Heliport Gorinchem

Designing an Aerial Logistic Network

Final Report

Design Synthesis Exercise

Delft University of Technology

Faculty of Aerospace Engineering

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Designing an Aerial Logistic Network

Final Report

Bachelor of Science - Design Synthesis Exercise

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Preface

City centres are becoming increasingly more difficult to access, due to growing traffic congestion problems. In the past, many initiatives have been taken to solve these accessibility problems, but these have lacked viability and feasibility. The Heliport Gorinchem project investigates possible designs of profitable aerial logistic transport networks, which accommodate the economic and urban development of the city. In the long term, the expansion of the initial network will aim at reducing the accessibility problems of Gorinchem.

A team of ten students of the faculty of Aerospace Engineering at Delft University of Technology has been set out to investigate the accessibility problems in Gorinchem and to come up with a final design of an aerial logistic network. The students have had ten weeks to complete the work, upon completion finalising their Design Synthesis Exercise of the Bachelor of Science programme.

This report is the final report of the Heliport Gorinchem project and is a follow-up of the midterm report. It contains all the steps that have been taken to arrive at a detailed final design. The report provides a step-by-step read through of the process executed and provides insight in the technical aspects of the project, as well as a feasibility study of the business model.

The students that have participated in this project would like to thank their principle tutor prof. dr. ir. J.A.A.M. Stoop and their coaches ir. V.P. Brügemann and ir. P.P. Sundaramoorthy, for their support, feedback and knowledge they have contributed to the project. The project group would also like to thank the municipality of Gorinchem, especially Mr P. van der Werff and Mr C. van der Roest, for providing necessary information and their cooperation. Furthermore, the project group would like to thank both the National Aerospace Laboratory of the Netherlands and the foundation Behoud Erfgoed De Vries Robbé, for sharing their knowledge in similar projects. This project would not have been possible without the help of these individuals and organisations.

The team would like to hand over the final report of the Heliport Gorinchem project to the foundation Behoud Erfgoed De Vries Robbé, whom is the project initiator. The foundation shall take the responsibility to continue on with the further developments regarding the Heliport Gorinchem project.

Summary

The Dutch city of Gorinchem has great economic growth opportunities for the future, but is limited by its transport system. It is strategically located at a crossroad of two motorways and two rivers, the Boven-Merwede and the Linge. Gorinchem is home to a number of multinationals, among others Damen Shipyards and Van Oord. This sets the right conditions for economic growth. However, the city roads are congested and the limited accessibility of the area by train and car slows this economic growth. Therefore, a solution is required to make Gorinchem more accessible. The development of an aerial network is an approach that could comply with the vision of the city as an innovative regional business centre. This project, called Heliport Gorinchem, aims to provide a final design for an aerial logistic network that can be implemented in Gorinchem in the year 2020.

The project consists of three main parts: the project initiation and definition, a conceptual design part, and a detailed design part. This report contains a review of the project initiation and definition, and the conceptual design part. The main focus of this report is on the detailed design part of the project.

The aim of the project initiation and definition is to structure the project, come up with a time management plan and organise the group. Also, the requirements and constraints for the project are set. The goal of the project is to design a concept for a sustainable logistic network of multi-purpose aerial vehicles in Gorinchem, competitive with the current transport market, within ten weeks. A market analysis is performed after the project initiation, to identify the traffic problem in Gorinchem on a local and regional scale. Locally, the city has three connection points to the motorways and these points form the entry and exit of the city. The capacity of the roads to these points is too low for the traffic they have to handle. It is estimated that there is an overload of 4000 travellers per hour during rush hours. On a regional level, a connection with a railway to the north and south of the country fails to appear and there is no aerodrome near Gorinchem to have any connection by air.

The outcome of the conceptual design part is a concept for an operational aerial network. To come up with ideas for possible concepts for the network, multiple brainstorm sessions are held. A selection procedure is executed in order to reduce the amount of possible concepts and to come up with a final concept for the detailed design part of the project. From this, a combination of a linear local and a linear regional network is selected.

The verification of the conceptual design has led to the conclusion that an aerial network alone will not solve the traffic problem entirely at this moment. However, there is a demand for a better accessibility and economic growth in of the city. Therefore the aim of the project is altered into a new vision. The goal of the aerial network is to serve economic growth of the city. An aerial network will allow Gorinchem to improve its accessibility to important locations, while becoming an important link in the aerial infrastructure of the Netherlands. The aim is therefore to implement an aerial network before 2020. In the short term, up to 2030, the goal is to realise a profitable aerial network. In the years thereafter

an expansion of the aerial network will allow for an improvement of the traffic situation in Gorinchem. This is the aim of the long-term vision.

The detailed design part elaborates on the design of all aspects of the aerial network in the short term, while keeping its long-term development in mind. The main customers are identified to be business travellers. Other smaller markets are determined as well, like tourism, medical assistance and governmental flights. The aerial vehicle for the short term is selected to be an Eurocopter EC135 helicopter that makes use of a hybrid engine and noise reducing technology. The helicopter should operate under visual flight rules to limit the investment costs. The aerodrome is designed to be a self-sustaining heliport with a low investment cost of 750,000 euro for the landing site. For the location, the industrial estate Avelingen at the edge of the suburbs is chosen. It has a direct connection with the motorway and can be linked with the future railway from Breda to Utrecht. Furthermore, it is located at the Boven-Merwede river which has an extra advantage. An approach route for helicopters will minimise the environmental impact regarding noise and safety. A business model for the aerial network has been developed and analysed. Unfortunately, the business model shows that it will not be profitable in the short term to set up a transport service for business travellers. The main reasons for this are the high maintenance costs of the vehicle, call out costs, and airport charges.

From the conducted research, it can be concluded that it is possible to realise a heliport in Gorinchem and start its operations in the year 2020. Although the implementation of a profitable aerial network seems currently not feasible, it is reasonable to invest in the construction of a heliport as there is demand for a heliport in Gorinchem. It is advised to develop a heliport that allows companies like Damen Shipyards and Van Oord to use the facilities with their own helicopter. Furthermore, this will be a first and innovative step in the development of a regional aerial network, which provides fast and high quality transport. This can offer Gorinchem the opportunity to take a leading role in aerial transportation on a regional scale in the Netherlands . Furthermore, it will support the economic growth of the city.

Further research should focus on the design of a new aerial vehicle. It is recommended that maintenance and fuel cost are reduced for the new aerial vehicle in order to make the aerial network profitable. Other research should focus on the expansion of the aerial network and find alternative locations with low landing charges. In this way, the high landing fees at the airports can be avoided and the possibility to make a profitable aerial network will increase. It is recommended to perform a market analysis on the willingness to pay of the future business travellers and other markets. This will have influence on the income of the business model. In the best case scenario, the design can even become profitable in the short term.

Table of contents

Nomenclature

List of acronyms

AFIS	Aerodrome flight information service
AIP	Aeronautical information package
ALS	Alerting service
ASM	Air space management
ATC	Air traffic control
ATFM	Air traffic flow management
ATM	Air traffic management
ATS	Air traffic service
CBS	Centraal Bureau voor de Statistiek
EADS	European Aeronautic Defence and Space Company
EU	European Union
FATO	Final approach and take-off area
FBS	Functional breakdown structure
FFBD	Functional flow block diagram
FIS	Flight information service
FL100	Flight level 100
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
IMC	Instrument meteorological conditions
IMF	International Monetary Fund
INM	Integrated Noise Model
KIAS	Knots indicated airspeed
KNMI	Royal Netherlands Meteorological Institute

LVNL	Air Traffic Control the Netherlands
MNS	Mission need statement
MTOW	Maximum take-off weight
pax	Passengers
PHAWPP	Pumping high altitude wind power plant
POS	Project objective statement
PRM	Persons with reduced mobility
RDT	Requirements discovery tree
SDR	Special drawing rights
STOL	Short take-off and landing
TLOF	Touchdown and lift-off area
TU Delft	Delft University of Technology
UDP	Universal daylight period
UNESCO	United Nations Educational, Scientific and Cultural Organization
VAT	Value-added tax
VFR	Visual flight rules
VMC	Visual meteorological conditions
VTOL	Vertical take-off and landing
WBS	Work breakdown structure
WFD	Work flow diagram

Chapter 1

Introduction

Many city centres are becoming increasingly difficult to access, due to growing traffic congestion problems. The Dutch city of Gorinchem is one of them. It is strategically located at a crossroad of two motorways, the A15 and the A27, lies near the Betuweroute railway and on the banks of two rivers, the Boven-Merwede and the Linge. Gorinchem is home to a number of multinationals, among others Damen Shipyards and Van Oord. This sets the right conditions for economic growth.

However, the city's roads are congested, a railway connection to the north and south of the country fails to appear and there is no aerodrome near Gorinchem to have any connection by air. To support the economic growth of the city, a solution is required to make it more accessible. The Heliport Gorinchem project sets out to come up with an innovative approach to tackle this problem.

The project investigates possible designs of a profitable aerial logistic transport network, which accommodate the economic and urban development of the city. The implementation of the design should be feasible in five years. Combining new concepts and new technologies should eventually lead to a system that would decrease travel time and that has less impact on the environment than the current transportation system.

The purpose of this final report is to design a profitable aerial network. This report is a follow-up of an earlier presented project plan, baseline report and midterm report [1]. A final conceptual design is determined in the midterm report and is worked out in more detail in this report. The final report guides the reader through the different steps that have been taken to arrive at a final detailed design. The gathered information used for this design is found in existing literature.

The report is divided into three parts: part I is named the orientation phase, part II is defined as the development phase, and part III is called the implementation phase.

Part I focuses on the work that has been performed for earlier reports. It starts with chapter 2, in which the project definition, organisation and functionality are described. A market analysis is presented in chapter 3, in which the local and regional accessibility problems of Gorinchem are discussed. The final chapter of part I is chapter 4, which describes the steps taken to arrive at a final conceptual design.

Part II starts with chapter 5, in which the vision statement for the final design is presented. Chapter 6 identifies the different customers and services that the network will serve. The detailed product design works out the different aspects of an aerial network and can be found in chapter 7. The sustainability approach for the design can be found in chapter 8. In chapter 9, the business model together with the profitability is discussed.

The long-term vision of the project is elaborated upon in chapter 10. The verification and validation of the final design are carried out in chapter 11, after which part II is ended.

Part III begins with chapter 12, in which the implementation strategy of the project is presented. Finally, the conclusions and recommendations are summarised in chapter 13.

Part I

Orientation phase

Chapter 2

Project definition

Prior to commencing the study of a possible aerial network for the city of Gorinchem, the project at hand is defined. This is useful in order to provide guidance for the rest of the project. In this chapter, the definition, requirements, functionality and the overall planning of the project are described. These system engineering tools have been used to initiate and to guide the project. In section 2-1, the project objective and mission need statement are given. Section 2-2 describes the describes the design process of the project. In section 2-3 a clear overview of the different functions that the design should perform is given. Finally section 2-4 gives a clear overview of the requirements and constraints of the project.

After the midterm review, it has become clear that the focus of this project should be slightly adjusted. The adjusted focus of the project and its implications are described in chapter 5.

2-1 Project objective statement and mission need statement

The project can be defined by using a project objective statement (POS) and mission need statement (MNS). The POS states the objectives and constraints of a project, and is formulated as follows:

> ***Ten aerospace students design a concept for a sustainable logistic network of multi-purpose aerial vehicles in Gorinchem, competitive with the current transport market, within ten weeks.***

The next step in defining the project is to summarise the required performance and the constraints for the project in the MNS.

> ***Accommodate Gorinchem's economic and urban development, by designing a multi-purpose aerial transport system that is implementable in five years, while acknowledging the desires of different stakeholders and preserving its cultural heritage.***

It is known that there are a lot of stakeholders in this project, leading to an even larger number of desires. As these desires are most likely conflicting with each other, it is chosen to write "acknowledging the desires of different stakeholders" in the MNS.

2-2 Project planning

Now the POS and the MNS have been defined, it is possible to describe the applicable project planning. In this section, the system engineering tools work flow diagram (WFD), work breakdown structure (WBS), organogram and Gantt chart for the current project are described. The most recent graphical representations of these tools can be found in appendix A.

2-2-1 Work flow diagram

The WFD gives an overview of the sequence of the work that needs to be done to arrive at a final detailed design of the aerial transport system for Gorinchem. This can be seen in figure A-1, in appendix A. It indicates the division of the project into the following five parts:

1. **Project initiation and organisation:** this part is used to make sure that the project runs smoothly. It is described in the project plan [2].
2. **Project definition:** the project definition uses a literature study and a market analysis to come up with the demands, wishes, constraints and requirements for the project. This part of the project is described in the baseline report [3].
3. **Conceptual design phase:** this part of the project focuses on narrowing down the number of options and selecting a final conceptual design that will be worked out in more detail in the detailed design phase. This process is described in detail in the midterm report [1].
4. **Detailed design phase:** in this phase, the final conceptual design is further worked out. Here the final product is presented alongside with a business model. The final report elaborates on this part of the project.
5. **Project close-out:** this contains the final report, a poster, an executive summary, and a final presentation.

2-2-2 Work breakdown structure

The work that needs to be done in each phase of the WFD is carried out in more detail in the WBS. This can be seen in figure A-2, in appendix A. Parallel with the WFD, the WBS consists of the same five blocks.

2-2-3 Group organisation

To ensure that resources are being used efficiently, each group member is responsible for one or more specific functions. The functions can either be technical or non-technical. Each group member performs at least one technical function. The exact descriptions of the different functions have been given in the project plan [2]. These functions are illustrated in an organogram, which can be seen in figure 2-1.

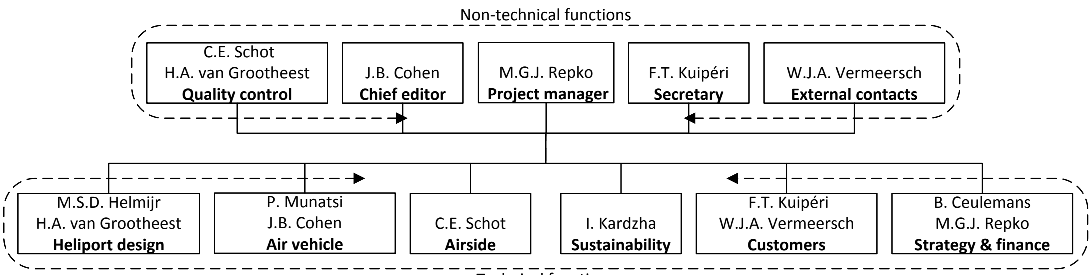


Figure 2-1: Organogram for the Heliport Gorinchem project (January 2013)

2-2-4 Time planning

Good time management is required to ensure an efficient execution of the project within the given ten weeks. Furthermore, it is also used to make sure that deadlines will be met. A certain period of time is assigned to each element of the WBS. These time periods are graphically indicated on a Gannt chart. This chart has been constantly updated throughout the project. It can be seen in figure A-3, in appendix A.

2-2-5 Internal quality procedures and backup

Writing rules are set at the beginning of the project to ensure a good quality of the individual work and consistency throughout each report. A file hosting service is used to have all the collected information and documents distributed over different computers. Furthermore, a backups are made on an external hard drive disk on a regular basis.

2-3 Functional analysis

After the group organisation and time planning are done, a functional analysis is performed. This is done in order to get a clear overview of the different functions that the design should fulfil. The tools used in this analysis are the functional flow block diagram (FFBD) and the functional breakdown structure (FBS).

2-3-1 Functional flow block diagram

The FFBD illustrates all the functions from the design to the implementation of the system in a sequential order, from a top level perspective. It can be seen in figure A-4, in appendix A.

2-3-2 Functional breakdown structure

The FBS gives a breakdown of the system's entire functionality according to predetermined criteria (see figure A-5, in appendix A). On a top level, the function of the system is to improve the accessibility of the city of Gorinchem. This top level function is broken down into three categories: provide transport for passengers, provide transport for cargo, and provide other services such as emergency transport and private transport.

2-4 Requirements discovery tree

Different requirements and constraints originated from the project description and different stakeholders. A few of these requirements are referred to as killer requirements, as those requirements on themselves might lead to either success or failure of the entire project. A RDT is used to give a clear overview of these requirements and constraints. It is an AND tree, meaning that a combinations of all options in the tree form the entire system. It states all the (sub)requirements that the system should meet. Figure 2-2 illustrates the RDT, with the killer requirements highlighted in red.

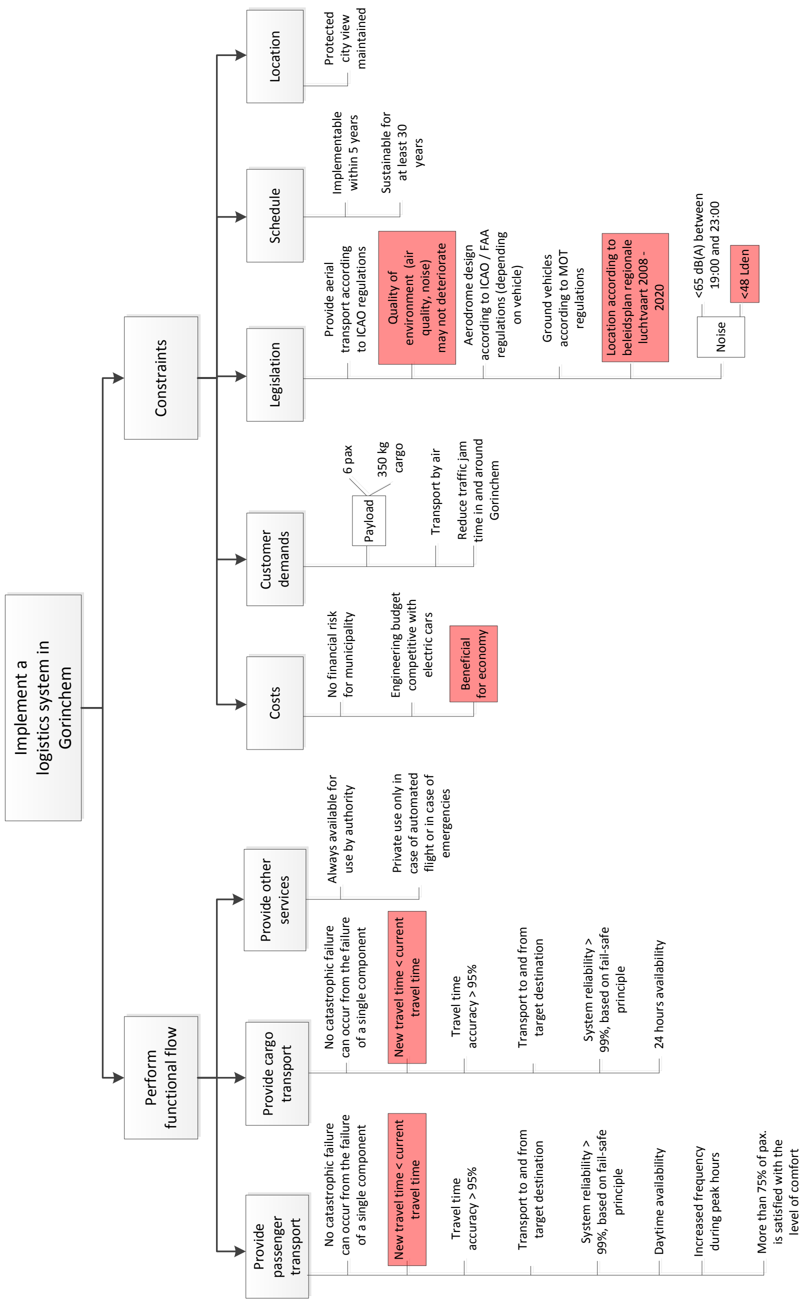


Figure 2-2: RDT for the current project

Chapter 3

Problem identification and market analysis

After the project has been defined in the previous chapter, the next step is to investigate the current traffic problem of Gorinchem. For this purpose, a market analysis has been performed. The market analysis topics is focused on: the regional and local accessibility of Gorinchem, the investigation of possible locations for the implementation of an aerodrome in Gorinchem, and the identification of different stakeholders that might have an interest in this project. The market analysis components mentioned in this chapter have been used as a starting point for the final design. For a full presentation of the entire market research, the baseline and midterm report should be consulted [3], [1].

This chapter is structured as follows. First, the regional accessibility of Gorinchem is discussed in section 3-1. Next, the local accessibility and traffic overload are identified in section 3-2. From these two sections, it is clear that there currently is a traffic congestion problem in Gorinchem, and that connections both on a local and a regional scale are lacking. This research made the project group focus on the design and implementation of an aerial system that could help reducing the traffic congestion. Subsequently, locations that are currently available for the construction of an aerodrome are given in section 3-3. Finally, a stakeholder analysis presents the different potential stakeholders and their interest in the project in section 3-4.

3-1 Regional accessibility of Gorinchem

The existing infrastructure of water-, motor- and railways does not allow cities in the surroundings of Gorinchem to connect in a direct way. Motor- and railways cannot easily cross certain areas, mainly due to existing nature reserves. The current infrastructure of motor-, water- and railways is shown in the map in figure 3-1. As this map indicates, Gorinchem is criss-crossed by three waterways, two motorways and two railways. In this map, purple lines are used to indicate a number of connections between Gorinchem and other cities that are missing. They are described below.

1. **Gorinchem to Gouda and Woerden:** the direct ground connection between these cities is absent in order to protect the natural reserve the Groene Hart [4].

2. **Gorinchem to Schiphol:** this connection is absent for the same reason as mentioned above.

3. **Gorinchem to 's-Hertogenbosch, Tilburg, and Eindhoven:** this direct ground connection is not possible due to the rivers, the Boven-Merwede and the Bergsche Maas and the national parks Loonse and Drunense Duinen.

4. **Breda to Utrecht:** there is no railway line between these cities. It is a desire to construct this within 30 years [5].

5. **No existing aerodromes in the surroundings:** the only aerodromes in the vicinity of Gorinchem, are for private or emergency transport, as illustrated in figure 3-2.

From this list, it is clear that the infrastructure around Gorinchem is lacking. The limited accessibility of the area by train and car slows the economic growth. Therefore, a solution is required to make Gorinchem more accessible. It can be said that realising an aerodrome in Gorinchem will help improve the transport network within the Netherlands.

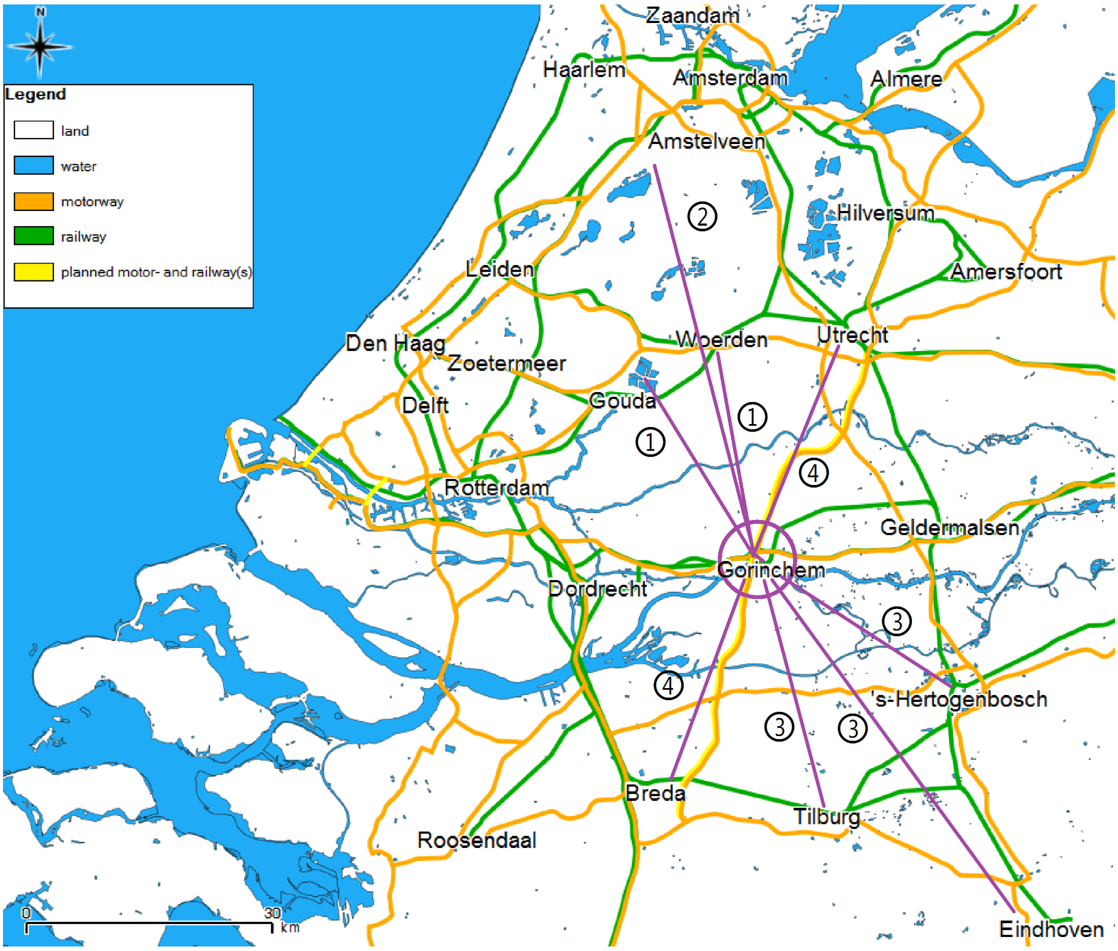


Figure 3-1: Gorinchem's regional ground infrastructure, showing water-, motor- and railways [6], [7], [8], [9]

Figure 3-2: Current aerodromes in the central and south of the Netherlands [10]

3-2 Local accessibility of Gorinchem

The traffic movement in Gorinchem is examined in detail to identify the bottlenecks in the mobile infrastructure and to get an idea of the traffic overload inside the city. Once the traffic overload is known, it is possible to make a quantitative estimation of the actual traffic problem in Gorinchem. For the project it is important to have an indication of the actual problem, because this helps in considering which concept is the most effective in helping reduce the traffic problem.

