with professionals in the business..

D. Status of Project

At this moment the analysis of the strategic level of the air taxi service is almost finished. A questionnaire is send to several parties to ground the choice for important regions of potential customers. Based on demographic data and busy business travel routes the most important cities are determined. Based on these cities and the constraints mentioned in the research proposal the most important airports are selected.

The development of a simulation tool is in progress. This is done with the Rockwell software ARENA. ARENA is discrete simulation software and is based on flow-oriented simulation. ARENA is perfectly able to show the consequences of processes during air taxi operations.

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