Local accessibility approach

To make an initial estimation, the city of Gorinchem is assumed to be a system with an in- and outflow of traffic. The boundaries of the system are enclosed by the A15 and A27 motorways and the Boven-Merwede river, as indicated in figure 3-3.

The system in figure 3-3 indicates the congested routes, where traffic intensity exceeds the capacity of the roads. The in- and outflow of the system through these routes need to be known to make a quantitative estimation of the overload of traffic. Three access roads to the system are taken into account, because all in- and outflow of the system passes through these access roads. The access roads (1), (2) and (3) are indicated by the orange lines in figure 3-3.

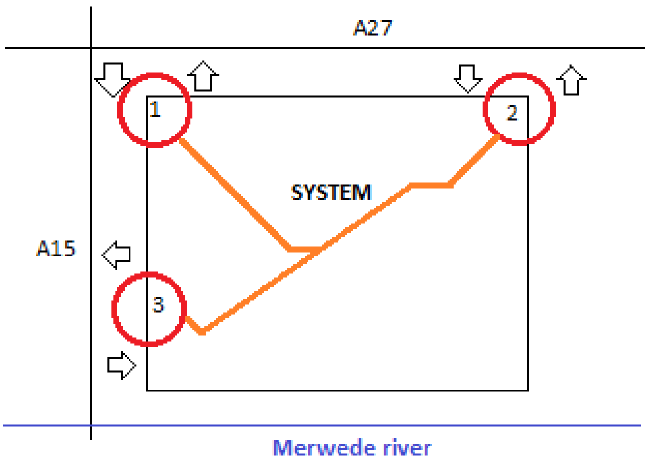


Figure 3-3: System definition and boundaries

Once the in- and outflow of the system are known, the peak in- and outflow of the system can be calculated. It is necessary to find the daily traffic distribution, since the traffic is distributed non-uniformly throughout the day. This will provide a quantitative value for the intensity of the traffic problem. The daily traffic distribution is determined for a period of 24 hours.

The next step is to check the capacity of the access roads into and out of the system. Once the capacity of the access roads is known, the traffic intensity can be compared to the capacity of the access roads and the difference can be considered to be the overload of the system. Below, a brief overview of the findings and results of the local accessibility problem is given. For more detailed information, the reader is referred to the midterm report [1].

Findings and results

After collecting all necessary information regarding the traffic problem in the city of Gorinchem, the traffic problem of Gorinchem can be quantified. When combining the in- and outflow numbers for the three access points of the city and the daily traffic distribution, the number of cars on the road during the peak hour of the day can be calculated. It is possible to calculate the overload of the traffic problem, when subtracting the intensity of the traffic from the actual capacity of the access routes.

Each car is assumed to contain 1.1 passengers on average, since peak hour traffic consists mostly of commuter traffic [11]. A quantitative estimation of the traffic overload, in terms of passengers, can be made for Gorinchem. The results are shown in table 3-1.

Table 3-1: In- and outflow of Gorinchem's traffic problem, in terms of number of passengers per hour

In- and outflow points	Intensity (pax/hr)	Capacity (pax/hr)	Overload (pax/hr)
Point 1	2100	1650	450
Point 2	3200	1500	1700
Point 3	3400	1500	1900
Total	**8700**	**4650**	**4050**

From table 3-1, it is clear that the overload of passengers for both the in- and the outflow has a magnitude of approximately 4000 passengers per hour.

3-3 Available locations to implement aerodrome

The possible locations in and around Gorinchem for implementation of an aerial logistics network are listed in this section. These places are examined in feasibility on size, clearance area, compliance with the International Civil Aviation Organization (ICAO), the Dutch law regulations and the Beleidsplan Regional Luchtvaart 2008 - 2020 [12], [13], [14]. Figure 3-4 shows locations that are currently available for building an aerodrome, without the need of having to demolish buildings.

The different locations were examined for the following criteria in the suburbs of Gorinchem and outside the city.

- **Estimated area size**: the amount of area available for a possible building site for an aerodrome.
- **Area > 5600 m^2**: the minimum area required for an aerodrome (ICAO regulation).
- **Distance to residential zone**: the amount of space between the aerodrome and residential zone. In the policy regional air traffic 2008 - 2020 it is stated that it is not allowed to build any aerodromes within 500 m from residential areas. However, under certain circumstances, these criteria are negotiable.

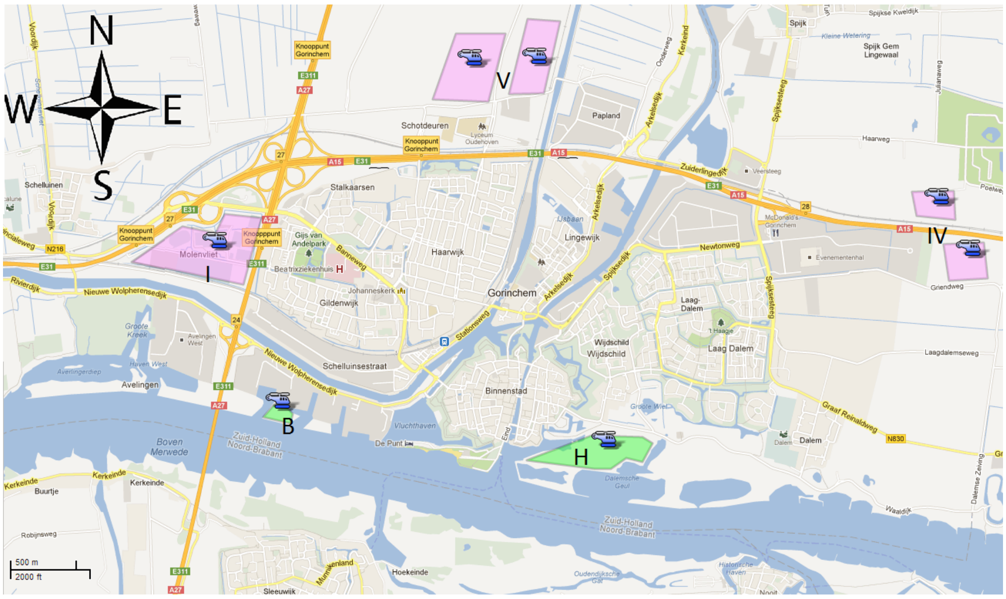


Figure 3-4: Possible locations for aerodromes in Gorinchem [15]

From the examination, it has become clear that there are feasible locations within Gorinchem: location B, H, I, IV and V are worth investigating in more detail to finally determine the heliport location. The midterm report should be consulted for a more detailed examination of the process.

3-4 Stakeholder analysis

The final element of the market analysis focuses on the identification of different stakeholders. Stakeholders are an inevitable part of the project. The reason is that the boundaries and requirements of this project take their shape according to stakeholders.

For the different requirements, a distinction has been made between regulations, demands and constraints. Regulations are laws and acts that should be complied with; demands are wishes that the stakeholders would expect from the project; constraints give the boundaries of the project.

Below, the different stakeholders for the project are stated, together with the possible benefits they have from the project and the influence they have on it. For the detailed stakeholder analysis, the baseline report should be consulted.

- **The municipality of Gorinchem:** will benefit from the traffic congestion being reduced, and when an alternative for the current transportation systems is developed. They will come up with regulations and demands.

- **The national government:** will benefit from a reduction of congestion on the motorways, A15 and A27. The government will mostly come up with regulations.

- **The province of Zuid-Holland:** the new transportation system will improve the accessibility of a part of the province. The province will also influence the project with regulations.
- **Citizens of Gorinchem:** are influenced by the operations of the transportation network and might benefit from the increased accessibility of the city. They will influence the project by their demands.
- **Multinationals:** might benefit from the project, as the project will provide the possibility to transport clients to or from Gorinchem in a quick and efficient way. The main multinationals in Gorinchem are Van Oord and Damen Shipyards. It is expected that these companies will influence the project with their demands.
- **Other companies in Gorinchem:** can benefit from the project, as the aerodromes can be used to save time while travelling for business. The presence of the aerodrome might attract new companies to the city, as they might also want to make use of the aerodrome.

Chapter 4

Conceptual design

From chapter 3 it is clear that Gorinchem currently has a traffic congestion problem. The chapter identified a number of stakeholders that might have an interest in reducing or solving traffic congestion. Therefore, the project group focused on reducing this traffic congestion as much as possible, by making a concept for an aerial transport network. This chapter gives a brief summary of the concept selection process, which is explained in more detail in the midterm report [1].

Multiple brainstorm sessions have indicated that a large number of options are possible to come up with a feasible design concept for an aerial transport network which would help reducing the congestion problem. To be able to manage this, it is decided to divide the selection of a conceptual design into three phases. These phases are: selecting a plausible network type, narrowing down the number of concepts by using predefined criteria and selecting the final concept by checking the concepts on feasibility and comparing them on aspects such as traffic impact. The purpose of these three phases is to narrow the number of concepts down to one final concept.

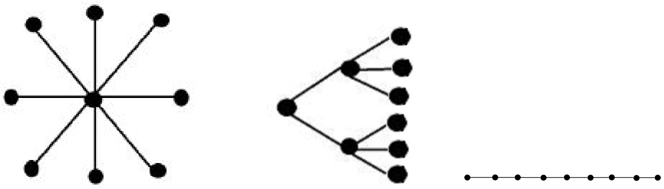
This chapter is structured as follows. In section 4-1, the first phase is described. This phase focused on selection a topological structure of the network. Subsequently, section 4-2 focuses on narrowing down the number of concepts, after working the remaining ones out in a more detailed level. The third and final design phase are used to select the conceptual design, as described in section 4-3. Finally, in section 4-4 the verification of the conceptual design is explained. This is an important part of the project, as it indicates that the project group has had a focus on a problem that is beyond their scope. Therefore, the focus towards the project is slightly adjusted. In part II, the continuation of the project is described after this turning point.

4-1 Phase one: transport network selection

The first design phase focuses on the selection of topological structures for the possible network. This selection analysis is used to investigate the problem from a top-level perspective. The ones that help the most in reducing Gorinchem's current traffic are selected by combining information from the current traffic situation with different network types. Seven plausible network types remain from this first phase.

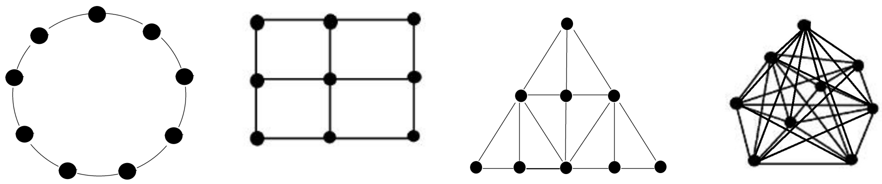
Network types definition
The analysis has been done on network types in general. One of the properties of network types is their topological structure. Figures 4-1 and 4-2 give the different types of networks

that have been used in the first design phase. As these figures indicate, a difference between the types of networks is whether they are open or closed. Open networks have end nodes which are connected to only one other node, as shown in figure 4-1. In closed networks, each node is connected to at least two other nodes, as shown in figure 4-2 [16].



(a) Radial **(b)** Branched **(c)** Linear

Figure 4-1: Plausible topological structures for open transport networks



(a) Circular **(b)** Rectangular **(c)** Triangular **(d)** Free-route

Figure 4-2: Plausible topological structures for closed transport networks

Ranking network types

In order to compare the network types, key network performance measures have been identified and used as criteria for the network selection. These performance measures are based on literature studies [16]. More detail on them can be found in the midterm report [1]. Some of the network performance measures depend on the network size. In order to make a fair comparison between the network types, it has been assumed that each network type has nine nodes. The ranking is based on a qualitative analysis, meaning the best is assigned a rank 1 and the worst a 7. According to the ranking given in table 4-1, circular and linear networks receive the highest ranks and the branched system receives the lowest.

Network selection

From table 4-1, it is clear that the branched network structure is not a feasible option. Furthermore, it indicates that the free route network is ranked lowest on three out of the six possible criteria. Therefore, this structure is disregarded as well. Finally, figures 4-1 and 4-2 shows that with a large number of nodes, a clear distinction between different network

Table 4-1: Ranking table for the different topological structures of transport networks

Criterion	**Transport network**						
	Radial	Branched	Linear	Circular	Rectangular	Triangular	Free
Network capacity	5	6	7	4	3	2	1
Frequency	3	4	1	2	5	6	7
Capital costs	3	4	1	2	5	6	7
Recurring costs	3	4	1	2	5	6	7
Centrality	5	7	4	6	3	2	1
Robustness	5	6	7	4	3	2	1
Total	**24**	**31**	**21**	**20**	**24**	**24**	**24**
Final rank	**3**	**7**	**2**	**1**	**3**	**3**	**3**

types is visible. However, on a local scale, with a limited amount of nodes, the circular, rectangular and triangular do not clearly differ from one another. Therefore, only the one with the highest score, the circular one, will be further taken into account. This results in the usage of only the linear, radial and circular network types.

The next step in the selection of the network, is to make a distinction in whether operations are on a local or on a regional scale. This is important because it determines the type of operations and customer demand. At a regional scale, multiple municipalities are involved. This might lead to problems with the implementation of the project, as multiple municipalities involved implies more regulations that need to be tackled and complied with. This might severely delay the implementation phase of the project. Therefore, for the regional scale, only the linear system is chosen, as it is the simplest one and it involves the lowest amount of municipalities. Concluding, this leads to the following seven network types:

- Local linear;
- Local radial;
- Local circular;
- Local linear combined with regional linear;
- Local radial combined with regional linear;
- Local circular and regional linear;
- Regional linear.

4-2 Phase two: concept trade-off of networks

After defining possible network types, the second selection phase is focused on narrowing down the number of concepts on a more detailed level. First, the remaining network types from the first design phase have been worked out in more detail. They have been analysed on a combination of the network type, location of aerodromes and the vehicle type. Then, obvious losers are eliminated. Subsequently, using predefined criteria, a trade-off has been performed to reduce the amount of concepts. Finally, a sensitivity analysis on the performed trade-off is used to see if the trade-off results were robust.

4-2-1 Further concept development with vehicle and location

The remaining concepts from the first design phase have been worked out in detail, with respect to a location and a type of aerial vehicle. Both are explained is detail below.

Location

The location of the aerodrome is of great importance when considering a possible network for Gorinchem. A rough position of the aerodrome will give more clarity in the physical appearance of the network. The selected location categories are as follows:

- **City centre:** location within the old city centre of Gorinchem.
- **Suburbs:** location outside the old city centre but within Gorinchem's city limits.
- **Outside the city:** location outside Gorinchem's city limits.

Aerial vehicle

Based on the literature study performed in the baseline report, the type of aerial vehicle has been divided into the two main aerial vehicle categories: vertical take-off and landing (VTOL) and short take-off and landing (STOL) vehicles. The main distinction between these vehicle types is that STOL vehicles require a runway, whereas VTOL do not.

4-2-2 Narrowing down concepts

The expansion of the remaining concepts from phase one with the location and the vehicle type, resulted into 42 design combinations. From these 42 options, the obvious losers have been eliminated. These obvious losers are not considered in the trade-off process, as they are highly infeasible. The eliminated design options are discussed in more detail below.

STOL vehicles in the city centre

A design that incorporates STOL vehicles requires a runway, whereas a VTOL vehicle requires only a small infrastructure, due to its vertical take-off and landing capability [3]. The positioning of a runway inside the city centre is considered highly infeasible due to its large required area. The only possible option for building a runway inside the city centre, would be by demolishing existing buildings.

Aerodrome outside the city
Whilst initially taking an aerodrome outside of the city as an option, it has become clear soon that such an option is not desirable. Since the congestion of the city is caused by going from the city to the outside and vice versa, locating an aerodrome outside the city seems to undermine the actual function of the system. For this reason, the possibility of having an aerodrome outside of the city is ignored.

A number of 21 possible design concepts remain after eliminating all design combinations that incorporated any of the two elements as mentioned above.

4-2-3 Trade-off of remaining concepts

The project group has considered the 21 remaining design concepts as being too many. Therefore, a trade-off method has been used to narrow the number of concepts further down. The concepts are graded on certain criteria. Each criterion has been given a weight in order to indicate its importance. Subsequently, the best ones have been selected.

Trade-off method
In order to determine the best possible design options, a trade-off has been applied. The method used is a classical numerical approach, in which each design option receives a score for each trade-off criterion. Next, the scores are multiplied by the weighing factor, and all scores for each trade-off criteria are summed to attain a final score. The higher the score, the better the design is. This trade-off method can be seen in appendix B including a table which explains the scale of scores. An elaboration on the choice of the criteria and their weight is given in the midterm report.

Concept trade-off
The results of the trade-off are given in appendix B. It is clear that the following three concepts are the winners:

1. Regional linear network, located in the suburbs using VTOL vehicles;
2. Local linear, regional linear network, located in the suburbs using VTOL vehicles;
3. Local linear network, located in the suburbs using VTOL vehicles.

From the results, similarities between the three highest scoring designs are apparent. Firstly, they are all linear networks of either a local or regional scale. Secondly, the design options all make use of a network situated in the suburbs. Finally, all three make use of a VTOL vehicle.

4-2-4 Sensitivity analysis of trade-off

It is possible that the results from the trade-off are highly dependent on the weights given to the criteria. To check this, a sensitivity analysis has been performed. The approach and findings are given below. A more detailed explanation of the sensitivity analysis and its results can be found in the midterm report.

Approach for the sensitivity analysis

The method used for the sensitivity analysis depends on the iterative process of changing the assigned weight of each criterion by a certain amount. It is done for three different scenarios. This shows if the concept is very dependent on a single criterion. The changes made are relatively extreme, and could even lead to a negative weight. This means that the stakeholders would desire the opposite of the defined criterion.

In the first scenario, the weight of one criterion from the table is decreased by ten points, while the others are increased by one point. In doing so, the overall sum of the assigned weights is kept constant. As the total amount of all the assigned weights on the table is a hundred, every increase by one point corresponds to 1% increase. This method has been applied for each criterion and the resulted ranks of each concept are documented. In the second scenario, the same approach has been applied but this time the increase of one factor was 10% while the others are decreased by 1%. Finally, for the third scenario, an increase of 20% for each criterion and decrease of 2% for the others is examined in an iterative process. A check is done to see whether the selected concepts show a variation in terms of ranking.

Findings of the sensitivity analysis

The sensitivity analysis has resulted in the following.

- For 97% of the scenarios, one of the chosen concepts is ranked number one.
- For 94% of the scenarios, two of the chosen concepts are ranked as the top two.
- For 88% of the scenarios, the chosen concepts are ranked as the top three.
- When the weight of robustness is increased by twenty points, the chosen concepts are only ranked third, seventh and ninth. In that case, a local circular/regional linear-VTOL system both in the suburbs and outside the city, would be best. However, the chances of robustness being the most important criterion are very small. No stakeholder has mentioned this in the constraints or requirements. With the exception of the robustness + 10 scenario, none of these two concepts are ever in the top three.
- In general, the regional linear-suburbs-VTOL concept is ranked the highest. The local linear/regional linear-suburbs-VTOL is ranked second. The local linear-suburbs-VTOL system is ranked third.

Conclusions of the sensitivity analysis

Looking at the three different scenarios, it can be concluded that the selected concepts are highly insensitive to fluctuations in different criteria, as the rankings of the first three concepts stay in the top three in the majority of the cases. Only when the weight of the robustness of the system is increased by twenty points, the highest ranked is a different concept than the chosen concepts. However, this scenario is highly unlikely, since no stakeholder has mentioned this as a requirement. Hence, it can be assumed that the best concepts have been selected.

4-3 Phase three: selection of the final concept

In the third selection phase, the remaining concepts from the second design phase are investigated further. In the selection of the final concept a division is made between a regional concept with connections with cities within a range of 30 km and within a range of 60 km. First, a feasibility check with respect to safety, noise and locations of aerodromes has been done. However, as not sufficient information about the design was available at that stage, this is not relevant for the selection of the final concept. Next, the different concepts have been compared with respect to travel times, travel costs and traffic impact. This eventually resulted in the selection of one final concept. All calculations made for the concept comparison can be found in the midterm report.

The three remaining concepts from the second phase have been compared with respect to travel time, travel costs and traffic impact.

Travel time of the aerial network
The time saved by using aerial transport has been set as a percentage of the total time it takes to travel by ground. The amount of non-cruising elements (e.g. check-in and check-out) for travelling by air is relatively high compared to travelling by road. Therefore, the regional concepts have more time saved than the local concept. For the local concept, this is unclear.

Operational costs of the aerial network
The fuel costs of the helicopter have been compared to the costs per trip by personal car, travelling the same distance. Although the costs are only rough estimations, it gives a first indication of the profitability of the different concepts. The calculations show that for the local concept, travelling by air costs approximately the same as travelling by car. For the regional 30 km concept, the travelling costs will be less than travelling by car. This indicates a possibility for a profitable concept. The costs for the regional 60 km concept are higher than the cost of ground transport.

Traffic impact of the aerial network
The goal is to design an aerial network that can reduce the traffic intensity on the main routes. It is difficult to estimate to what extent the regional concepts will contribute to reducing the traffic problems. However, the impact of the local concept is assumed to be significantly higher because the traffic congestion is mostly located inside the city and not on the motorways.

In table 4-2, an overview of the selection criteria on profitability of the different concepts is presented. If a concept is feasible on a criteria, it has a green colour (+). If it is probably infeasible, an orange colour (−) is used. Finally, yellow boxes (+/−) are used to indicate that a further investigation is recommended. This shows that the linear 30 km concept is the best one. However, the local linear system also requires further attention, as it is the only one with a direct solution to the traffic problem. Therefore, the local/regional linear 30 km system is assumed to be the best concept.

Table 4-2: Profitability of different concepts

Criteria	Local	Regional 30 km	Regional 60 km
Travel time, faster than car [%]	24 (+/−)	38 (+)	37 (+)
Operational costs, compared to road transport	Equal (+/−)	Less (+/−)	More (−)
Traffic impact on problem	Provide solution (+)	No direct solution for the short term, but might provide a solution in the long term (−)	No direct solution for the short term, but might provide a solution in the long term (−)

4-4 Verification of the conceptual design

As explained in the previous sections, the remaining concept after the three design selection phases is the one that uses a VTOL vehicle in a local/regional linear system, with a range of 30 km. The results of the concept selection have been presented to amongst others the project tutors, and a council member of the municipality of Gorinchem, Mr C. van der Roest during the midterm review. Together with the feedback received during the midterm presentation, it became cleat that solving or reducing the traffic congestion problem of Gorinchem is beyond the scope of this project. The project group agreed that the focus of the project should be to implement a profitable aerial logistic transport system. In the long term, the objective might be redirected towards reducing the traffic congestion in Gorinchem.

In order to make the concept selection convenient, the assumption has been made that it is possible to fly to any location of choice. However, this does not seem to be realistic in the short term. The only possible destination within a radius of 30 km would be Rotterdam Airport. Therefore, a decision has been made to add other destinations, and to include routes to Schiphol and Eindhoven Airport. Both locations have a high passenger potential and a relatively poor connection to Gorinchem. Taking Gorinchem as the central point of the aerial logistic transport network including these destinations could prove the system to be both profitable as well as helpful in making Gorinchem itself more accessible.

Due to high uncertainty on feasibility, the local system has not been considered in the final design of the system. In the future however, this could still be interesting, as it might help in reducing the congestion around Gorinchem.

Part II

Development phase

Chapter 5

Vision statement

Initially, the aim of the project was to help Gorinchem in reducing the current traffic problems during rush hours. Investigation of the possible implementation of an aerial network has shown that the vision of the project should be slightly altered in this second part. Reducing the traffic problem in Gorinchem by means of a local aerial network will not be realistic, as explained in section 4-4. Therefore, the vision of the project has been adjusted to come up with a realistic plan for the implementation of an aerial network. The vision of the project is now formulated as follows:

> ***The goal of the aerial network is to serve economic growth of the city, to attract tourism and to give assistance in emergency and governmental services. An aerial network will allow Gorinchem to improve its accessibility to important locations, while becoming an important link in the aerial infrastructure of the Netherlands. The aim is therefore to implement an aerial network before 2020. In the short term, up to 2030, the goal is to realise a profitable aerial network. In the long term, an expansion of the aerial network will allow for an improvement of the traffic situation in Gorinchem.***

The vision statement is supported by figure 5-1, which illustrates the phases of the project. The implementation phase of the project will run from 2013 until 2020, as explained in section 7-1. After 2020, the operation of the aerial network will start. The first ten years will be considered to be the initial phase of the project in which the project aims at fulfilling the short-term vision. From 2030 onwards, the project will slowly start completing the long-term goal, of reducing part of the accessibility problem of Gorinchem, by making the aerial network available for commuter traffic.

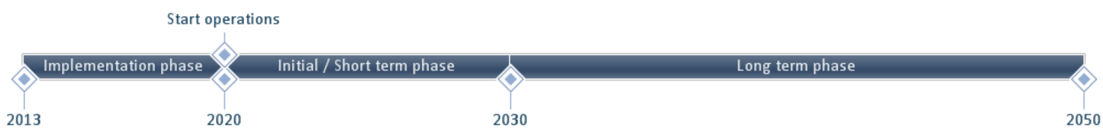


Figure 5-1: Project timeline

Now that the general vision statement has been clearly defined, both the short- and long-term visions are further elaborated upon. In section 5-1, the short-term vision is discussed, and in section 5-2, the long-term vision is briefly explained.

5-1 Short-term vision

The short-term goal of the aerial network of Gorinchem is to realise a profitable aerial network within ten years. By doing so, Gorinchem will receive more national and international appeal by expanding the network and making Gorinchem an important and centrally located node in the flying infrastructure of the Netherlands.

In order to succeed in making the initial network profitable, the product should focus on different market segments. The market segments will be identified in chapter 6. To serve the different market segments, an aerial network is designed, while complying with the regulations. Chapter 7 explains the design of the short-term aerial network. A requirement of the design is to be sustainable, the sustainability of the designed aerial network is discussed in chapter 8. In order to investigate the profitability of the project, the costs and income of the design are identified in a business model in chapter 9.

5-2 Long-term vision

From 2030 onwards, an expansion of the aerial network in the long term will provide opportunities to attract a larger customer group. The aim of future development and expansion of the aerial network is to look for more niche-markets that might be interested in the use of the heliport. By identifying more niche-markets, the long-term vision aims to make the heliport more feasible for commercial use.

Future expansion of the heliport network should stay ambitious in using new technology that helps in reducing noise and pollution of the helicopters. Developments should aim on improving the environmentally-friendly picture of the heliport and work on the social acceptance of the community of Gorinchem. Chapter 10 will elaborate on the long-term vision of the heliport Gorinchem in detail.

Chapter 6

Market identification

The aim of this chapter is to define the market segments and the services that the network is going to offer. The market segments are the source of income for the project. They are identified to compare them with the costs and to come up with the profitability of the aerial network in the business model, in chapter 9. The different markets are listed and clarified in section 6-1. In this section, the destinations and the amount of customers are determined and their willingness to pay is investigated. In section 6-2, the price for the operations that the aerial network is going to serve, is determined. In addition, the expected growth of the customers in the next years until implementation is explained in this section.

6-1 Aerodrome Gorinchem market segments

Comparable companies have shown that aerial transport is expensive [17]. Therefore, a first selection is made in the customers with a high income and a short amount of time available for travelling. From this the following markets are defined to investigate in detail:

- **Business to business travellers:** business travellers are in general the people with higher incomes which want to travel efficiently because their value of time is relatively high [11].
- **Tourists:** spend a lot of money and want to see as much as possible in a short amount of time.
- **Events:** in the north-east of Gorinchem an event hall is located, where both business and leisure events take place [18]. Visitors of these events can be identified as possible customers.
- **Medical assistance by helicopters:** in emergency cases hospital patients would need fast transfers to other hospitals.
- **Government and third parties:** there is a demand for helicopter services by the government and other companies, for example in inspections of gas- and electricity lines, dikes, video and photography flights.
- **Private helicopter landings:** owners of private helicopters can use the heliport to have a safe landing area and parking place.
- **Cargo services:** the opportunity for fast cargo transport through the air, can be served by an aerial network.

6-1-1 Business to business travellers

The business to business market consists of two main segments. The clients visiting companies and the employees heading for business trips. Because three large international companies are located in Gorinchem. The business to business market is considered to be a main market segment.

Destinations of business to business travellers
The three main companies in Gorinchem are Damen Shipyards (headquarters), Van Oord (headquarters Netherlands). Because of their global orientation, a lot of business trips are made to the main airports in the Netherlands. Most of the business trips are assumed to go to Schiphol, as this is the largest intercontinental airport in the Netherlands. For European trips, Rotterdam airport and Eindhoven airport are most likely to be used, as they are located closer to Gorinchem.

Amount of business to business travellers
Statistics from the Centraal Bureau voor de Statistiek (CBS) and the airports of Schiphol, Rotterdam and Eindhoven are used to estimate the amount of travellers [11], [19], [20], [21]. In appendix C, the calculation for the amount of business to business travellers is given. The number of passengers per year is 8,490 for Schiphol airport, 1,460 for Rotterdam airport, and 4,480 for Eindhoven airport. An average amount of travellers of four per flight is assumed for business to business travelling. This is because business travellers are served by a fast transfer.

Business to business travellers willingness to pay
The business to business travellers want to pay a certain amount of money for a trip. Therefore, their willingness to pay is investigated from which the price for a flight can be determined. The willingness to pay is assumed to consist of two parts: the taxi price for the same route and the value of the saved time for the business traveller. The taxi price is assumed to be the maximum taxi price determined by the government [22]. It is assumed that business to business travellers travel by two persons per taxi on average. In determining the amount of business travellers, it is assumed that the 10% of business travellers with the highest income would use the aerial vehicle. The price they want to pay per saved hour is approximately 60 euro. This is a rough estimate by using calculations for the value of travel time from the University of California [23]. In table 6-1, the willingness to pay for a flight with four business travellers is calculated by equation 6-1.

$$p_w = p_t \cdot O_t + (T_s \cdot p_s) \cdot O_a \tag{6-1}$$

Where p_w is the willingness to pay, p_t is the taxi price, T_s is the saved time and p_s is the value of saved time for business to business travellers. O_t is the number of taxis needed for one flight and O_a is the amount of passengers for one flight. To get the maximum possible income per flight, the amount of passengers per flight is set to six. The price for the willingness to pay is for the entire flight and thus for 6 persons in total. The prices are including value-added tax (VAT)

Table 6-1: Willingness to pay business to business travellers

Parameter	Schiphol airport	Rotterdam airport	Eindhoven airport
Travel time air [min]	25	20	23
Travel time taxi [min]	70	60	65
Saved time p_s [min]	45	40	42
Value of saved time T_s [euro/min]	1	1	1
Taxi price p_t [euro]	183	123	164
Willingness to pay p_w [euro]	630	620	580

6-1-2 Tourism

The city of Gorinchem is part of a tourist attraction, called the Vesting3hoek. This consists of three other places around Gorinchem with a history that goes 600 years back. About 100,000 tourists visit this attraction every year [24]. Close to Gorinchem, there is another tourist attraction, called Kinderdijk with roughly 250,000 visitors each year [25]. In Kinderdijk, the largest concentration of old windmills in the Netherlands can be found. They are a UNESCO world heritage site. These type of attractions are suitable for round trips by helicopter.

Amount of tourists
There are no numbers available for the amount of round trips by helicopter at this moment. But an estimation of 200 to 500 flights for each attraction is made with a total of 1000 to 1500 passengers, based on the following elements:

- It is an exclusive experience to see the castles, monuments and nature from a different perspective. 25 to 30% of the visitors want the choice to have an active, custom-made guided tour [24].
- Law, legislation and landing permits will limit the amount of flights that can be perform on a daily basis. The availability of trips depends on the weather. Insufficient visibility will have a negative impact on the amount of tourist or even cancel a flight.
- Unfortunately, not every active visitor is willing to pay the price of such a round trip. This is further explained in the next paragraph.

Tourists willingness to pay
The current pricing for a trip by helicopter is 150 euro per hour per person [17]. Based on the flight time to reach destination and hover around, a price per trip can be determined. If an average of five persons per trip is taken, the round flight to Vesting3hoek will cost 50 euro per person and the round flight to Kinderdijk will cost 100 euro per person. That gives

a turnover 250 euro per flight for the Vesting3hoek and 500 euro per flight for Kinderdijk. When on holiday, tourist are willing to pay something extra to have an unique experience. They often travel in groups and if reservations must be made, it can be planned to transport multiple persons in a helicopter. It is assumed that there will be an occupancy rate of 80% for tourist flights.

6-1-3 Events visitors

There are trade fairs and industrial exhibitions taking place in the Evenementenhal Gorinchem throughout the year. Each month, an average of four business events take place in the Evenementenhal. One event is a big-scale fair that attracts around 10,000 visitors. The other three events attract around 3,000 visitors each, due to being medium-scale fairs.

In order to calculate the target group, which can afford to pay for the helicopter service. The assumption is made that 10% of the visitors will have more than average income since this is a specific business event. Thus, in total approximately 1,900 visitors a month would be potential users.

Another assumption states that 50% of potential users would be willing to fly with helicopter to the target destination. This results in approximately 950 people that might use the service to fly to the Evenementenhal Gorinchem each month. Annually, around 11,000 people are willing to use transport by air to avoid the risk of getting stuck in traffic-jams. It has to be taken in account that since the type of events change each time, the origins of the customers change accordingly. If a visitor lives nearby, other types of transport can be in favour. The information related to the origins of customers is missing.

Another aspect that is reducing the number of customers, is the urgency of being on time. Not every visitor needs to be at the event on a specific time and in most cases, foreign guests rent a hotel room the day before the event. Future research can be done in better defining the main sources of this target group.

6-1-4 Medical assistance and emergency operations by helicopter

In 1995, the first medical emergency helicopter was positioned in Amsterdam. In the years that followed, the network of helicopters was expanded to six helicopters: four operational and two reserves. They are strategically distributed over the Netherlands, thereby covering the entire country to minimise response time. The purpose of this medical air assistance network is to deliver a doctor or surgeon as fast as possible on a location, where transport by road is not possible or sufficient. Furthermore, they provide transport of organs and medical assistance at major events. Each helicopter is dispatched around 1000 times per year [26]. The network could have a new medical centre situated in Gorinchem, based on the central location of the city. The hospital in Gorinchem already has a helipad for emergency use.

The medical hospital in Gorinchem or the patients are a potential customer. Patients are transferred from one hospital to another when time is critical, the transfer by helicopter could provide a solution. There are no numbers available for the amount of high urgent patient transfers from one hospital to the other. The nearest specialised big hospital from Gorinchem is the Erasmus Medical Centre in Rotterdam. In case a patient must be transferred, the likelihood of a transfer to Rotterdam is high.

It is difficult to determine the amount of flights per year for medical transport. The costs to operate a specialised medical helicopter are high and the willingness to pay is dependent on the urgency to transport a patient. An estimation of the profit of medical transport of patients is not possible at this stage. Therefore, customers for medical assistance by air will not be taken into account in the business model.

6-1-5 Government and third parties

In 2008, research by the Platform Nederlandse Luchtvaart has shown that almost half of the helicopter flights in the Netherlands are government related [27]. This includes law enforcement (police helicopters), medical intervention and flights for inspection of dikes, gas- and electricity lines. Furthermore, a small amount of helicopter flights are performed to make pictures or films. This is done by external companies who land a helicopter with camera equipment mounted in or outside the vehicle.

Medical intervention and the opportunity for a new medical emergency centre near Gorinchem is already described in the previous section. In the same way, this opportunity exists for law enforcement. It will not be discussed further, because the aim is to find profitable customers.

Destinations of government flights

The area surrounding Gorinchem is well suited for inspection flights by helicopter. The area consists of nature reserves and wetland areas that are not always easily accessible by car. The central location of the city in the Netherlands is favourable to cover a large area and reach inspection sites without losing time. A helicopter with camera equipment can be rented by film makers and television stations, to produce aerial shots. Big sport events like the Rotterdam Marathon and the Amstel gold race are examples of events that use aerial shots for broadcasting.

Amount of government flights

In order to get an estimation of the amount of flights per year, the provided numbers of the research by the Platform Nederlandse Luchtvaart are used [27]. Most flights are for inspection. The amount of helicopters that are used during sport events or for the use of aerial pictures is combined with the number of inspection flights. Approximately 10% of the helicopter flights per year are used for inspection or camera work [27]. Based on these numbers, an estimation of 410 flights for governmental use is made.

Government willingness to pay

The research done by the Platform Nederlandse Luchtvaart states that there is an expected growth in the request for inspection and measurement flights. Companies can save a lot of money if defects in their infrastructure can be spotted in time. Television stations and the film industry can make profit with footages taken by helicopter. Therefore, it can be concluded that the willingness to pay is high, due to the absence of alternatives.

6-1-6 Private helicopter landings

A limited amount of people in the Netherlands has a private helicopter. Heliport Gorinchem can provide a safe landing and parking place for them. In the Netherlands, there is currently only one commercial heliport, located in the harbour of Amsterdam. The number of private landings per year on heliport Amsterdam is not available, but there are numbers of private helicopter flights on other airports [27]. In this report, it is given that there are performed around 18000 private flights on Hilversum airport in 2007. Roughly 6% of the flights are performed by helicopters. In that year, 90 helicopters have been registered in the Netherlands. Of these helicopters, only a small part has been used for private use. Based on these numbers and the fact that Hilversum airport is situated near a larger city, a calculation has been made. This leads to an estimation of 500 private landings per year for Heliport Gorinchem.

First of all, landing fees are necessary to pay for administration, air traffic control, government taxes, security and services like parking of the helicopter. In order to determine the willingness of the customers to pay a certain amount of landing fees, the following elements are taken into account. For example the landing fee at heliport Amsterdam is 100 euro [28]. Therefore, the willingness to pay for landing at the heliport is set to be 100 euro.

6-1-7 Cargo services

Numbers about the amount of cargo transport by air are difficult to obtain. Railway and water transportation are cheaper per kilometre, since ships and trains can carry more cargo at once due to the cargo space they have available compared to helicopters.

Cargo transportation by water from Gorinchem to the Rotterdam harbour is already convenient for global companies such as Damen Shipyards and Van Oord. The size of parts that need to be transferred from one location to the next are big, such as vessels and dredger equipments. Furthermore, the real problem in Gorinchem is currently the long waiting times of passengers who get stuck in traffic congestion. Water transportation by ferries already offers a solution to the problem of cargo transfer. Therefore, the willingness to shift to air transportation of cargo is not anticipated within seven years.

6-2 Operation determination

The aim of this chapter is to set the services the project will offer. This can be seen in table 6-2. The total amount of passengers served is 16,680 and the total number of flights is 4,485 per year. In the previous section, the different customers are defined and analysed. From the analysis, it has become clear that the focus should be to serve business to business travellers and tourists, because they have clear destinations and are willing to pay additional costs. Table 6-2 gives an overview of the destinations that will be reached from Heliport Gorinchem, the amount of passengers per year and the willingness to pay per flight. To identify the maximum possible income, it is assumed that the aerial vehicle flies at full capacity.

To serve the business to business travellers with fast transfers, connections with the airports of Schiphol, Rotterdam and Eindhoven are provided. The attractions with most

Table 6-2: Definition of destinations

Parameter	Schiphol airport	Rotterdam airport	Eindhoven airport	Vesting-3hoek	Kinderdijk	Govern-ment	Total
Amount of passengers per year	8,490	1,460	4,480	1,000	1,250	n/a	16,680
Amount of flights per year	2,120	365	1,120	210	260	410	4,485
Willingness to pay [euro/flight]	630	620	580	300	600	n/a	2,730

visitors are Kinderdijk and the Vesting3hoek. Therefore, two routes are designed around the attractions. One around the Vesting3hoek and one around Kinderdijk. Also, the opportunity is provided for the government to rent a helicopter, as explained in subsection 12-2.

Depending on the size of the helicopter, the opportunity is offered to land at the heliport with other private helicopters. It is expected that 500 helicopters will use this per year. The landing fee is set to be 100 euro.

With the numbers in table 6-2, an amount of operations a day, is calculated to be fourteen on average. An operation means a departure or an approach to the heliport. In this the flights to the airports are defined to be single route, consisting only of a take-off or a landing at Gorinchem. The tourist and government flights are defined to consist both of a take-off and landing in Gorinchem.

Expected growth until implementation

It is likely that the numbers stated in table 6-2 will increase before the implementation of the project, because of an expected economic growth. The expected growth in business travelling is 2.5% and the expected growth in tourism is 3.0%, as mentioned by the Dutch institute for conventions and tourism [29]. The amount of customers for the first year after implementation is set to be at 70% of the total because it is assumed to take time to get familiar with the clients.

Chapter 7

Detailed product design

The previous chapters have described the preliminary work in order to come up with a detailed design. This work has lead to the choice of designing a profitable aerial network in Gorinchem, that is implementable within five years.

This chapter describes the detailed design process of the current project. Its purpose is to give the reader insight of all the choices that have been made to come up with a final design. Figure 7-2 shows an establishing demonstration of what the design should look like.

The detailed design has been divided into four interconnected parts. This can be seen in figure 7-1. The first design part is the vehicle design. As the project should be implementable within the short term, there is no possibility to design a completely new vertical take-off and landing (VTOL) vehicle. Therefore, the aerial vehicle design is focused on existing helicopters and possible technological improvements. This also means that the aerodrome will be a heliport. The second design part is the design of the air traffic management system. Every heliport should have a kind of air traffic management system. Research shows that the need for specific elements of this system depends on the type of flight rules and the airspace classification. Once the aerial vehicle and the type of flight rules are known, the next design part is the design of the heliport. This includes the location and the layout. Finally, the fourth design part is the design of the approach and departure routes. Once these routes are known, a check needs to be made if high objects should be removed. The approach and departure routes are also used to create noise contour maps. These maps show whether the operations at the heliport induce noise nuisance or not.

In table 7-1, an overview of the determined elements of the four design parts is given. Furthermore, it states in which (sub)sections of this chapter the design procedure of the elements is described.

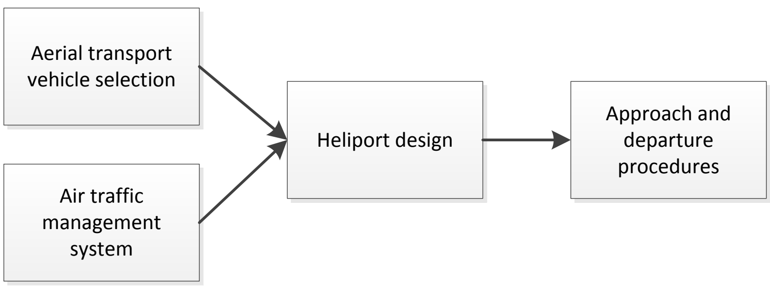


Figure 7-1: WFD of the detailed design process

Table 7-1: Determined elements of the four design parts of the project

Design part	Design element	Choice and or value	(Sub)section of explanation
Aerial vehicle transport vehicle selection	Selected vehicle	Eurocopter EC135 helicopter	7-1-1
	Technological improvements	Bluecopter	7-1-3
		Hybrid engine (diesel-electric)	7-1-4
Air traffic management system	Flight rules	Visual	7-2-2
	Airspace classification	G, uncontrolled	7-2-3
	Air traffic service provided	AFIS	7-2-4
Heliport design	Estimated required area size	20,860 m^2	7-3-1
	Site selection (GPS coordinates)	Avelingen (51°49'53"N 004°56'47"E)	7-3-2
	Type of heliport	Surface-levelled land-based	7-3-3
	FATO shape	Rectangular	7-3-3
	FATO dimensions	110 x 12.5 m	7-3-3
	FATO markings	White "H" at middle	7-3-4
	TLOF shape	Circular	7-3-3
	TLOF dimensions	2 spots: ⌀ 11 m	7-3-3
	TLOF markings	Yellow coloured circle	7-3-4
Approach and departure procedures	Routes	One northern, one southern	7-4
	Obstacle limitation	Mast removed	7-4-2
	Significant obstacles	Mast 184 m NW of heliport, height 40 m	7-4-2
		Bridge 500 m SW of heliport, height 31.7 m	7-4-2

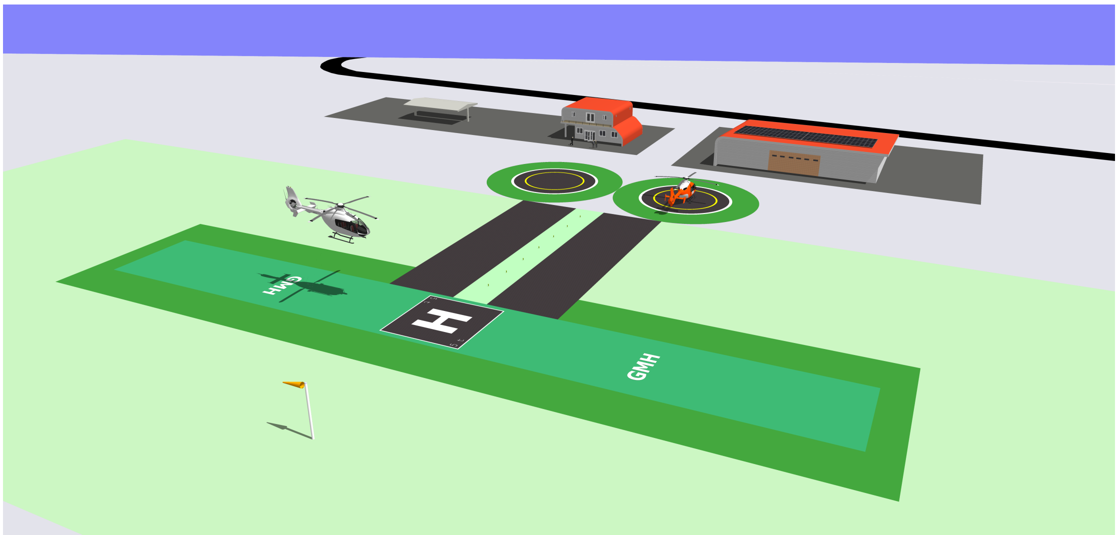


Figure 7-2: An establishing demonstration of the design

7-1 Aerial transport vehicle selection

As mentioned in chapter 5, the project should be implemented within a short term. A complete new design for a VTOL vehicle cannot be made in such a small period of time. It is therefore chosen to use an existing type of helicopter. The purpose of this section is to present the steps taken in the selection of a final helicopter design. This selection is performed as illustrated in the WFD in figure 7-3.

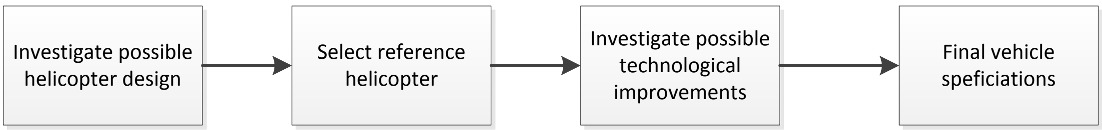


Figure 7-3: WFD of the aerial transport vehicle selection

The process starts with investigating possible helicopter designs. The next step is to select one reference vehicle. Subsequently, technological improvements should be investigated, to see if reductions in noise, emissions and fuel consumption are possible. Finally, the specifications of the vehicle can be described, by combining the information on the selected reference helicopter with the possibilities of technological improvements.

7-1-1 Selection of existing vehicles

Multiple helicopters have been investigated to select a suitable helicopter design. The fuel consumption and emission levels of each helicopter are investigated in order to choose the most environmentally-friendly helicopter design.

The exhaust gases that are discharged into the atmosphere are the result from the combustion of fuel. They are mainly composed of carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (soot), methane (CH_4), carbon monoxide (CO), unburned hydrocarbons (C_xH_x) and water vapour (H_2O). The only data on exhaust gases readily available for the selected helicopters is on CO_2 and NO_x.

A comparison has not been made for the different helicopter designs due to a lack of information regarding sound emission levels. The selected helicopters are all able to carry four or more passengers in order to meet the design requirements. The helicopter performance characteristics and emissions levels are presented in table 7-2.

Table 7-2: Performance characteristics of existing helicopters

Model	**Pax***	**Range [km]**	**Engine**	**Power [kW]**	**MTOW [kg]**	**Fuel consumption** [30] **[L/hr]**	**CO_2** [31] **[kg/hr]**	**NO_x [g/hr]**
Bell 206	5	693	1x Allison 250-C20B	310	1451	121	306	9.9
AS350	6	662	1x Turbomeca Arriel 2B	632	2250	170	431	14
Bell 407	7	598	1x Allison 250-C47B	606	2722	170	431	14
EC135	7	635	2x Turbomeca Arrius	473	2910	242	612	19.8
MD500C	5	605	1x Allison 250-C20	207	1157	87	220	7.1
Bell 222U	7	900	2x Lycoming LTS-101	505	3742	314	794	25.7
MD600N	8	429	1x Allison 250-C47	447	1860	155	392	12.7

* Passenger capacity includes the pilot

According to ICAO regulations, there must be emergency landing spots in case of engine failure if a single engine helicopter is used for commercial use [32]. In the case of a twin engine helicopter, it is possible to land safely with only one engine operating. Since the helicopter will be used in urban areas, it might be difficult to find space for emergency landing spots. Hence, a twin engine helicopter should be used. This leaves the Eurocopter EC135 and the Bell 222U as feasible helicopters.

In addition, the helicopters were compared on maintenance costs. However, this was difficult because in most cases the actual maintenance costs incurred in use tended to be around one and half to two times more than the costs estimated by the manufacturer. Also the comparison was made difficult by the fact that different manufacturers have different maintenance schedules. Hence, it is difficult to find commonalities for comparison. However, it was found that helicopters that were manufactured after the year 2000 tended to be cheaper to maintain than models that were manufactured before the year 2000. This is because older models have more frequency maintenance inspections per year than newer models. One other factor that made it difficult to compare maintenance costs is that the costs include the cost of inspection and the cost of replacing parts. With the same part having different lifetime limit on different models, there is no better way to see which model is cheaper to maintain in that respect.

However, despite the differences in maintenance schedules of different helicopters, assuming that all the helicopters have the same lifetime of twenty years, it has been found that the EC135 requires the least amount of maintenance for the entire lifetime. Also, when looking at the fuel consumption and emission levels of the two helicopter designs, it becomes clear that the Eurocopter EC135 is the most suitable. It has a lower fuel consumption compared to the Bell 222U and hence lower emission levels. Therefore, it has been decided to use the Eurocopter EC135 as the reference vehicle for further investigation.

7-1-2 Eurocopter EC135 helicopter specifications

The Eurocopter EC135 is a light, multipurpose, twin engine helicopter that offers room for one pilot with six passengers, plus room for an additional passenger or second pilot next to the pilot. The Eurocopter EC135 is often selected for police and ambulance services, as well as for private individuals and companies. The helicopter belongs to performance class 1 of the ICAO standards [32]. The relevance of this becomes important during the design of the heliport in section 7-3. A representation of the Eurocopter EC135 can be seen in figure 7-4. Figure 7-5 illustrates the general dimensions of the Eurocopter EC135.

The two most recent models of the Eurocopter EC135 are similar in performance, however differ in selected engines. The Eurocopter EC135 P2e makes use of two Pratt & Whitney PW206B2 engines, whereas the EC135 T2e makes use of two Turbomecca ARRIUS 2B2 engines. Specifications of the most recent Eurocopter EC135 can be found in table 7-3.

Figure 7-4: A representation of the Eurocopter EC135 helicopter [33]

Fuel consumption

During different phases of flight, helicopters consume different amounts of fuel. In order to get an indication of the fuel consumed during a typical mission, an average fuel consumption is taken. The average fuel consumption of jet fuel of the Eurocopter EC135 is equal to 242 L/hr.

Emissions

The average fuel consumption of the Eurocopter EC135 allows for a calculation of the carbon

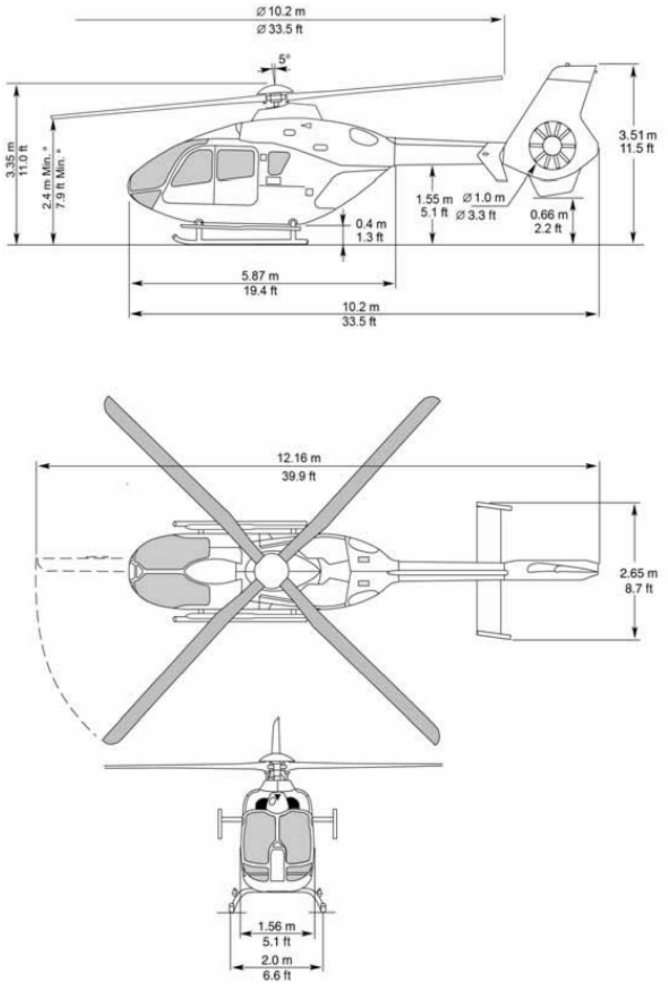


Figure 7-5: Dimensions of Eurocopter EC135 helicopter [33]

dioxide and nitrogen oxide emission levels [31]. Specifications of the EC135 concerning emissions of carbon dioxide and nitrogen oxides are 612,000 g/hr and 19.8 g/hr respectively.

Noise

Specifications regarding noise levels and limits of the Eurocopter EC135, in different phases of flight can be found in table 7-4. The noise levels and limits are low in comparison to other comparable helicopters, making it suitable for flying over densely populated areas. The Eurocopter EC135 is approximately 6.5 decibels below the ICAO standards concerning noise levels, making it one of the quietest helicopters in its category [34]. A 6.5 decibel noise reduction is to the human ear perceived as a noise reduction of approximately 50%.

Table 7-3: General specifications of the Eurocopter EC135 [33]

Parameter	Value
Empty weight [kg]	1,455
Maximum take-off weight [kg]	2,910
Cruising speed [km/hr]	254
Maximum speed [km/hr]	287
Range [km]	635
Service ceiling [m]	6,096
Greatest overall dimension [m]	12.16
Height [m]	3.51
Rotor diameter [m]	10.2
Undercarriage width [m]	1.56
Power [kW]	473

Table 7-4: Noise levels and limits during different phases of flight

Flight Phase	Measurements [dB(A)]	ICAO limits at 2910 kg [db(A)]
Flyover level	84.0	93.5
Take-off	88.6	94.5
Approach	92.7	95.5

7-1-3 Bluecopter technology

Eurocopter is part of the European Aeronautic Defence and Space Company (EADS). The helicopters developed by EADS will have new innovative technology applied to them in the short term. The technology aims at optimising the main rotors in such a way that the external noise is reduced and that the vibrations within the cabin are reduced. EADS has come up with two new technologies that have already been successfully tested and are ready to be implemented into new and existing helicopter designs. The first alteration is the blade shape, which is called Blue Edge. The second alteration integrates piezoelectric actuators into the trailing edge of the rotor blades, and is called Blue Pulse. A conceptual design of the Bluecopter can be found in figure 7-6, in which both the Blue Edge and Blue Pulse technologies have been applied.

The manufacturer has not yet released final data on the reduction of noise of the Blue Edge and Blue Pulse technology. EADS however has given indications of the noise reduction, based on actual flight tests, which can be taken as an indication of the total noise reduction [35] [36].

Blue Edge technology

The Bluecopter makes use of a revolutionary rotor blade shape, named the Blue Edge blade. This technology will lead to a reduction in noise generated by blade-vortex interaction. Blade-vortex interaction occurs when a rotor blade passes through or close to the tip vortices

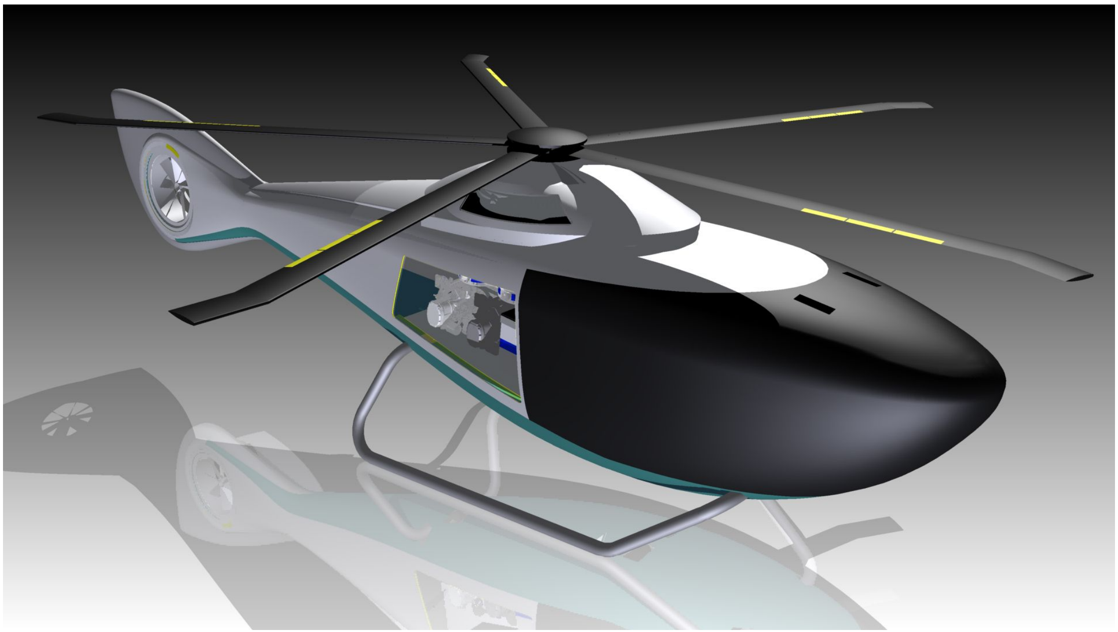


Figure 7-6: Design of the Bluecopter [35]

caused by a previous blade. This interaction causes a rapid, impulsive change in the loading of the rotor blade. This change in loading results in a high amplitude impulsive noise. The blade-vortex interaction noise is considered to be the predominant noise of a rotorcraft and hence the reduction of such noise will lead to an overall reduction of noise.

The Blue Edge main rotor, unlike usual rotor blade designs, makes use of a double-swept shape to reduce the noise created by the blade-vortex interaction. The double-swept shape allows the blade to interact with the vortex for a longer period of time. By doing so, it decreases the amplitude of the impulsive noise. Due to the longer interaction time, the impulsive characteristic of the blade-vortex noise is also smoothed out. The double-swept shape of the blade can be seen in figure 7-6.

Since July 2007, test flights have been performed using a five-blade main rotor on an Eurocopter EC155. The vehicle has made multiple flight hours in which it has successfully demonstrated a noise reduction of 3 to 4 decibels. The Blue Edge technology has been presented to the public during the Heli-Expo in February 2010. This new rotor blade design has demonstrated considerable noise reduction while also demonstrating very good blade performance. Eurocopter has therefore decided to implement the technology into the production process in the immediate future.

Blue Pulse technology

Another innovation used on the Bluecopter is the Blue Pulse technology. It is another way of reducing the noise due to blade-vortex interaction. For this technology, a rotor control system is used.

The innovative rotor control system uses piezoelectric actuators to reduce the interference of the rotor blade vortices from one rotor blade with the following one. Three actuator flaps are built into the trailing edge of the rotor blade, as figure 7-6 indicates. These flaps are able to fluctuate 15 to 40 times per second. The rapid movement of the fluctuation neutralises the blade slap noise of the blade-vortex interaction, resulting in a reduction of noise.

Besides a significant noise reduction, it will also considerably reduce the vibrations experienced in the helicopter. This reduction of vibrations increases passenger comfort, as well as service life of sensitive components, such as electronics. The cabin vibrations are reduced by up to 0.05 times the gravitational force, which allows for a near to "jet smooth" ride according to the manufacturer.

The technology of the Blue Pulse has been tested first in 2005 on a Eurocopter EC145. These tests have shown that the technology results in a noise reduction of up to 5 decibels. EADS is continuing to investigate the use of such a system and is developing a miniaturised version of the system for implementation into the production process. Currently, all the costs and maintainability aspects of the Blue Pulse system are explored. Like the Blue Edge technology, this one will also be available in the immediate future.

7-1-4 Hybrid helicopter

The corporate research and technology network department of EADS has been working on a diesel-electric hybrid helicopter for an extensive time. Such a diesel-electric hybrid helicopter makes use of a highly efficient opposed piston, opposed cylinder diesel engine in combination with an electric motor. The diesel engine and the electric motor are used to operate the main and tail rotors, and do not require a main rotor gearbox and tail rotor drive shaft compared to conventional helicopter engines.

The aim of EADS is to develop a reliable engine with a reduced carbon dioxide and nitrogen oxide footprint [37]. The diesel-electric hybrid system reduces the overall power demand and hence fuel consumption of the system, with the implementation of certain features. The objective of the manufacturer is to achieve a power-to-weight ratio which could be competitive with the conventional turbine engine. The hybrid engine design of EADS can be found in figure 7-7.

The diesel engines are designed to operate on algae-based biofuel which charge the two batteries, as can be seen in figure 7-7. By using two generators, the electrical power is delivered to the electrical motors of the main and tail rotor to drive the rotor blades. The batteries are used as a buffer storage. The capacity of the batteries is high enough to fully function on batteries alone for a limited period of time, for example during take-off and landings. This allows for quieter take-offs and landings, hence significantly decreasing the noise impact at locations near the heliport.

The hybrid system is designed in such a way that the diesel engine operates at its most efficient point, charging the two batteries. The power to the main and tail rotors are then managed by the power electronics which are linked to the two batteries. The design of an electrically driven rotor blade allows for flexible and power-optimised rotation settings, in comparison to conventional helicopter engines and gearboxes.

Since the main rotor blade is not driven by a drive shaft, the electric main rotor drive

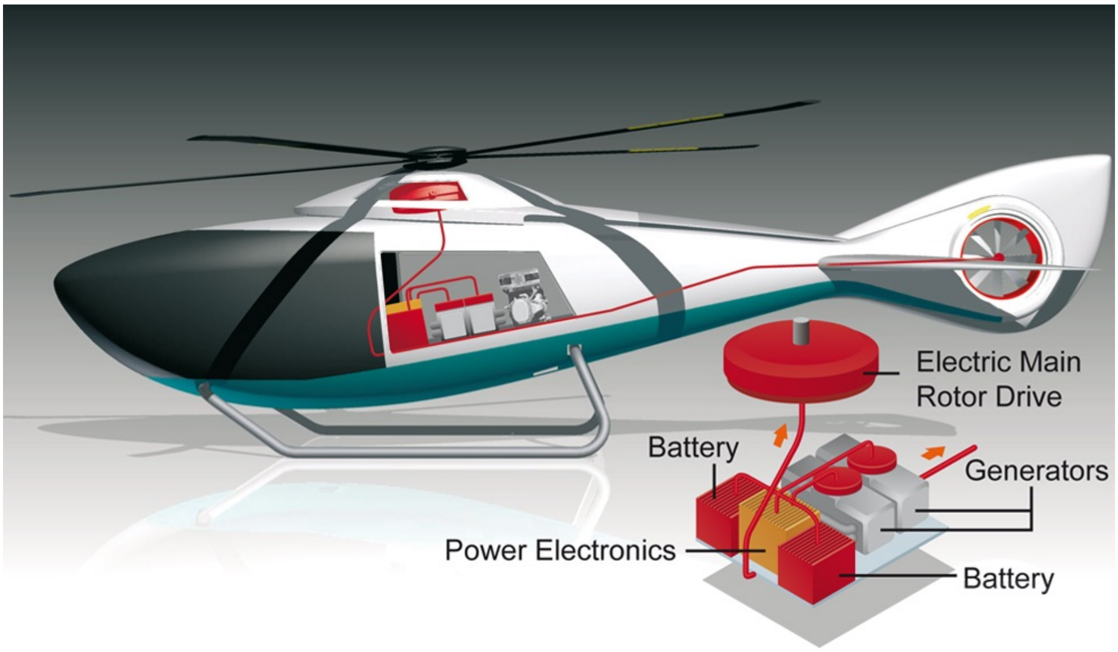


Figure 7-7: Design of a diesel-electric hybrid helicopter [37]

can be tilted for forward thrust while the fuselage remains in its optimum position with respect to the aerodynamics of the vehicle. This reduces aerodynamic drag, resulting in a lower power demand and a lower fuel consumption. The tail rotor can be turned of during cruise flight to further reduce power demand and hence fuel consumption. The reason for this is that the aerodynamic forces of the helicopter can be used to maintain directional control.

The investigation of a diesel-electric hybrid propulsion have shown that it has the potential to decrease fuel consumption by 50% compared to a twin-turbine helicopter such as the Eurocopter EC135 [38]. The engine itself is 30% more fuel efficient than a conventional turbine engine, while other fuel saving features which are described above decrease the total fuel consumption by 50%. Carbon dioxide and nitrogen oxide emissions are reduced by 50%, decreasing the footprint of the helicopter over its life cycle. The manufacturer EADS has reported to start implementing diesel-electric hybrid systems in single-engine models such as the Eurocopter EC120, AS350 and EC130 [39], [40]. The hybrid engine will be used in designs such as the EC135 in the coming years and are reported to be ready for commercial use before 2020 [41].

7-1-5 Selected vehicle

As described in the previous subsections, the selected helicopter that will be used in the initial phase of the project is the Eurocopter EC135. It is assumed that new proven technologies shall be implemented into the existing design of the Eurocopter EC135 by 2020. The new technologies that shall be implemented will contribute significantly to the reduction of fuel consumption, emissions and noise levels.

Fuel consumption
As mentioned earlier, the fuel consumption of a diesel-electric hybrid engine will decrease by 50% in comparison with the traditional turbine engine of the Eurocopter EC135. The average fuel consumption for a hybrid is found to be 121 L/hr.

Emissions
The hybrid engine will decrease both carbon dioxide and nitrogen oxide emissions by 50%, because of the reduced fuel usage and the reduced emission from the biofuel respectively. The carbon dioxide and nitrogen oxides emission levels of a Eurocopter EC135 with a hybrid engine are 306,000 g/hr and 9.9 g/hr respectively.

Noise
Eurocopter's Bluecopter technology is assumed to be implemented into the EC135 within five years. The Blue Edge technology is reported to result in a 3 to 4 decibels noise reduction. The Blue Pulse technology is reported to decrease noise reductions by 5 decibels. The hybrid system that is assumed to be implemented into the Eurocopter EC135 within 5 years, will also contribute significantly to lower sound emissions during the take-off and landing phases. There is however no data available which shows the noise reduction of both technologies combined. For this reason, a total decrease of 5 decibels is assumed for all phases of the flight, for both the limit as well as the overall level. The new noise levels and limits of the different flight phases can be found in table 7-5.

Table 7-5: Noise during different phases of flight

Flight phase	Measurements [dB(A)]	ICAO limits at 2910 kg [dB(A)]
Flyover level	79.0	93.5
Take-off	83.6	94.5
Approach	87.7	95.5

7-2 Air traffic management system

As mentioned in section 2-4, safety is one of the requirements of the entire project. By providing elements of an air traffic management system, safe and efficient movement of aerial vehicles during all phases of flight can be ensured. The purpose of this section is to present all the steps taken in the selection of the specific elements of the air traffic management system. After determining the specific elements of the air traffic management system, the next step is to design the approach and departure procedures for the selected heliport location. These procedures are necessary to create noise contour maps and to maintain safe and orderly flow of air traffic in uncontrolled airspace. The WFD in figure 7-8 gives an overview of the steps taken in designing the air traffic management system and the approach and departure procedures.

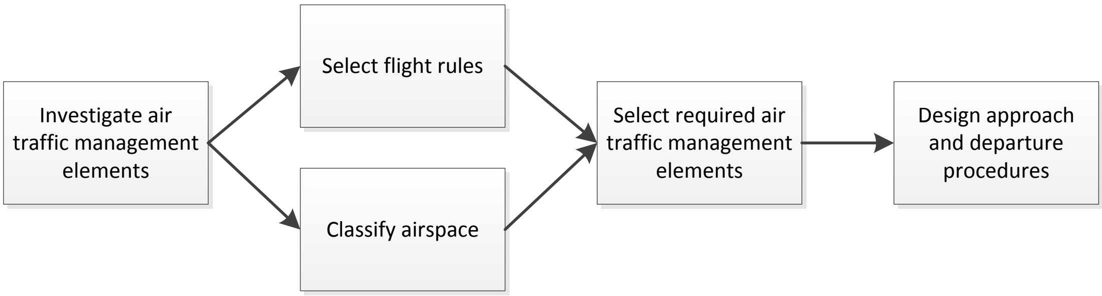


Figure 7-8: Work flow diagram of air traffic management element selection

The process starts with a general introduction on air traffic management, to clarify the steps taken. The actual design of this system starts with determining the flight rules and classifying the airspace. The selection of the flight rules and the airspace classification combined, will determine the need for specific elements that are required. The final step in this process is to design the approach and departure routes. These routes are necessary to calculate the noise impact from the operations. The noise impact and the noise contour map will be explained in section 8-3.

7-2-1 Air traffic management

Air traffic management is the aggregation of airborne and ground based functions and services to ensure safe and efficient movement of aerial vehicles during all phases of flight. It includes air traffic flow management (ATFM), air space management (ASM) and air traffic service (ATS) [42].

- **ATFM**: the strategic planning to control the flow of air traffic. It is used to match demand with available capacity, in order to minimise congestion. In Europe, the Central Flow Management Unit of Eurocontrol performs this task [43].
- **ASM**: the function that increases availability of the airspace for civil flights. ASM is a national function [42].
- **ATS**: the measures and services aimed at providing information necessary to perform safe and efficient flights. Aerodromes are responsible for providing this function. According to ICAO Annex 11, the need for the provision of ATS is determined by factors such as the type and density of air traffic involved, and by meteorological conditions [44]. Due to the number of elements involved, it has not been possible to develop specific data to determine the need for ATS in a given area. According E. de Both [45] from Air Traffic Control the Netherlands (LVNL), ATS includes the following:

- **Flight information service (FIS)**: provides information necessary for safe and efficient flights.
- **Air traffic control (ATC)**: prevents collisions between aircraft, maintains an orderly flow of traffic and minimises environmental impact such as noise.
- **Alerting service (ALS)**: notifies and assists appropriate organisations regarding aircraft in need of search and rescue.

In order to determine the ATM elements that will be provided at Gorinchem's heliport, it is necessary to analyse the type of flight rules and the airspace classification. It will become clear that these elements combined will determine the need for elements of the ATS system. The following is an example of this: if IFR flights will be operated at the heliport, a kind of system is required to ensure separation between different helicopters. Usually, this is ATC. However, it is also possible to fly IFR in uncontrolled airspace. This, however, raises safety issues. Below, the flight rules and the airspace classification are elaborated on.

7-2-2 Determination of the flight rules

Flight rules are regulations that determine under which operating conditions pilots are allowed to control aircraft. A division can be made between visual meteorological conditions (VMC) and instrument meteorological conditions (IMC). The type of flight rules depends on meteorological conditions and the type of airspace that the aircraft is operating in. There are two types of flight rules are visual flight rules (VFR) and instrument flight rules (IFR).

Visual Flight Rules
VFR are regulations that allow pilots to navigate by themselves. As mentioned in the lecture notes of the Aerospace Engineering master course AE4444, Air Traffic Management [43], pilots are responsible for the separation of aircraft. This means that ATC is not required. In the Netherlands, the following rules for flying VFR with helicopters apply.

Firstly, VFR flights are only allowed when in VMC. The minimal visibility for different airspace classes can be found in appendix D-1. Secondly, NACA mentions that, due to the risk involved, night VFR flights in the Netherlands are only allowed for helicopter medical emergency service, police and search and rescue flights [46]. Unlike in other European countries, other helicopters are not allowed to fly VFR outside the universal daylight period (UDP) in the Netherlands, as mentioned in the Integrated aeronautical information package (AIP) in ENR 1.2, paragraph 3.1 [47]. Figure 7-9 indicates the UDP of the Netherlands in 2012. Helicopter VFR flights are only allowed at times in between the red and blue line. It is assumed that the operating hours are between 7:00 and 19:00 on average .

Instrument Flight Rules
IFR are regulations when instruments are used for navigation. This results in a larger utilisation of the heliport, as pilots are allowed to fly at times outside the UDP and when visibility criteria for VFR are not met [48]. Flying IFR means that pilots might not be able to ensure separation between vehicles. This can be solved by offering air traffic control (ATC) or limiting the number of operations per hour by providing ATFM locally [45].

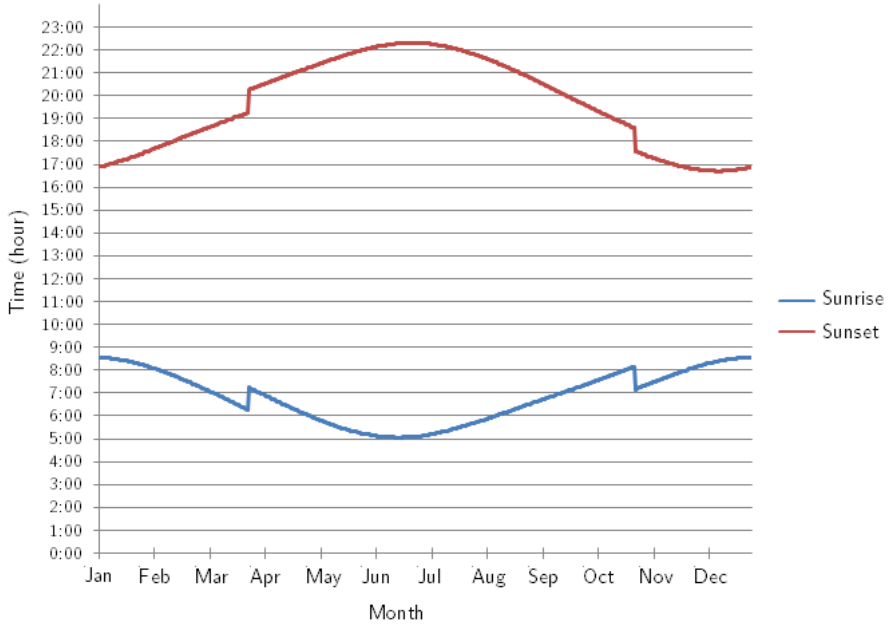


Figure 7-9: Uniform daylight period in 2012 in the Netherlands [47]

IFR operations require more investment costs than VFR operations, as a number of specifications should be satisfied. First of all, it is noted in JAR-OPS 3.940 that pilots should have a valid instrument rating [49]. Secondly, to fly outside UDP, pilots should have a night qualification, as mentioned by B. Fischer [50]. In other European countries, this qualification allows pilots to fly VFR outside the UDP. However, in the Netherlands, this night qualification is only valid when the pilot also holds a valid instrument rating. Thirdly, the AE4444 lectures notes mention that helicopters should be equipped with suitable instruments and navigation equipment to allow for communication and navigation in low visibility conditions [43]. Finally, the heliport should have suitable instruments to allow take-offs and landings. An example of such instruments is the Instrument Landing System, where an approach path towards the runway is provided.

Selected flight rules

In the short term, only VFR flights will be allowed to operate at the heliport. There are several explanations for this. According to E. de Both [45], all helicopters currently operate under VFR conditions at heliports in the Netherlands. Once the helicopters are airborne, pilots can switch to IFR, in order to enter VFR prohibited areas. An example of this are off-shore helicopters that fly IFR in uncontrolled airspace. In this case, ATS routes are used to guide the off-shore helicopters towards their destination. In the end, these helicopters also take off and land visually. Furthermore, for having only seven approaches and seven departures a day, the benefits of being able to fly under weather conditions that do not allow VFR will not outweigh the expenses of the required instruments and licensing for flying IFR. Implications of only allowing VFR flights are the possibility of cancellations due to weather conditions and not being allowed to fly at times outside the universal daylight period.

7-2-3 Airspace classification

After determining the flight rules applicable to this project, the next step is to analyse the airspace the vehicles are flying in. According to the AE4444 lecture notes, airspace can be classified as being controlled or uncontrolled. In controlled airspace, pilots should fly according to routes determined by the ATC. The main objectives of controlling the airspace are to ensure orderly flow of traffic and to prevent collisions. In controlled airspace, ATC, FIS and ALS are provided. In uncontrolled airspace, pilots are free to navigate by themselves. In this case, ATC is not provided; FIS and ALS can be provided, but this is not required.

ICAO airspace classification
The ICAO has classified seven airspace classes: A to G. AIP Netherlands describes these classes as follows: "*Classes A up to and including E are controlled airspace, advisory service is provided in class F airspace and flight information service is provided in class G airspace*" [47]. AIP Netherlands has slightly adjusted the ICAO airspace classification: they are using different minimum flight visibility in certain classes of airspace and they are not using airspace class F. Appendix D shows properties of the different airspace classes in the Netherlands.

Selected airspace classification
Currently, all autonomous heliports in the Netherlands are uncontrolled [45]. As the number of operations in the short run is limited to fourteen a day, as explained in section 6-2, there is no need to control the airspace around Gorinchem. It is therefore decided to assign airspace class G around the heliport, because this is the only uncontrolled airspace used in the Netherlands.

7-2-4 Air traffic service provided

As mentioned in subsection 7-2-1, ATS is usually the only element of air traffic management that is provided locally. The need for ATS depends amongst others on the number of aircraft types, the traffic density and weather conditions. For the first number of years, one type of helicopter will be used and the density of air traffic will be low. Therefore, ATS it is not required at the heliport. However, as safety is one of the main factors for the social acceptance of the implementation of a heliport, ATS will be provided.

In subsection 7-2-1, the elements of ATS are mentioned as being FIS, ATC and ALS. As it has been decided to classify the airspace as Class G, ATC is not required. The two remaining elements of ATS can be combined by using an aerodrome flight information service (AFIS) officer. AFIS is an intermediate step between no service at all and an aerodrome control service. This is currently used at Lelystad airport [45]. According to Eurocontrol, AFIS is used to provide information useful for the safe and efficient conduct of aerodrome traffic [51]. It is locally provided by an AFIS unit, which provides flight information service (FIS) and alerting service (ALS) to all aerodrome traffic. The officer maintains a continuous visual watch during the operation times of the aerodrome. Examples of information that should be provided are:

- local traffic information;
- occupation of landing spots;
- essential information on aerodrome conditions, such as snow on the runway or construction or maintenance work;
- assistance to appropriate organisations regarding aircraft in need of search and rescue.

7-3 Heliport design

As mentioned in section 4-2 the final concept is based on a heliport situated in the suburbs on Gorinchem. Therefore, a site in the suburbs of Gorinchem should be selected for the final design. After the heliport site is known the design of heliport itself can begin. The purpose of this section is to present the steps taken in selecting the heliport site and the design of the different parts of the heliport. The WFD in figure 7-10 shows the process for the heliport design.

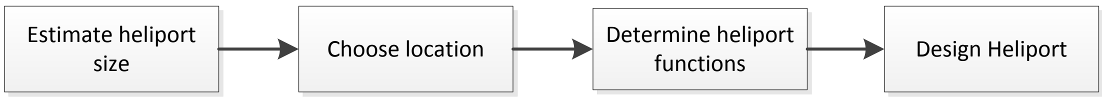


Figure 7-10: Work flow diagram for the heliport location selection and design

In designing the heliport, the first step is to estimate the heliport size. The heliport has to comply with regulations and certain conditions. These conditions determine the required area for a heliport and is discussed in subsection 7-3-1. Next, a site that suites certain criteria and the minimum required area size best is chosen. This is explained in subsection 7-3-2. After the location is selected, the various operations, services and characteristics desired at the heliport are established and is worked out in subsection 7-3-3.

The final site is determined to be near the industrial estate Avelingen in Gorinchem. Provisionally, the site is called Transferium Avelingen.

7-3-1 Conditions and estimated area

A number of laws and regulations have to be taken into account in order to build a heliport. In the Netherlands, the provincial government has the authority to give permission for building a new heliport. A request to build a heliport must comply with the national law for aviation. It must also comply with safety regulations, and noise and environmental pollution restrictions set up by the province. Each province is free to adapt their policy with additional restrictions to regulate the development of a heliport or to safeguard the residential areas around the heliport.

The province of Zuid-Holland has developed a policy regarding new heliports for the period 2008 - 2020 [14]. This policy distinguishes between heliports with a social or a utility function, and commercial and private heliports. In section 6-1, it can be read that the heliport shall not only have a social or utility function, but also a commercial one. This means that the request for a new heliport has to be checked on compliance with strict regulations. These are set up due to the high noise pollution of helicopters. The regulations are as follows.

- The quality of the environment shall not deteriorate in the future.
- The development of heliports is limited to one for each city area.
- The heliport area shall be situated 500 m away from a residential area to avoid noise peak loads disturbance. Figure 7-11 gives the 500 m zone around the heliport.
- A noise and risk contour map of the area around the heliport shall be provided. The noise is not allowed to exceed 48 L_{den}.
- The heliport area shall be situated 1000 m away from sanctuaries.
- The take-off and approach routes shall prevent flying over sanctuaries and residential areas.
- The operation time shall be limited to certain hours and days in a year.

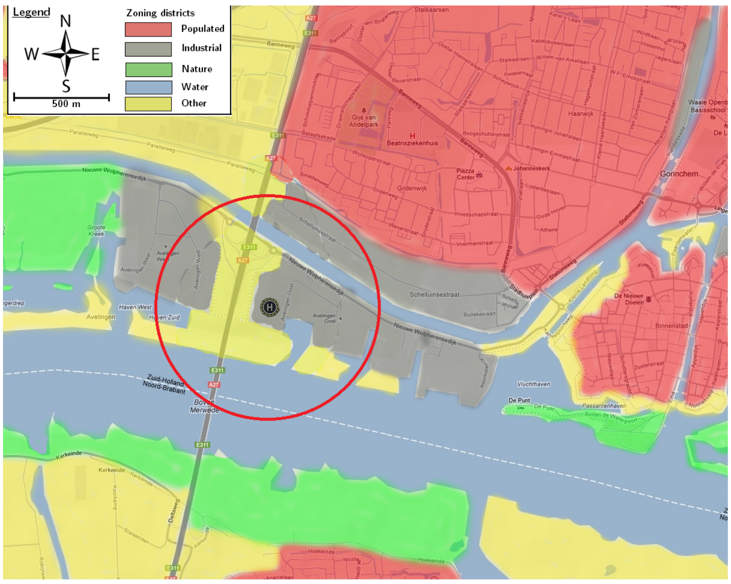


Figure 7-11: The populated area is outside the 500 m zone.

Safety contour map

One of the mandatory parts to get a provincial order for constructing a heliport is the provision of a risk contour map. This map shows the area around the heliport where there is a risk of a fatal casualty of one in a million. Due to the complexity of such a risk map, it is not created for this project.

Factors related to heliport site selection

From section 6-1, the demand for a helicopter service is known. The demand refers to the amount of passengers per hour that the heliport has to be able to manage. The next step is to choose a site that can satisfy this demand as best as possible. A heliport site selection can be done while taking into account several factors. Horonjeff, et al. (2010) have set up the factors listed below [52]. These factors are based on earlier development of heliports.

- The most suitable sites to serve potential customers.
- The provision of minimum obstructions in the approach and departure areas.
- The provision of minimum disturbance from noise and desirable site with respect to adjacent land use.
- The provision of adequate access to surface transportation and parking.
- The cost to acquire and develop.
- The provision of two approach paths separated by at least 90° and orientated with respect to prevailing winds.
- The avoidance of traffic conflicts between helicopters and other air traffic.
- The consideration of turbulence and visibility restrictions presented by nearby buildings.
- The provision of emergency landing areas along the entire route for single-engine helicopters.

Finally, there are two factors originated from the project itself. The first one is obtained from section 4-2, while the second one is related to section 2-4.

- The heliport site should be as close as possible to the city centre.
- There should be enough place for expansion of the heliport in the future.

Approximation of required area

A certain amount of area is required to build the heliport. Area is needed for the arrival, departure and surface movement of helicopters, but also for buildings, installations, and equipment. Sizes of these types of area are based on the dimensions of the type of helicopter to be used and the kind of customers to be expected. In the introduction of this chapter, it is assumed that two helicopters will be used when the heliport starts operating. Eurocopter

EC135 helicopters will be used as can be read in section 7-1-2. The kind of customer is defined in section 6-1. In essence, people on high incomes are expected at the start of heliport operation. In the list below the methods to approximate the area sizes and the actual minimum sizes of area needed are stated below.

- **Area for the arrival, departure and surface movement of helicopters**

  This type of area is determined in subsection 7-3-3 hereinafter. It should be at least 20,115 m^2.

- **Area for buildings, installations, and equipment**

  - *Hangar*

    In particular, a hanger is needed for protective storage, maintenance and repair of the helicopters. The hanger should have a width of 20 m, a length of 30 m and a height of 5 m. These dimensions fulfil the condition of necessary clearance for the total length, width and height of two helicopters. The area for the hanger should be at least 600 m^2.

  - *Passenger building*

    Next, a passenger building is necessary at the heliport. This should provide space for the following passenger activities: waiting and circulating, and check-in queues. It may be possible that two helicopters need to operate at the same moment with the maximum number of passengers. The Eurocopter EC135 has a seating capacity of 6 passengers. It could mean that 12 passengrs need to have certain space. Therefore, the area of the passenger building is determined to be 100 m^2. The reason for this is to provide a comfortable waiting area for the passengers at the heliport and also administrative offices. It has to be mentioned that the area is the ground area required for the building and not the total floor area of the building.

  - *Fuel depot*

    The amount of fuel that needs to be stored is determined in subsection 7-3-3. An amount of 9,000 L might be needed for fuel storage on a weekly basis. Hence, 10 m^2 is reserved for a possible fuel depot.

  - *Car park*

    The specific type of people will arrive at the heliport by using a taxi transfer. The parking space for one car is 4.5 m by 2.4 m [53]. Hence, the area of one parking place is equal to 10.8 m^2. A minimum of four parking spots is planned because the taxi's only pick up and bring the clients and after that they leave. A minimum car park area of 45 m^2 is needed to provide the taxi service. This parking are can be expanded as operations grow.

The minimum required area for the heliport is determined by adding all the areas listed above together. This will result in an approximated area size of 20,860 m^2.

7-3-2 Selection of possible sites

In the midterm report, possible heliport sites around Gorinchem are found which could comply with the regulations of the province Zuid-Holland. Figure 7-12 shows them on a map as coloured fields with a letter and a helicopter icon. Here, the green fields (A, C, D and E) indicate the sites which do comply with the regulations. The orange field (B) indicates the site that partially complies with the province regulations and may comply fully with these regulations after more detailed investigations. In the figure, another helicopter icon can be noticed. This icon indicates the hospital Beatrixziekenhuis which provides Helicopter Emergency Medical Services [54].

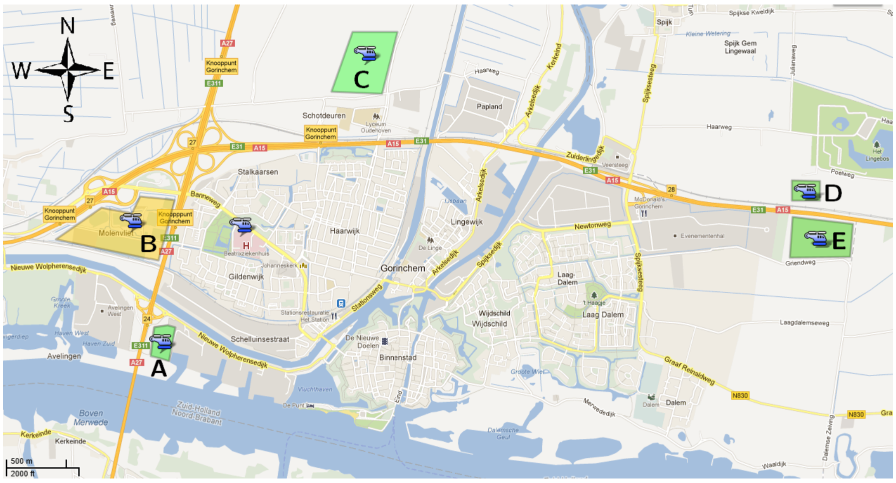


Figure 7-12: A map of the possible heliport sites around Gorinchem [15]

From all the possible sites, one single site should be selected. From section 4-3, the heliport location should be in the suburbs of Gorinchem. Site C, D and E are not feasible then because they are located outside the city limits. Site B is not feasible in the short term. The current sport facilities on this site shall not disappear in this period. The disposal of sites B, C, D and E results in the only remaining site A.

A recent news item has shown that space is becoming available at site A, because the company currently situated there will be closed [55]. It has to be said that the sites B, C, D and E can still be considered in the long-term phase of the project. For example, helipads can be made at these sites.

Transferium Avelingen

Site A is near the industrial estate Avelingen in Gorinchem. From now on, site A has the provisional name Transferium Avelingen. An indication of the location is given in figure 7-13. In essence, it is a very good site to build a heliport because of its accessibility. These advantages are listed below.

- It is situated along an underlying road to the city centre of Gorinchem.

- It is close to the motorways
- Is is close to the railway station [56]
- It is situated along the waterway Boven-Merwede, which can be navigated by ferries.

A map of the site can be seen in figure 7-13.

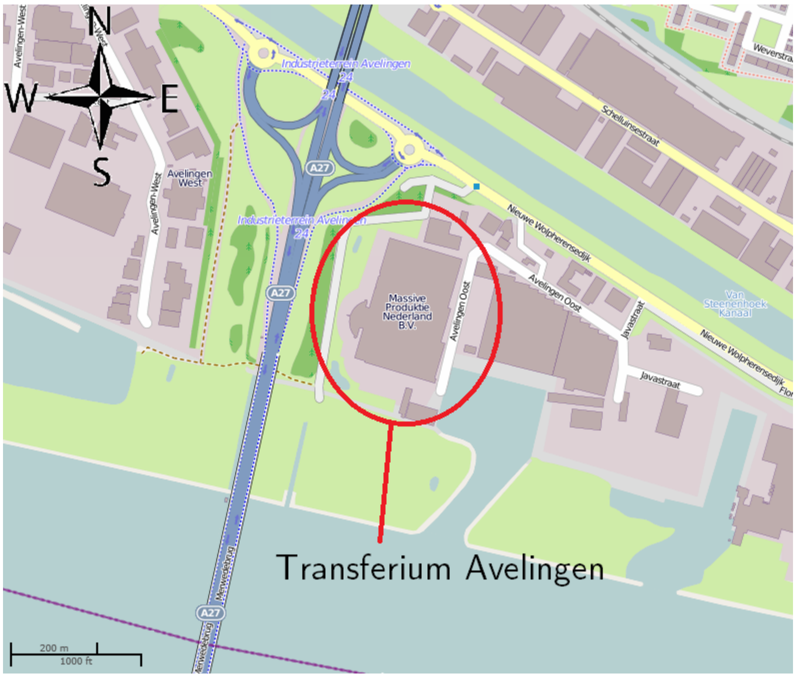


Figure 7-13: Transferium Avelingen in Gorinchem [57]

7-3-3 Heliport layout

The next main step in the heliport design process is the design of the layout of the heliport. In essence, this subsection deals with the physical characteristics of the heliport for the arrival, departure and surface movement of helicopters.

The design of the heliport has been done according to the international standards and recommended practices set by the International Civil Aviation Organization (ICAO). The leading document that has been used is Annex 14, Volume II, Heliports (2009) [58].

Physical characteristics

A surface-level land-based heliport shall be developed on the chosen site as described in subsection 7-3-2. From subsection 7-4 herinafter, it is clear that the heliport shall provide the possibility to take-off in two opposite directions. In section 7-1-2, it can be found that the Eurocopter EC135 helicopter shall be used. It is classified to operate in performance class 1. Reference is made on this type of helicopter in order to come up with a physical characterisation of the heliport.

Figure 7-14 shows a plan view on which all the main physical characteristics with certain dimensions are indicated. This is shown at the beginning of this paragraph to get a clear overview. All the required physical characteristics for the heliport are described below. For clarity's sake, the definitions according to the ICAO and applied to the heliport for this project are italicised.

- **Final approach and take-off area**

  The final approach and take-off area (FATO) is the defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. The area includes the rejected take-off area available, because it is to be used by helicopters operated in performance class 1.

  The heliport shall have one FATO. One will be satisfactory for the number of flights to performed both in the short and in the long term. The FATO shall have a rectangular shape with a width of 12.5 m and a length of 100 m. The latter value is based on the fact that rejected take-off areas are needed. The rejected take-off lengths are determined to be 50 m from the centre of the FATO. This is chosen in accordance with the high obstacles situated around the location as described in subsection 7-4-2 hereafter.

- **Helicopter clearways**

  The helicopter clearways are the defined areas on the ground, selected and prepared as suitable areas over which helicopters operated in performance class 1 may accelerate and achieve a specific height.

  The heliport shall have two helicopter clearways to take-off in the two opposite directions. They shall be located beyond the end of the rejected take-off area available. The length shall be 56.5 m in the short term. This value is the distance between the edges of the short- and long-term safety areas in a certain direction. It is recommended that the width should not be less than that of the associated safety area. It can be read in the item about safety areas below, that this width is 25 m in the short term. The width will increase to 90 m in the long term. Hence, there is already the possibility to have a 90 m helicopter clearway width.

- **Touchdown and lift-off area**

  The touchdown and lift-off area (TLOF) is the area on which a helicopter may touch down or lift-off.

  Two TLOFs shall be provided at the heliport as it is assumed that two helicopters may be in operation at the same moment. The TLOFs shall be collocated with the helicopter stands. The TLOFs shall have a circular shape with a diameter of 11 m.

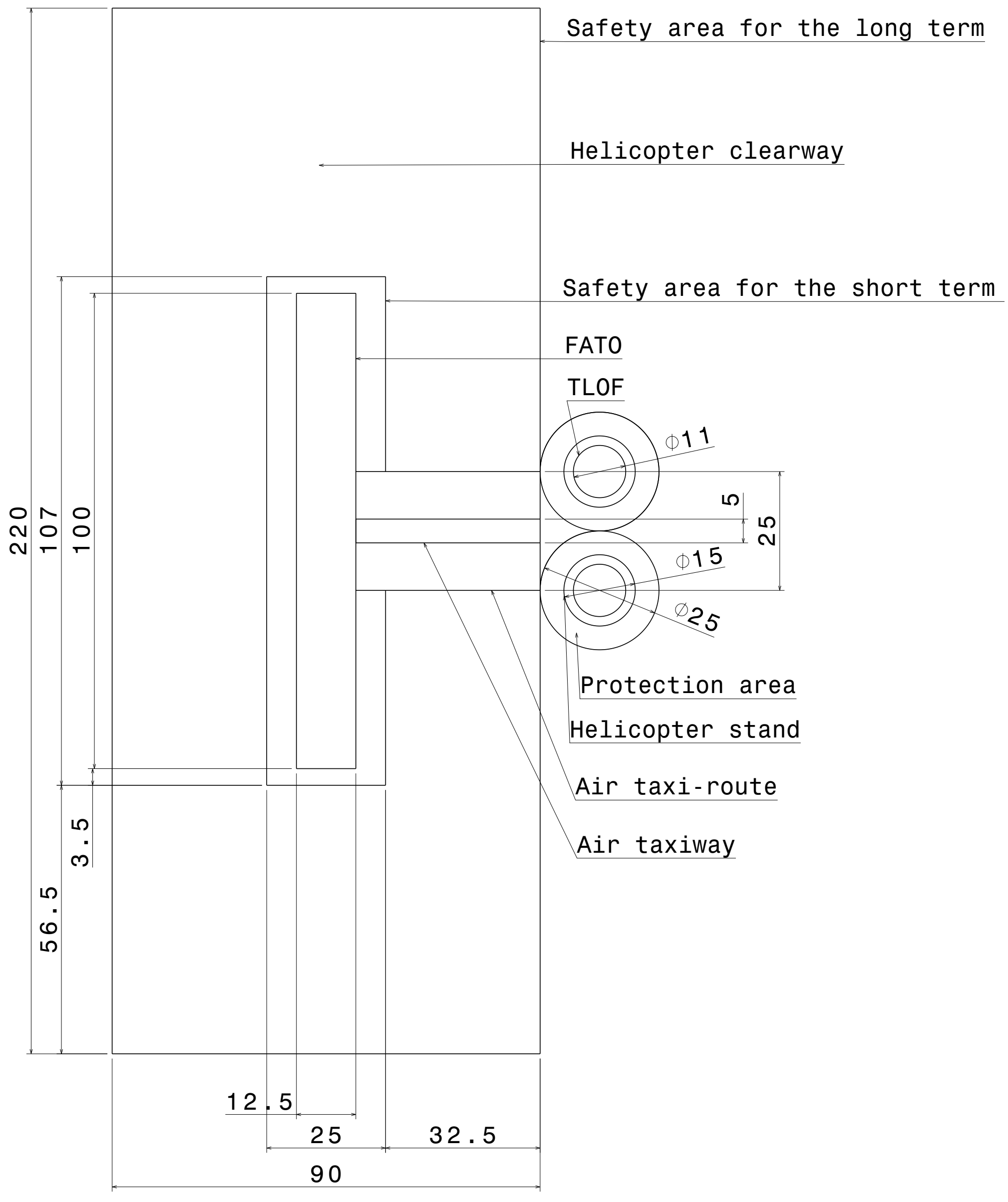


Figure 7-14: Heliport plan of the main physical characteristics with dimensions in metres

- **Safety areas**

  The safety areas are the defined areas on the heliport surrounding the FATO which are free of obstacles, other than those required for air navigation purposes, and intended to reduce the risk of damage to helicopters accidentally diverging from the FATO.

  The FATO shall be surrounded by a safety area. In subsection 7-2-2, it can be read that helicopters shall only operate in VMC in the short term. The safety area surrounding the FATO shall extend outwards from the periphery of the FATO for a distance of at least 3.5 m and each external side of the safety area shall be at least 25 m. It follows that the safety area shall have a width of 25 m and a length of 100 m + 2 × 3.5 m = 107 m. In the long term, it will become possible for helicopters to operate in IMC. In the future, the safety area surrounding the FATO shall extend laterally to a distance of 45 m on each side of the centre line and longitudinally to a distance of at least 60 m beyond the ends of the FATO.

- **Helicopter air taxiways and air taxi-routes**

  Helicopter air taxiways are defined paths on the surface established for the air taxiing of helicopters. Air taxi-routes are the defined paths established for the movement of helicopters from one part of the heliport to another. Air taxi-routes include helicopter air taxiways which are centred on air taxi-routes.

  Helicopter air taxiways are intended to permit the movement of helicopters above the surface at a height normally associated with the ground effect and at ground speed less than 37 km/hr.

  The width of the helicopter air taxiway shall be 5 m. The helicopter air taxiway has to be centred on the air taxi-route. On each side of the centre line, the helicopter air taxi-route needs to extend symmetrically for a distance equal to 25 m.

- **Aprons**

  Helicopter stands are aircraft stands which provide for parking helicopters and where ground taxi operations are completed or where helicopters touch down and lift-off for air taxi operations.

  The heliport needs to have two helicopters stands, because two helicopters are used in the short term. The helicopter stand is circular and has a diameter of 15 m Because the helicopter stand is used for turning, a protection area is needed. The dimension of the helicopter stand and the protection area needs to be 25 m. This dimension is also more than sufficient to allow taxi-through. The protection area of the helicopters stands and their associated taxi-routes shall not overlap, becasuse simultaneous operations can take place.

7-3-4 Other physical aspects

Besides all elements of the heliport design mentioned before, there are a number of other physical aspects. These elements are visual aids, used to support safe operations, refuelling facilities and firefighting services.

Visual aids

Visual aids are used to support visual operations in visual meteorological conditions. There are different kinds of visual aids, such as markings and lightings. A heliport which will only be used in daylight and under appropriate visibility conditions requires markings and does not need lightings [58], [59]. The following visual aids should be provided at the heliport.

- Wind indicator: provides the wind direction and an indication of the wind speed. At least one should be located at the heliport. The characteristics can be seen in figure 7-15a.
- Heliport identification marking: identifies the heliport as such. It is a white letter "H", located in the middle of the TLOF and orientated with the cross arm of the "H" at right angles to the preferred final approach and take-off directions.
- Touchdown and lift-off area marking: outlines the limits of the TLOF area. It is a continuous white line with a width of 30 cm. At the heliport there are two helicopter stands that have a TLOF inside. The TLOF marking shall be located such that when the pilot's seat is over the marking, the undercarriage of the helicopter will be inside the load-bearing area.
- Touchdown marking: indicates the specific position where the helicopter can park. It is a yellow coloured circle and has a line width of 0.5 m.
- Air taxiway marker: shows the pilot how to taxi to the helicopter parking stand. They are located along the centre line of the air taxiway and are placed at 5 m interval. The height of the air taxiway marker should not be higher than 35 cm above the surface. the colours are yellow green yellow. The characteristics can be seen in figure 7-15b.
- Heliport name marking: alphanumeric designator of the heliport. The colour of the name marking can be any colour.

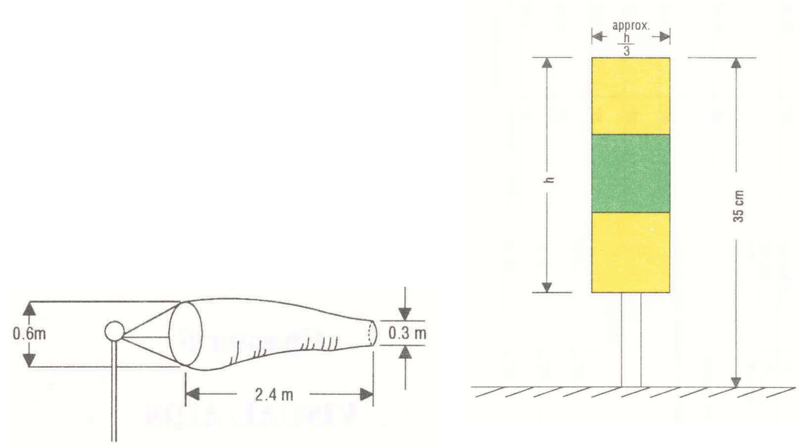
All the markings are combined in one final 3D drawing, in figure 7-16, to illustrate how the heliport would look like.

Helicopter fuelling

In order to have a high operation efficiency and to avoid extra costs for travelling towards a refuelling location, refuelling should be possible at the heliport. For an estimate of the fuel usage over a period of time, a week worth of flying is assumed. The fuel used over a period of time is used to determine the fuel storage area required for a certain amount of days of operation. The amount of fuel required for this can be calculated by using equation 7-1.

$$V_{\text{total}} = t_{\text{operations}} \cdot \dot{V}_{\text{fuel}} \cdot N \cdot D \tag{7-1}$$

In equation 7-1, V_{total} is the total amount of fuel used in a week, $t_{\text{operations}}$ is the flying time per flight, $\dot{V}_{\text{fuel}}$ is the fuel consumption per hour, N is number of flights per day and D the planned number of days worth of fuel. As mentioned in section 9-1, one flight takes



(a) Wind indicator [59] **(b)** Air taxiway marker [59]

Figure 7-15: Characteristics of the wind indicator (a) and air taxiway marker (b)

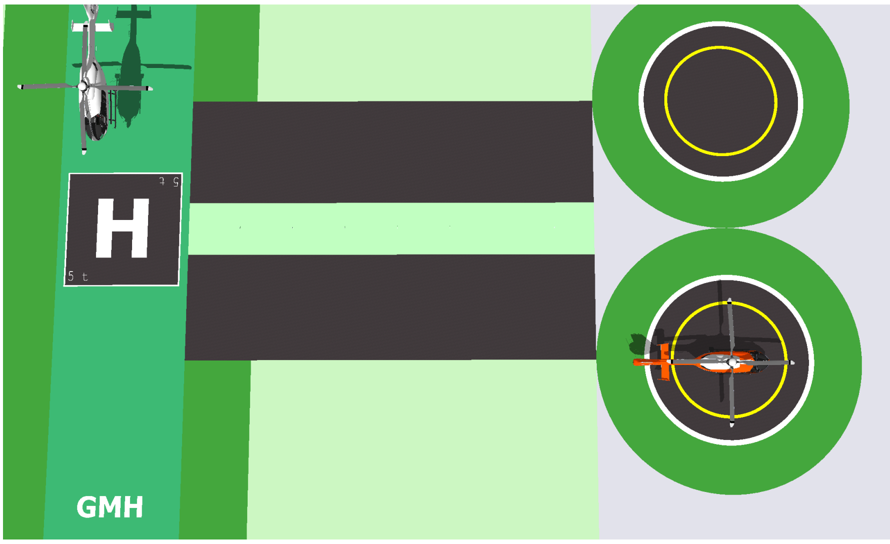


Figure 7-16: Illustration of heliport markings

approximately half an hour. Furthermore, according to section 7-1-5 the fuel consumption of the helicopter used is 121 L/hr and according to section 6-2, there are twelve flights a day. This results in a weekly fuel usage of 5082 L.

Heliport services for fire fighting

In case of an accident, rescue and fire fighting services should be at hand. The fire brigade of Gorinchem can turn out in case of an accident and store a fire fighting car that is adapted to extinguish kerosene fires. According to the ICAO regulations, the response time should not exceed two minutes. As the fire station is too far away to achieve this, appropriate extinguishing equipment should be available at the location itself. The appropriate equipment can be found by looking at the size of the helicopters that will operate at the location. The heliport will be designed for category H1 helicopters, which means that the overall length of the helicopter does not exceed 15 m [33]. For this category, a minimum water supply of 500 L is sufficient. The fire extinguisher or small car must have a foam solution discharge rate of 250 L/min. A complementary chemical powder extinguisher with a minimum amount of 23 kg must be available as well.

7-4 Approach and departure routes

Approach and departure routes for aerodrome traffic at uncontrolled aerodromes are used to ensure a safe and orderly flow of traffic. With these routes, it is possible to design the obstacle free surfaces. No objects should penetrate these surfaces. If objects do penetrate them, either the object should be removed or the route should be adapted. Furthermore, with these routes it is also possible to illustrate the noise impact by creating noise contour maps. However, the noise contour maps for the designed routes will be analysed in section 8-3.

7-4-1 Internal quality procedures and back-up

Manuals for designing approach and departure routes for instrument operations have been published by the ICAO. However, no manuals have been found on the design of visual routes. The design for the approach and departure routes is based on information from official documents on VFR flights in the Netherlands [60], rules that meet the international standards of ICAO [61] and the aeronautical information and flight filing of the Netherlands [47].

For the design of the approach and departure routes, a number of elements should be taken into account. First, helicopters are not allowed to make a turn before being at an altitude of 90 m. Second, no objects should penetrate the surface of the obstacle free area, as explained in later on in this section. Third, it should be avoided to fly over populated areas at low altitudes. As subsection 7-3-3 described, the noise level in populated areas should not be higher than 48 L_{den}. If this limit is exceeded, the province will not allow the heliport to be built. To limit the noise nuisance as much as possible, flying over densely populated areas such as the inner city should be avoided. Finally, in order to gain social acceptance, the routes should minimise flying over nature areas at low altitudes.

Designed approach and departure routes

With the different elements that should be taken into account in mind, the approach and departure routes has been designed. The approach routes for the heliport are shown in figure 7-17. Approaching helicopters enter the aerodrome traffic circuit at approximately 3 km west of the heliport, at an altitude of 700 ft. As for aircraft, it is preferable for helicopters to land into the direction of where the wind is coming from [62]. Therefore, depending on the wind

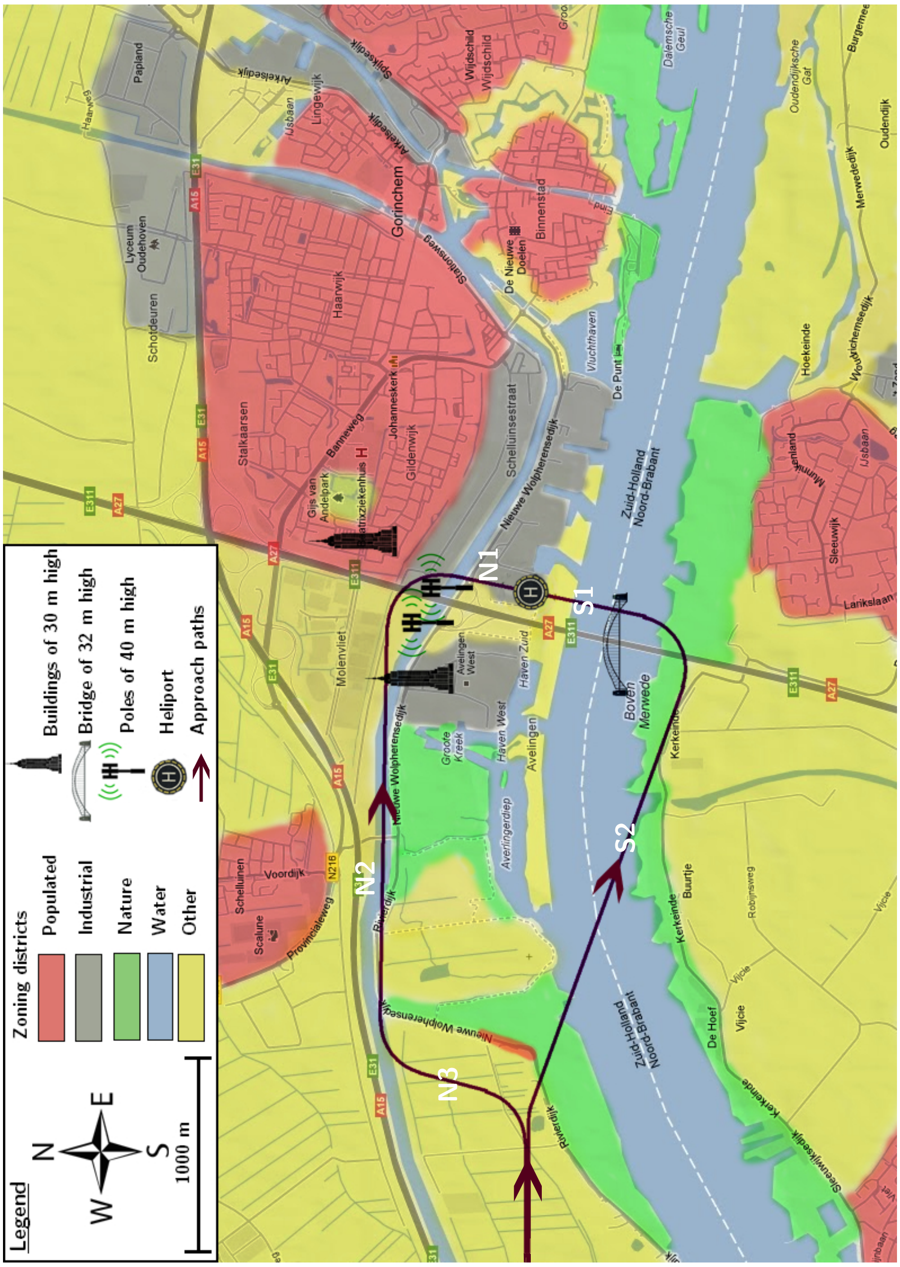


Figure 7-17: Approach routes for Heliport Gorinchem

direction, the pilot flies either the northern or the southern flight circuit. The AFIS officer is responsible for providing the wind direction to the pilot and determining the approach route that should be selected.

For the northern approach route, the helicopter enters the flight circuit and makes a left turn of 75° towards section N_3. The circuit continues in a straight line for 350 m. Then, the helicopter turns 76° right, to enter section N_2. The helicopter follows the Nieuwe Wolpherensedijk for 2 km and should descend to 300 ft before making its final turn of 101° towards section N_1. At this final section, the pilot has 400 m to descend the final 300 feet towards the centre of the FATO.

For the southern circuit, the helicopter enters the traffic circuit by making a right turn of 20°, to enter section S_2. At this straight line section, the pilot has 2.25 km to descend to 300 ft altitude. After 2.25 km, the helicopter makes a left turn of 98°, to approach the heliport from the south at section S_1. Now, the helicopter has 600 m to descend the final 300 ft.

For take-off routes, helicopters follow the same circuit and altitudes, again depending on the wind directions. The helicopters leave the traffic circuit at the same point as where they enter it. In both circuits, all turns made by the helicopters have a minimum radius of 270 m [58]. To simplify calculations for the obstacle restriction areas, it is assumed that the curves are made in the horizontal plane.

Wind direction

The final approach sections (N_1 and S_1) are parallel to the A27 motorway. The reason for this is that, as mentioned above, it is preferable for helicopters to operate into the direction of the wind. A windrose has been created to indicate the prevailing wind directions in Gorinchem. For this windrose, wind measurement data from the Royal Netherlands Meteorological Institute (KNMI) from 1981 to 2012 has been used. The data is measured at station Herwijnen, approximately 10 km east of Gorinchem. Figure 7-18 illustrates that most of the time wind is coming from south-western direction. It would be preferable to have sections N_1 and S_1 aligned with this, to allow pilots to land and take-off into the direction of the wind.

Due to the location of the motorway, it is not possible to have the approach and departure paths directly aimed into the prevailing wind direction. By aligning the sections N_1 and S_1 with the motorway, it is possible to operate into the direction of the wind for 66% of the time, by approaching via the northern route and departing via the southern one. During the remaining 34% of the time, helicopters should operate in opposite direction. This includes the time that the wind is coming from the north-east (23%) and the time that the wind is coming from an angle of 90° with respect to sections N_1 and S_1 (11%).

The reason for assigning approaching helicopters to the southern approach route when the wind is coming from a 90° angle with respect to the sections N_1 and S_1 is as follows. In section 7-1-2, it has been mentioned that helicopters emit less noise when approaching, compared with taking-off. As there is a populated area north of the heliport, but not south of it, it is preferable to have approaching helicopters from the south.

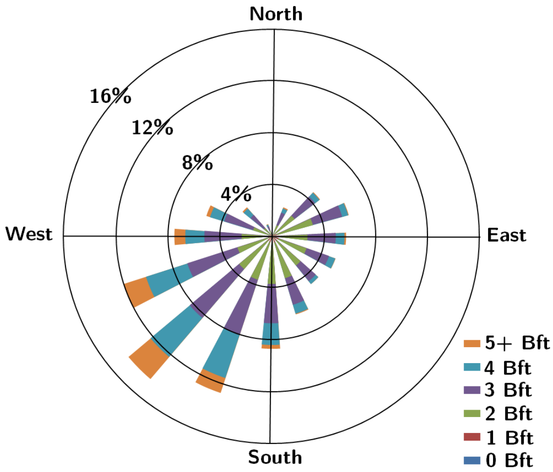


Figure 7-18: Windrose for station Herwijnen in the period from 1981 to 2012 [63]

7-4-2 Obstacle restriction and removal areas

After designing the approach and departure routes, it is possible to design obstacle restriction areas. The purpose of obstacle restriction areas is to ensure safe helicopter operations during approach and departures. Three obstacle restriction areas have been investigated: the protected side slope around the safety area, the approach surface area and the take-off climb surface area. No single obstacle should penetrate either of these surfaces.

Protected side slope

A protected side slope, rising at 45° from the edge of the safety area to a distance of 10 m should be provided. Its surface may not be penetrated by obstacles. They may be permitted to penetrate the side slope surface only in a case of obstacles that are located to one side of the FATO [58].

Regulations for obstacle restriction areas

The regulations for the obstacle restriction areas are specified by the ICAO in the Heliport Manual and the Heliport Design Annex 14, [59], [58]. For the design of these areas, tables 4-1 to 4-4 from Annex 14 for non-instrument approaches have been used. In these documents it is stated that the design of the restriction areas should start at the edge of the FATO (the inner edge). From this point, the restriction areas diverge horizontally and vertically, along the same directions as the approach routes given in figure 7-17.

Width of obstacle restriction areas

According to ICAO Annex 14, the take-off climb surface should diverge in horizontal direction. Figure 7-19 illustrates the top view of the southern take-off climb surface, showing the horizontal divergence.
It has been decided to only diverge the width of the straight-line sections adjacent to the

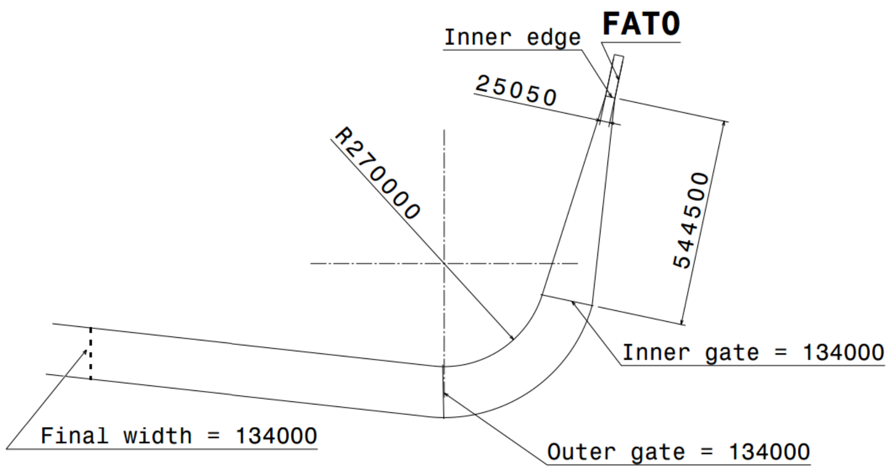


Figure 7-19: Top view of obstacle restriction area for the southern take-off direction. Distances are given in millimetres.

heliport, as it is assumed that this provides the pilot enough space to manoeuvre. The width of this surface depends on if operations are during day or night. As only operations during daytime will be allowed, the diverged width of the take-off climb surface section, $W_{\text{direction}}$, is given by equation 7-2.

$$W_{\text{direction}} = 2 \cdot D + 0.2 \cdot S_n \tag{7-2}$$

In this equation, D is the greatest dimension of the helicopter and S_n is the horizontal distance from the previous section to the current section. Using $D = 12.16$ m and $S_{S1} = 544.5$ m, the final width W_{south} becomes 134 m for the southern take-off surface. For the northern take-off surface, using $D = 12.16$ m and $S_{N1} = 344.5$ m, the final width W_{north} equals 94 m.

Slope of obstacle restriction areas

The slope of the restriction areas is based on data given in ICAO Annex 14. The geometry of the slope of the surfaces is given in figure 7-20, where the angle β is given in degrees and the height h_n and horizontal length S_n of the nth section are given in metres. This geometry is used to calculate the height of the obstacle free surfaces.

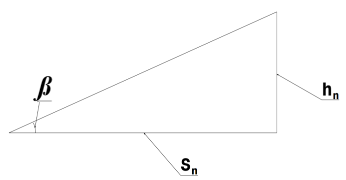


Figure 7-20: Geometry of the slope of the approach and take-off climb surfaces

According to the ICAO Heliport Design manual, more power is required during take-off than during the approach phase of a helicopter flight. In case of engine failure, it should be possible to safely land the helicopter [59]. Therefore, the maximum slope of the take-off climb surface should be less than the slope of the approach surface. According to the documents, for take-off climb surfaces, the maximum slope is 4.5%, whereas this is 8% for approach surfaces. Therefore, the take-off climb surface should be designed and checked for penetration of objects, as this has a less steep slope.

The take-off climb surface starts at the edge of the safety area around the FATO (the inner edge). From this edge, the surface diverges vertically and horizontally at a specified divergence slope for day or night operations. The slope for daylight take-off surface equals the maximum allowable slope of 4.5%. The reason for using the maximum allowable slope is to allow the helicopter to climb as fast as possible to decrease noise hindrance in residential areas. The slope of 4.5% gives an angle β of 2.6°, calculated with equation 7-3.

$$\beta = \tan^{-1}(\frac{\text{slope percentage}}{100}) \quad (7\text{-}3)$$

Height of take-off climb surface

Finally, the height of the take-off climb surface for the different sections can be calculated. The geometry of the heights of the southern departure route is given in figure 7-22.

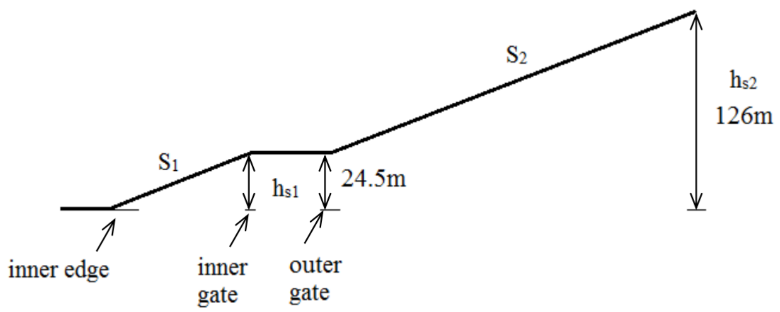


Figure 7-21: Geometry of the heights of the southern take-off climb surface

Equation 7-4 should be used for the determination of these heights. In this equation, S_n is the horizontal length of the section and h_{n-1} is the height of the preceding section. It is assumed that the slope in the curves is zero, in order to simplify calculations.

$$h_{\text{section}} = h_{n-1} + S_n \cdot \tan(\beta) \quad (7\text{-}4)$$

Using this equation, the following heights can be found: $h_{S1} = 24.5$ m, $h_{S2} = 126$ m, $h_{N1} = 15.5$ m and $h_{N2} = 106$ m.

Check for penetration of the take-off climb surface

Now that the obstacle free areas have been determined, a check is performed to see if there are any obstacles penetrating these surfaces. Figure 7-17 shows a number of structures that might penetrate the take-off climb surface. A mast with an estimated height of 40 m is located at a distance of 184 m from the heliport. From figure 7-22, it is clear that that the mast penetrates the surface. Therefore, the mast should be removed. Other high objects illustrated in figure 7-17 do not penetrate the take-off climb surface.

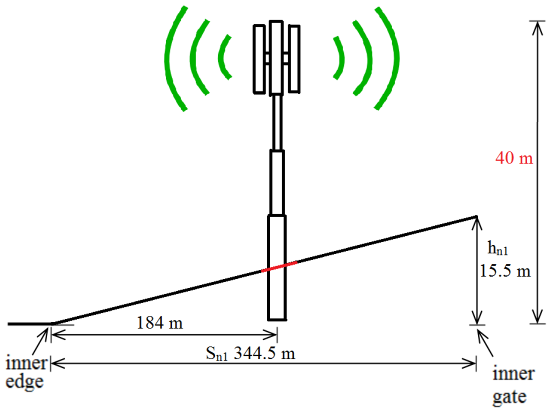


Figure 7-22: Mast penetrating the take-off climb surface

Chapter 8

Sustainability approach for the project

In the requirements discovery tree (RDT) given in section 2-4, one of the requirements is to provide a sustainable system. This chapter demonstrates a step by step approach to meet that requirement. The purpose of this chapter is to present the environmental impact of the project and to propose an alternative energy generation. In the midterm report, the environmental impact of the aerial transportation system is briefly discussed [1]. This chapter serves as a follow up to that.

The structure of this chapter is as follows: first, section 8-1 elaborates on the comparison of carbon emissions between a taxicab drive in the Netherlands and the chosen helicopter. Both a helicopter with conventional engines as well as with the upgraded hybrid engine is considered. Then, in section 8-2, the life cycle assessment of the environmental impact of the facilities is described. In section 8-3, the noise contour map for the short term is given and analysed. In section 8-4, different renewable energy options are considered to enhance the sustainability of the aerodrome. Finally, section 8-5 presents the general actions and guidelines to be considered, to ensure a sustainable system.

8-1 Carbon emissions

The helicopter type has been chosen by looking at factors such as the market demand, fuel consumption, weight, safety, noise and carbon emissions. The detailed reasoning behind this selection is given in section 7-1. This section will only give the comparison between the carbon emissions of the helicopter and a taxicab.

The selected helicopter type is an Eurocopter EC135 which has 473 kW of power, and a maximum take-off weight of 2910 kg. According to Eurocopter, the hybrid engines will reduce the carbon emissions by 50% with respect to the conventional engines [38].

A Mercedes-BENZ E-Class Saloon-2011 has been chosen as taxicab, since the majority of the taxicabs in the Netherlands belongs to this class of cars. In the midterm report [1], it is found that the average person per car is 1.1, thus the use of helicopter which can carry six passengers would lead to a removal of six cars from the traffic. This fact is used to compare the vehicles.

Table 8-1 shows that the environmental impact of one conventional helicopter per day in terms of carbon emissions is about five times the emission of six taxicabs in the Netherlands. The amount of carbon emissions of a hybrid engine helicopter is only two and half times the value of six taxis. A visualisation of these values can be seen in figure 8-1.

Table 8-1: Carbon emissions of the taxicab and the helicopter

	Road distance [km]	**Flying distance [km]**	**CO_2 emission per car [kg]**	**CO_2 emission of 6 cars [kg]**	**CO_2 emission [kg]***	**CO_2 emission [kg]****
Gorinchem-Schiphol	80	55	10	60	295	148
Gorinchem-Rotterdam Airport	50	40	6.5	39	224	112
Gorinchem-Eindhoven Airport	74	51	9.5	57	275	138

*CO_2 emission per flight with conventional engine (kg)
**CO_2 emission with hybrid engine (kg)

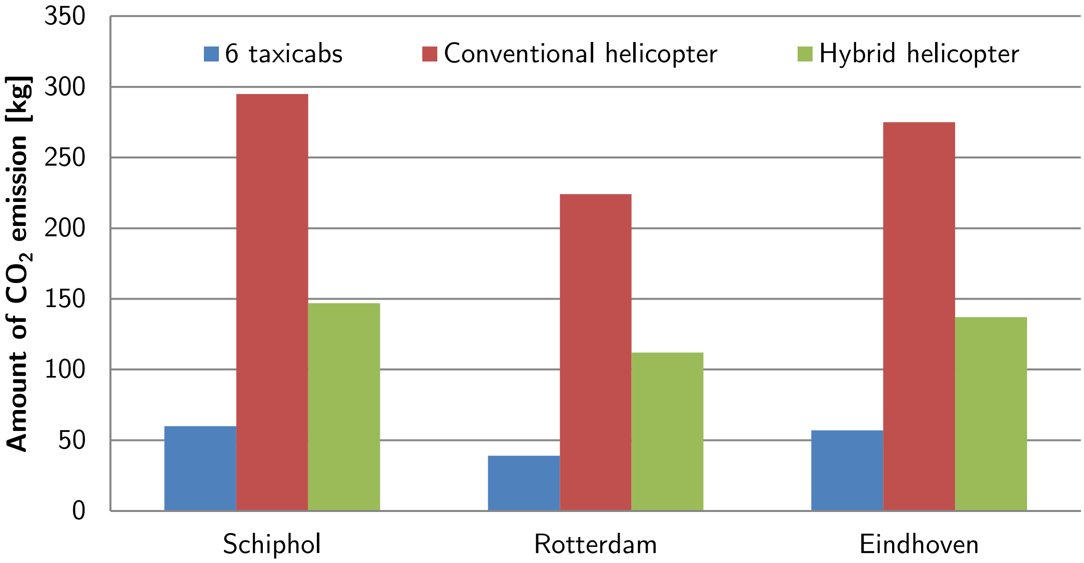


Figure 8-1: Carbon emissions of helicopters and taxicabs

As mentioned before, the carrying of six passengers by helicopter would take away approximately 6 cars from the traffic congestion, which would lead to removal of 60 kg CO_2 from the traffic between Schiphol and Gorinchem however, this would add 295 kg of CO_2 to the environment [3]. The net contribution to the environment therefore would be 235 kg of CO_2. When calculating the same for Rotterdam and Eindhoven airport, the net carbon input would be 185 and 218 kg respectively.

To summarise, neither a conventional engine nor a hybrid engine would prove to be environmentally friendly in comparison to a taxi in the short term. The adaptation of hybrid engines on the helicopter is foreseen within six to seven years from now and it can be implemented at the launch of the project. Therefore the use of hybrid engine helicopters would reduce the carbon emissions by 50% in which the system would be proven to be more environmentally friendly with respect to conventional helicopters. However, they would be still less environmentally friendly than the taxicabs.

8-2 Environmental impact of the facilities

In this section, the approach towards the life cycle assessment of the facilities such as the terminal and the hangar is shown. It will be explained to determine the environmental impact of them.

Life cycle assessment is a process of measuring the environmental impact of a product or a material based on the effects of attaining the raw materials from which it is made, the series of actions through which those raw materials get to become usable products, the assembly of those products into a structure, the maintenance and operations required to maintain those products, the effects of disposing the product after its usable life and the transportation impacts that occur between each of those stages [64].

In order to determine the environmental impact of the terminal and the hangar construction, the software called 'Athena EcoCalculator for Commercial Assemblies' is used [64]. This tool assists in determining the environmental effects of the materials used in the facilities based on four factors: energy consumption, global warming potential, acidification potential and smog potential. Energy consumption is the estimated amount of fossil energy used in the extraction, processing, transportation, construction and disposal of each material. Global warming potential stands for the amount of greenhouse gases created whereas the acidification potential shows the amount of acid-forming chemical created. Finally, the smog potential gives the approximate amount of chemicals that could produce photochemical smog and ground-level ozone when exposed to sunlight.

Knowing the dimensions of the terminal from subsection 7-3-3, the estimated values for the foundations, columns and beams, intermediate floors, exterior walls, windows, interior walls and roof can be inserted into the software. In general, the use of wood structures are preferred due to their low environmental impact. Only in the foundation wall and foundation slab the use of concrete is chosen because it is the only choice in the software. Other than that, a window-to-floor area ratio, equals to 15%, is favoured for conventional construction. This window-to-floor area ratio optimises energy, cost, and indoor environmental quality [65]. The values obtained for the terminal, the hangar and the total of both are shown in tables 8-2, 8-3 and 8-4.

Table 8-2: Environmental impact summary of the terminal

Assembly	**Total area [m^2]**	**Fossil fuel consumption [MJ]**	**GWP [tons CO_2]**	**Acidification potential [moles of H^+]**	**Smog potential [kg NO_x]**
Foundations	140	75,777	9	2,156	525
Columns & beams	100	14,977	1	263	49
Intermediate Floors	100	21,904	1	1,110	525
Exterior Walls	120	108,082	5	2,365	323
Windows	120	377,439	36	18,582	3,299
Interior Walls	30	14,939	1	269	50
Roof	100	239,102	20	5,761	1,365
Total	**925**	**852,220**	**73**	**30,507**	**6,145**

A sensitivity analysis has been performed by changing the material type used in the buildings. For this analysis, one iteration is performed by using steel, another iteration is focused on the

Table 8-3: Environmental impact summary of the hangar

Assembly	Total area [m^2]	Fossil fuel consumption [MJ]	GWP [tons CO_2]	Acidification potential [moles of H^+]	Smog potential [kg NO_x]
Foundations	700	323,420	37	9,332	2,283
Columns & Beams	600	87,821	5	1,541	289
Intermediate Floors	0	0	0	0	0
Exterior Walls	425	267,572	16	5,237	1,514
Windows	75	232,270	22	11,435	2,030
Interior Walls	0	0	0	0	0
Roof	600	632,351	34	11,996	2,429
Total	**2400**	**1,543,435**	**114**	**39,542**	**8,545**

Table 8-4: The summary of the total impact of the buildings

Building	Total area [m^2]	Fossil fuel consumption [MJ]	GWP [tons CO_2]	Acidification potential [moles of H^+]	Smog potential [kg NO_x]
Terminal	925	852,220	73	30,507	6,145
Hangar	2,400	1,543,435	114	39,542	8,545
Total	**3,325**	**2,395,655**	**187**	**70,049**	**14,690**

use of concrete. This iteration process is used to analyse how dependent the environmental impact is on the type of material used. Table 8-5 gives the results of the sensitivity analysis.

Table 8-5: The sensitivity analysis of the total impact of different materials

Material type	Fossil fuel consumption [MJ]	GWP [tons CO_2]	Acidification potential [moles of H^+]	Smog potential [kg NO_x]
Wood	2,395,655	187	70,049	14,690
Steel	3,773,414	220	80,784	13,927
Concrete	4,317,225	347	115,397	26,074

The increase of fossil fuel consumption is approximately 60% with steel and 80% with concrete in comparison to wood. Besides, the amount of greenhouse gases shows an increase of 18% for the steel and 85% for concrete. According to the results given in table 8-5, the use of wood throughout the construction would have less environmental impact than the others. This can be explained by the fact that wood products require less energy and resources to produce than concrete and steel. Since more fossil fuels will be saved, the air pollution will reduce accordingly [66].

8-3 Noise level of the aerial vehicle

In subsection 7-3, it is mentioned that, in order to set up a new commercial heliport, a noise contour map should be provided. Noise contours are maps that give a graphical representation of the sound distribution for a specified period. Now it is possible to create such a map since the type of vehicle, the location of the heliport, the approach and departure procedures and the number of operations per day have been defined. Current legislation will be briefly discussed before creating and analysing the noise maps.

8-3-1 Legislation on noise level

There are multiple different units to express noise. L_{den} is the European unit used to express the noise levels of aircraft. It is a cumulative measure that estimates the total noise effect of all aircraft movements taking place over a specified time period. For this unit, a distinction is made between flights during the day, evening or night, by adding a correction factor.

In Zuid-Holland, the maximum allowable noise level in noise sensitive areas, such as densely populated areas, is 48 L_{den} [14]. This also holds for surrounding provinces [67], [68]. The chosen design may not violate this. If it does, adjustments should be made in order to get approval from the province to build the heliport.

8-3-2 Noise impact for the short term

With the number of operations, selected helicopter, exact location of the heliport and the traffic circuit, sufficient inputs are known to calculate the noise impact caused by the helicopter operations. The program Integrated Noise Model (INM) 7.0 is used to calculate the noise impact, and then makes a graphical representation of this. Figure 8-2 shows the noise contour with the given inputs.

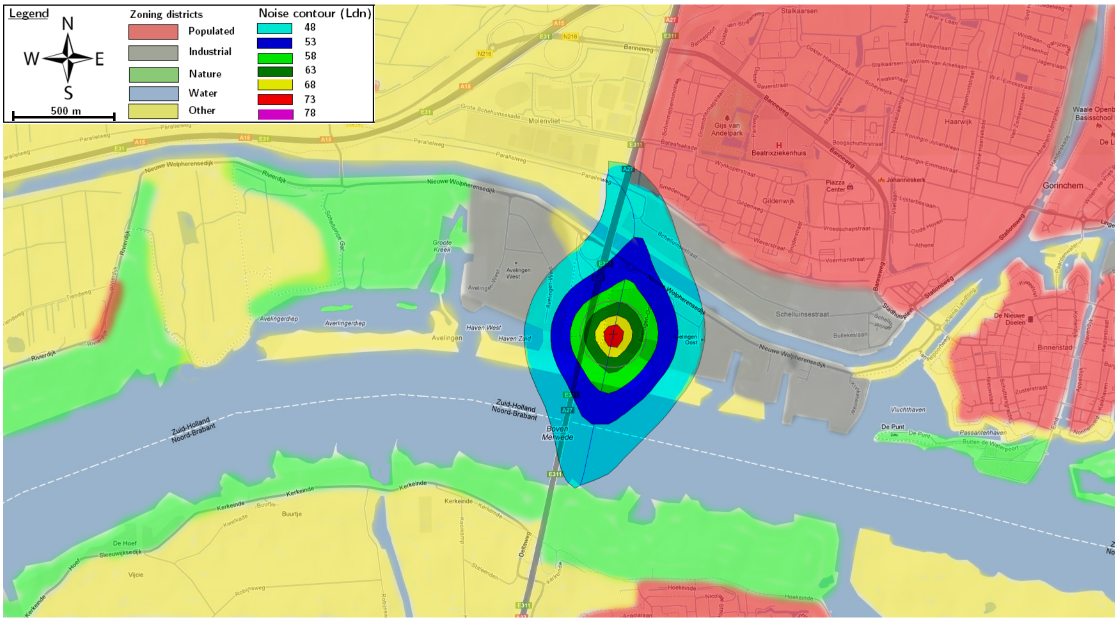


Figure 8-2: Noise contour map for the short term

A number of differences between the design and the input for INM need to be considered, as mentioned below:

- **Type of helicopter:** the Eurocopter EC135 helicopter is not available in the database of INM. Because the Eurocopter EC130 is the most comparable helicopter available in the database, this one has been used in the modelling. As a single engined helicopter, the EC130 creates less noise than the EC135. However, as the EC135 will contain the Bluecopter technologies to decrease noise, this difference is expected to be minimal.

- **Approach and departure procedures:** INM uses standard approach and departure procedures. They slightly differ from the designed procedures with respect to altitude. It is assumed that this does not have a significant impact on the noise contour.
- **Units:** INM uses L_{dn} as unit for noise level instead of the European unit L_{den}. The difference is that L_{dn} accumulates for day (07:00 to 22:00) and night (22:00 to 07:00), whereas L_{den} uses day (07:00 to 19:00), evening (19:00 to 23:00) and night (23:00 to 07:00. As VFR operations are only allowed during UDP, almost all flights will be performed between 07:00 and 19:00. This means there is no difference between the different units.

As all three differences are expected to have a minimal impact only, the calculated noise contour is assumed to give an accurate estimation of the noise impact caused by the helicopter operations. Further investigation on the noise level is recommended to obtain a more accurate map.

8-3-3 Analysis of noise contour

The noise contour in figure 8-2 is analysed to compare the noise level of the design with the legislation. The outer border of the light blue coloured part indicates the 48 L_{dn} noise level. Only in the northern route, near the turn, the 48 L_{dn} value is exceeded in a populated area. This area is small and with the expected future noise reducing technologies, it can be stated that the design complies with the noise legislation of the province of Zuid-Holland.

8-4 Alternative energy generation

The calculation of the average power consumption of the facilities should be determined before starting with the analysis of alternative ways of generating power. This will be explained in subsection 8-4-1. Then, alternative renewable energies are examined in detail for the sole purpose of making the heliport sustainable in subsections 8-4-2 and 8-4-3.

8-4-1 Average power consumption

An airport or an average household can be used as models in order to estimate the power consumption of the heliport facilities. However, in this project, an average household is preferred instead of an airport due to its convenience. Airports involve baggage handling systems, cargo facilities, customs and check-in areas, thereby increasing the total power consumption in great amounts. Therefore, this option is not suitable in estimating the average power consumption of the facilities. The facilities that are going to be built will be simple and relatively small-sized. They will only be used for the purposes of transferring and protection of passengers and of refuelling and maintenance of the helicopters. Hence, the second option will be more useful in order to estimate the total power consumption.

It is assumed that the terminal and hangar require as much power as the total amount of an average household of four. With this assumption, calculations on renewable energy can be performed.

The area of the terminal is approximately the same as the area of a middle class average Dutch house. Furthermore, the area of the hangar is six times higher. However, the hangar would require less electricity than the six average households as it is mainly going to be used for the protection of the helicopters. Hence, it is assumed that the total power consumption of the hangar equals to the sum of three average household electricity consumption. Nevertheless, the operations will be only during daytime in the short term. Therefore the total electricity consumption of the hangar and terminal would be reduced to 50% of the total calculated average value.

In the Netherlands, the average electricity consumption of a household is 3,400 kW · h per year [69]. Therefore, the total power consumption of the terminal would be equal to 6,800 kW · h annually, by bearing in mind the 50% of the calculated total power consumption.

Knowing that the global concern on sustainability increases, renewable energy options for the purpose of generation of the required electricity have been inspected. For the final design, mounting solar panels on top of the heliport facility is the most viable option.

8-4-2 Wind energy

Small-scale wind turbines (with < 50 kW rated capacity) have been used to provide electricity for the houses in remote areas as well as farms. For the heliport project, the option of implementing a small-scale wind turbine at the roof-top of the heliport facility has been considered.

There are pros and cons to such a concept. In the majority of the cases, the cost of the power produced by them is not competitive with grid electricity. However, the public demand of obtaining electricity from pollution-free sources is increasing and the government capital grants could provide the necessary compensation in the costs. The main advantage of realizing such a concept is having a self-sustained heliport in the end.

Equation 8-1 gives the maximum power, P_{max}, that can be extracted from a small wind turbine, where v is the wind speed, A is the swept area and ρ is the density of air.

$$P_{\text{max}} = \frac{16}{27} \cdot \left(\frac{v^3 A \rho}{2} \right) \tag{8-1}$$

The average wind speed on the ground, in the region of Gorinchem, is found to be 3.4 m/s. Furthermore, the average wind-speed at 100 m height is around 6 m/s [70]. Research on wind power generation has pointed out that the lowest speed at which turbines are able to generate power is 4 m/s [71]. Usually they work at wind speeds of between 12 m/s and 14 m/s. This means that, in order to generate a decent amount of energy at heliport's location, wind turbines should be at least at 100 m or higher. Therefore, the choice of having wind turbines providing energy for the heliport is not considered any more.

8-4-3 Solar energy

Another way of using green energy is by generating electricity via solar panels. The average solar intensity throughout the year in Gorinchem, with an optimal angle of $38°$ with respect to the Sun, equals 110 W/m^2 [72]. Different photovoltaic cell technologies have been researched, of which cadmium telluride (Cd-Te) has been selected to be used. This can be explained by their significantly lower environmental impact compared to other cells, as can be seen in the figure 8-3.

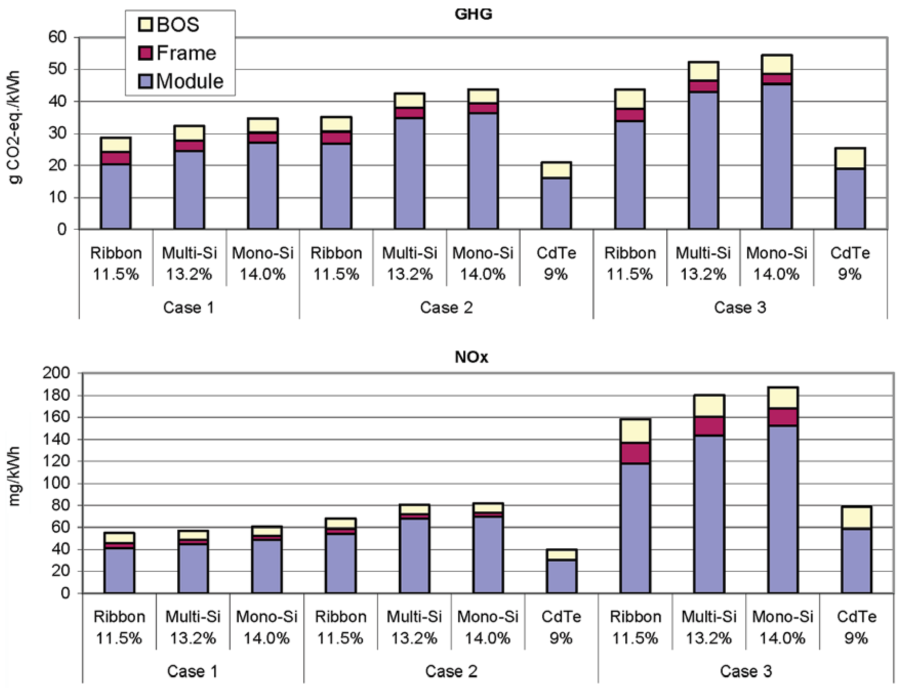


Figure 8-3: Comparison of environmental impact of different solar cell types [73]

The efficiency of Cd-Te cells is approximately 16% [73]. Using equation 8-2, the total area of the solar panels that needs to be implemented can be calculated. For this calculation, it is assumed that a solar system provides power output for five hours per day in average.

$$P_{\text{collector}} = \eta_{\text{collector}} \cdot S_{\text{illum}} \cdot A_{\text{collector}} \tag{8-2}$$

In equation 8-2, $P_{\text{collector}}$ is the power output in Watts, $\eta_{\text{collector}}$ is the efficiency of cells, S_{illum} is the solar intensity in W/m^2 and $A_{\text{collector}}$ is the area of the collector in m^2. When the total energy consumption, efficiency of the panels and the average solar intensity are plugged into the equation above, the total required area of panels turns out to be approximately 215 m^2. Since the total roof area of the hangar and the terminal is higher than 215 m^2, there would be sufficient space to mount the panels on the roof. Grid electricity should be used in case of bad weather conditions that do not allow the solar panels to be used.

In terms of the environmental impact, it can be said that during the operational time of the panels no greenhouse gases are emitted. However, the manufacturing of the solar frames and trays as well as the disposal of the solar panels leads to a negative impact on the environment. The amount of CO_2 would be 20 g/kW · h during its life cycle. This is about 25 times less than the carbon footprint of the grid electricity from fossil fuels [74], [75]. For the photovoltaic cell types that might be used, 1 m^2 solar panel would produce approximately 32 kW · h of electricity per year. Since the findings from earlier researches on photovoltaic panels suggest that it takes 250 kW · h of electricity to produce 1 m^2 of solar panels, the payback time will be approximately eight years [76]. This is very short comparing it with the general expected life of solar panels from 25 to 30 years.

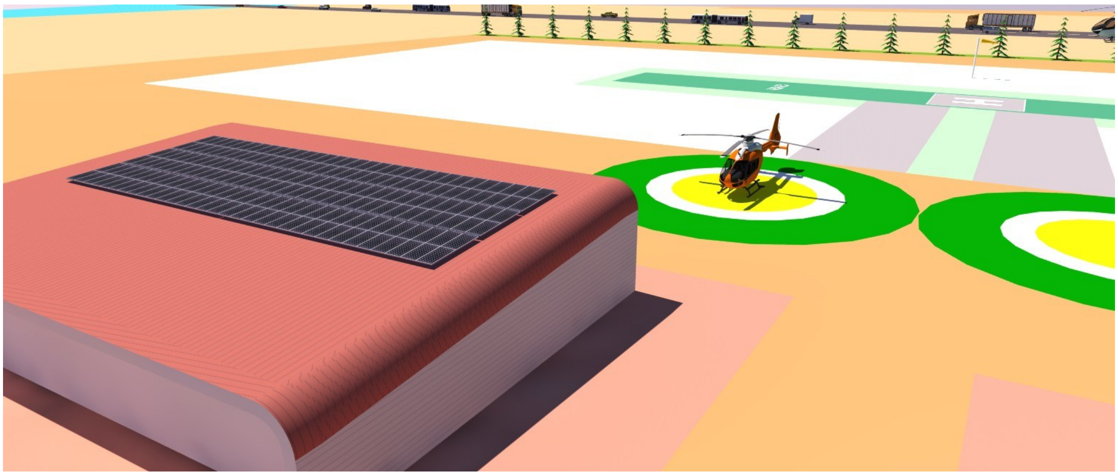


Figure 8-4: The solar panels mounted on the roof of the building

8-5 General actions and planning

In this section, general guidelines and actions that would help to sustain the heliport will be mentioned.

First of all, the site area covered by impervious surfaces such as concrete and asphalt is intended to be minimised in order to decrease surface run-off. The vertical building approach is considered to minimise the structural footprint, as in the case of construction of the terminal. For the hangar, this is not possible since both helicopters need to be kept on the ground level. Finally, parking areas could be located below building. However, for the easiness and convenience of the parking, it has been decided to assign them on ground level.

The site disturbance shall be limited to 12 m distance from buildings. For this project, the heliport site has a distance of at least 80 m from the neighbouring industrial area. Wetlands around the heliport will be preserved as appropriate. Besides, drainage features will be introduced if the site has no drainage features.

In-site clean-up technologies are preferred to minimise site disturbance and decrease clean-up costs. Furthermore, in-site generation of renewable energy could be included in the project, as discussed in section 8-4. The air side layout is designed with the purpose of reducing the helicopter delay in order to reduce greenhouse gas emissions. In the same sense, fuel consumptions will be reduced that would lead to cost savings for the project.

A noise and acoustical quality control plan needs to be prepared in order to ensure the noise levels comply with the local and country noise standards. During daytime acoustical enclosures, silencers and barriers should be installed in and around the the heliport. In this way, the noise impacts to neighbouring communities will be reduced.

Chapter 9

Business model

In chapter 6, the size of potential markets has been described. Chapter 7 describes the design of the helicopter, air traffic management system, heliport and flight paths. The noise is within its maximum limits, as described in chapter 8. With all this information, it is possible to derive a business model. This is done in order to see whether the operations could be profitable, which is the main goal in the short-term vision. The profit can be derived from the income and costs, where the costs are separated in fixed and variable costs.

Chapter 6 has given four possible markets; business flights to Eindhoven Airport, Rotterdam Airport and Schiphol, tourist flights over the Vesting3hoek and Kinderdijk, hospital flights, and governmental flights. All, except business flights, have relatively low demand, making it difficult to earn profit with those. This chapter will show that business flights are not profitable. From this, it follows that the other markets are also not worthwhile. Therefore, the results for these markets are not described in this report.

Section 9-1 gives all variable costs, and section 9-2 gives all fixed costs. Finally, section 9-3 describes the profitability of the devised business plan by combining the variable costs with the fixed costs. All values are given excluding VAT.

9-1 Variable costs

The variable costs are the costs incurred when performing one extra flight. For the heliport project these costs entail: insurance, airport charges, call out costs, fuel and maintenance costs.

9-1-1 Insurance for helicopter

The European Union (EU) has set requirements on the required insurance for conducting aerial transport [77]. The value that has to be insured is dependent on the weight of the vehicle, and the type and amount of payload. This value is given in special drawing rights (SDR), a standardised monetary value maintained by the International Monetary Fund (IMF). One SDR is approximately 0.86 euro [78]. For the Eurocopter EC135, with six passenger seats, the minimum insurance cover would be approximately 7.3 million euro. However, the required insurance cover drops to approximately 4.7 million euro by reducing the maximum take-off weight (MTOW) to below 2700 kg. Taking the average accident risk for a multi-engined turbine helicopter, which is $1.051 \cdot 10^{-6}$ per start and $1.608 \cdot 10^{-6}$ per landing, leads to a combined accident risk of $2.658 \cdot 10^{-6}$ per flight [79]. Combining this risk and the required insurance cover, the costs for the liability insurance can be calculated as 12.59 euro per flight, assuming no additional fees. The same number for the accident risk can be used to calculate the minimal value for the hull insurance. Assuming that the value of the helicopter is five million euro, the minimal insurance fee would be 13.30 euro per flight. Again, assuming that the insurance provider will not ask an additional fee. Combining both, an insurance fee of at least 25.89 has to be paid for each flight.

9-1-2 Airport charges

The airport charges can contain landing fees, passenger charges, a persons with reduced mobility (PRM) levy, governmental levies and handling costs. All charges are determined per MTOW, except for the passenger charges and PRM levy, which are charged per departing passenger.

The landing fees are charged for each landing and take-off separately. The passenger charges are separated into a passenger service charge and a security service charge, for which the price can be different for transfer and local passengers. All passengers are assumed to be transfer passengers. The PRM levy compensates for the costs made by the airport to provide assistance to the disabled. There are three governmental levies; a noise levy for which 2013 is the final year that it has to be paid, a planning compensation levy, to compensate for the expansion of the airport, and a local air traffic control levy, which is only charged per landing. Finally, handling costs are obligatory for each aircraft and contain among others transport of the passengers from the aircraft to the terminal.

The charges and costs applicable differ per airport. Figure 9-1 shows the total airport charges per airport per flight, assuming full capacity. Eindhoven airport does not publish its prices, therefore an estimation of those prices is used. Eindhoven is smaller than Schiphol, but it is larger than Rotterdam airport. Therefore, the average of Schiphol and Rotterdam airport is used. The total charges are almost the same for each airport.

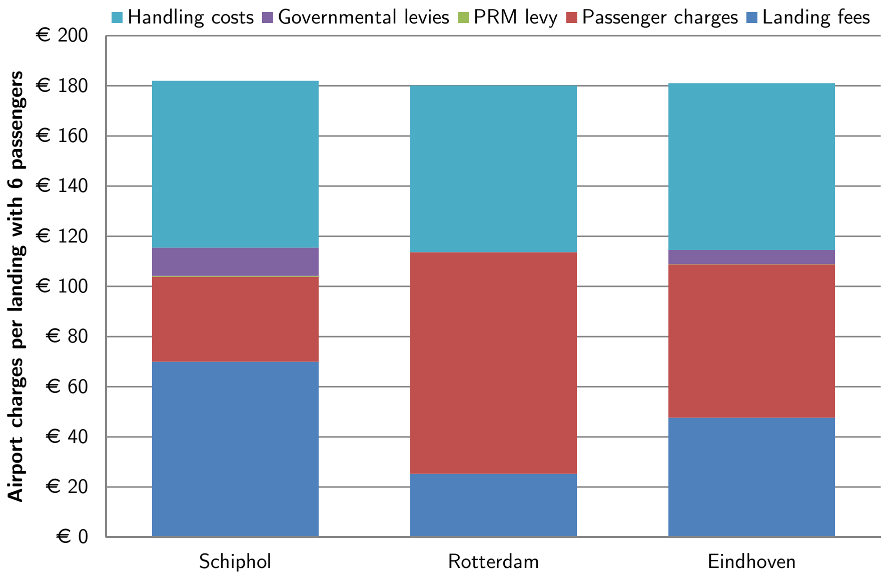


Figure 9-1: Total airport charges with 6 passengers

9-1-3 Call out costs

When serving the demand, depending on the amount of helicopters and locations, a call out charge has to be determined per location. To calculate the average costs, equation 9-1 can be used, which accounts for the fact that the closest helicopter is flown in. The results for the call out costs per flight are given in figure 9-2. It shows that an increase in the amount of helicopters will decrease the call out costs. The amount of passengers per location, which are calculated in section 6-2, are used for the calculation.

$$C_{co,A} = P_{\text{not},A} \cdot (P_{A_1} \cdot C_{AA_1} + P_{A_2} \cdot P_{\text{not},A1} \cdot C_{AA_2} + ...) + P^n_{A_{m-1}} \cdot C_{AA_{m-1}} \tag{9-1}$$

$$P_A = 1 - P_{\text{not},A} \tag{9-2}$$

$$P_{\text{not},A} = \left(\frac{\#\text{flights}_{\text{total}} - \#\text{flights}_A}{\#\text{flights}_{\text{total}}} \right)^n \tag{9-3}$$

In this case, m amount of airports and n amount of helicopters are used. P is the chance that there is at least one helicopter at the location. A is the airport of choice, A_1 the closest airport to A and A_{m-1} the furthest from it. $C_{co,A}$ is the call out costs for A and C_{AA1} is the costs for flying from location A_1 to A.

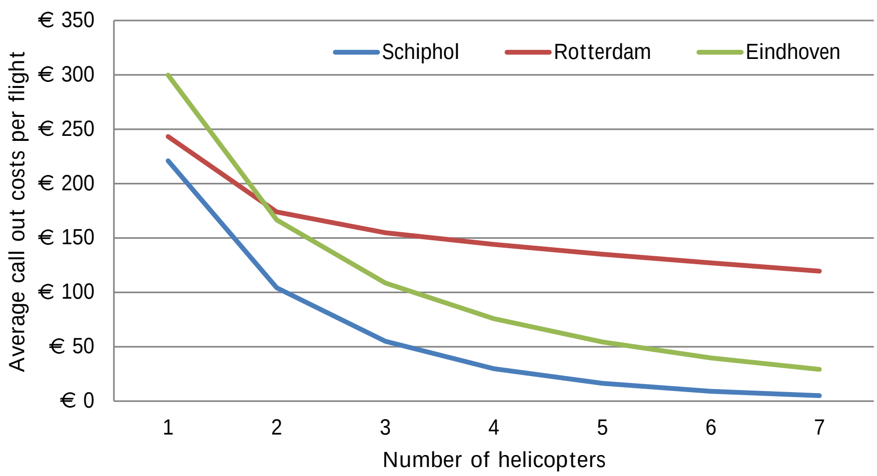


Figure 9-2: Average call out costs per helicopter flight

9-1-4 Fuel and maintenance costs

As explained in section 7-1-4, a hybrid, biofuel engine, has been selected. This makes the helicopter twice as efficient. One litre of biofuel is estimated to cost 1 euro, which leads to a fuel use of 2.02 euro per minute [80], [81], [82]. The maintenance costs are assumed to be 475 euro per hour, or 7.92 euro per minute [83]. Equation 9-4 gives to formula to derive the fuel and maintenance costs per flight.

$$C_{f,m} = \left(\frac{S}{V} + t_s\right) \cdot (C_f + C_m) \tag{9-4}$$

$C_{f,m}$ is the cost for fuel and maintenance per flight, S the distance in km between two locations and V the average cruise speed of the helicopter in km/min. Additional time is added for the stationary time. This is indicated with t_s and assumed to be 2 minutes in this case. Finally, C_f and C_m are the costs for maintenance and fuel respectively, both in euro per minute. The results are given in figure 9-3 together with the other variable costs. The call out costs are dependent on the amount of helicopters and the efficiency of planning. Therefore, they are not given in figure 9-3.

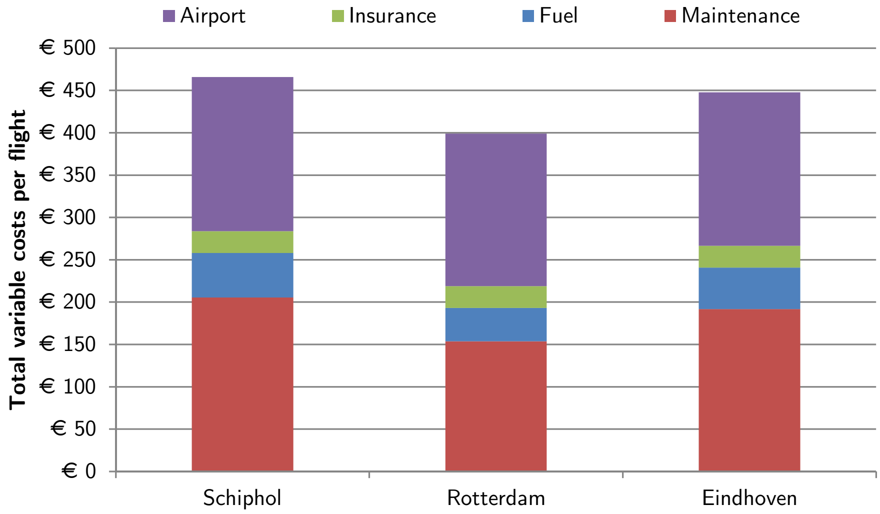


Figure 9-3: Total variable costs per helicopter flight

9-2 Fixed costs

Fixed costs can be split up into two parts. The aerial related fixed costs include helicopter depreciation, and pilot and ground crew salaries. The heliport related fixed costs include depreciation of the land and buildings, maintenance, and utilities.

9-2-1 Aerial related fixed costs

The aerial related fixed costs can be approximated. The salary costs for a pilot and the value of the helicopter are known. The lifespan of the helicopter does require an estimation, but this is based on accurate data. The amount of ground crew determines the salary costs. This is dependent on the amount of operations and is difficult to estimate. Therefore, these salaries are neglected in the aerial related fixed costs estimate.

Helicopter depreciation is the largest part of the fixed costs. The investment costs are divided by the lifespan of the product and these costs are added to the result of each year. With a price of five million euro and an approximated lifespan of 20 years, this would mean that per helicopter each year 250,000 euro is added to the yearly results.

The main influence to the total salary costs is the salary of the pilots. A pilot earns an average salary of around 60,000 euro per year [84]. Each helicopter is operated by one pilot, and it is assumed that no backup is required.

The total aerial related fixed costs per flight are shown in figure 9-4. The costs per location for the expected amount of flights are included in the graph. This is 219 euro for Schiphol, 1274 euro for Rotterdam and 415 euro for Eindhoven. This does not yet take into account the salaries of the supporting staff, which are dependent on the size of the operations.

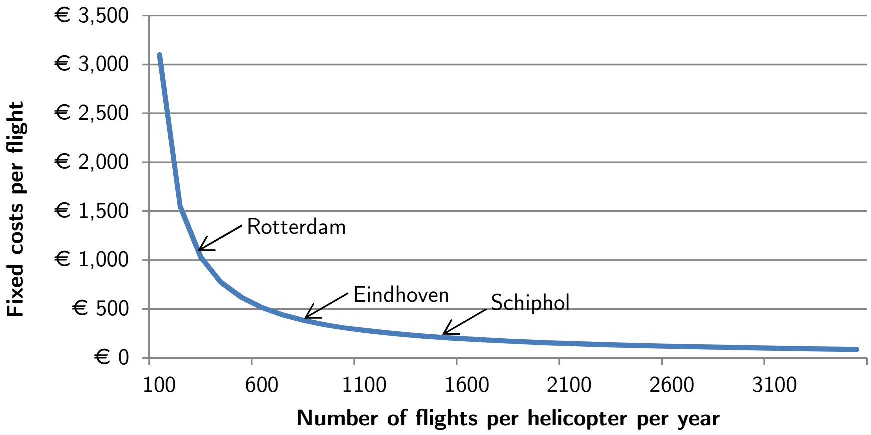


Figure 9-4: Aerial operations related fixed costs per flight

9-2-2 Heliport related fixed costs

A rough estimate can be given for both the building costs as well as for acquiring the land. These investment costs lead to the fixed depreciation costs. The heliport is assumed to be maintenance free, and it is assumed to have utilities close to zero as the heliport would be self sufficient.

The building costs of the heliport are difficult to predict, as too little detail is known of the design. An effort is made to find heliports of the same size, function, and use. These can be used for a preliminary rough cost estimation. The building price varies between 230,000 and 250,000 euro in Germany for surface-levelled land-based heliports with one helicopter stand. A rough estimation of three times the cost for a heliport with one landing pad is used to come up with a very rough building cost of 750,000 euro [85].

The ground prices in the region of Gorinchem are between 100 and 250 euro per square metre [86]. The Nederlandse Vereniging van Makelaars has published the ground prices for the Netherlands from 2002 until the first half of 2012 [87]. Also, the ground prices for Zuid-Holland are presented as an average of the area. In chapter 7 the estimated heliport area is given as 20,860 m^2. This translates into a maximum of 1.5 million euro for acquiring the land. However, indications have been given that it might be possible to acquire the land for a symbolic price of 1 euro if the heliport would significantly benefit the local economy.

The investment costs are relatively low and can be depreciated over a large amount of years. The leads to relatively low fixed costs compared to the aerial related fixed costs and variable costs. Therefore, the yearly costs are assumed to be negligible.

9-3 Profitability of the aerial network

The profitability of the system can be determined by subtracting the fixed costs per flight from the contribution margin. This is done for the devised business model.

9-3-1 Contribution margin

The contribution margin is calculated by multiplying the contribution margin per flight with the amount of flights. Combining all the variable costs with the willingness to pay, which are derived in section 6-2, leads to the results for the contribution margin per flight shown in figure 9-5. Income is plotted on the positive axis and costs on the negative axis. The ideal case is considered where all flights are fully booked and no call out fee has to be charged. The figure shows that in the ideal cases, a flight to Schiphol would generate 65 euro profit, Rotterdam approximately 125 euro and Eindhoven around 40 euro.

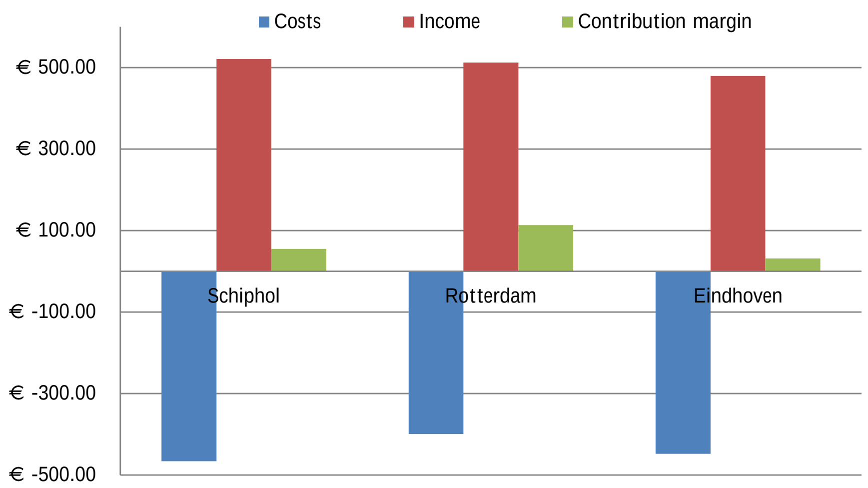


Figure 9-5: Contribution margin per flight

9-3-2 Profitability

Combining the results for the contribution margin per flight with the expected fixed costs per flight leads to the results shown in figure 9-6. This shows that the Schiphol connection is the closest to being profitable. However, still a total loss of 232,454 euro per year is incurred, which is shown in figure 9-7

Concluding, it becomes clear that an aerial network as suggested will not be profitable in the short term. The limited amount of locations which can be accessed by aerial transportation have too high costs compared to the price that can be asked per ticket.

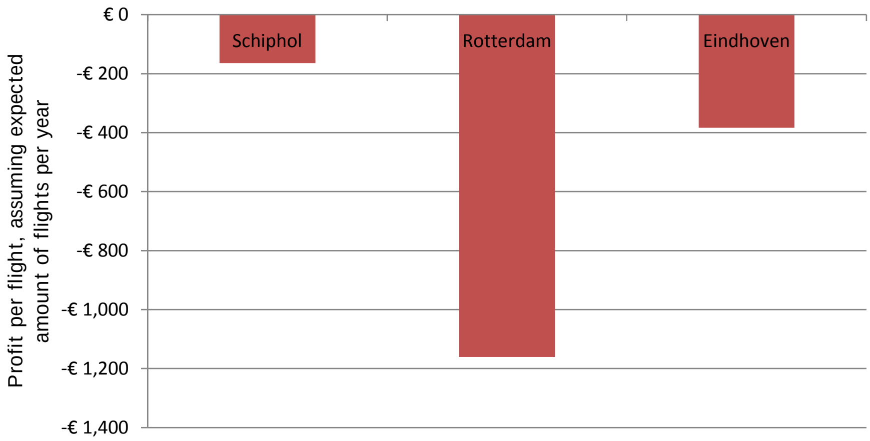


Figure 9-6: Total loss per flight, assuming the expected amount of flights per year

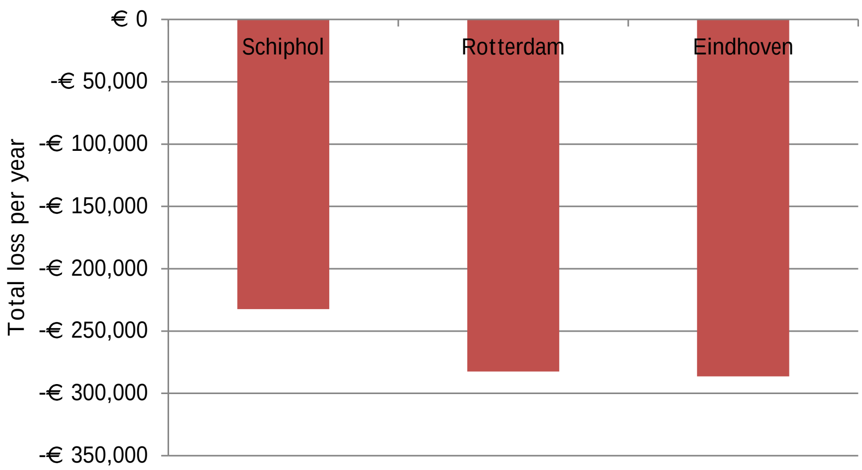


Figure 9-7: Total loss per year, assuming the expected amount of flights per year

Chapter 10

Long-term vision

In chapter 5, the timeline of the project has been explained. The subsequent chapters have elaborated on the design of the project in the short term. This chapter will state the long-term vision of the project. As mentioned in section 2-4, one of the requirements is that the design should be sustainable for at least 30 years.

The long term is defined to run from 2030 onwards. In the long term, the project aims to be a first and innovative step in the development of a national aerial network in the Netherlands, in which cities are connected with a high quality and fast transfer. In order to get there, innovative developments are needed, as the current design turns out to be not profitable. In this chapter, future developments are discussed and the long-term vision of the project is explained.

In section 10-1, the future business model is explained. In section 10-2, additional niche-markets are explored. Then, section 10-3 elaborates on the expected technological developments for the aerial vehicle and air traffic management (ATM). The influence of these developments on the heliport design is also explained in this section. The influence for the sustainability is elaborated on in section 10-4.

10-1 Long-term business strategy

As explained in section 9-3, the business model for the aerial network of Gorinchem lacks short-term profitability. The main issues that are identified, are high maintenance costs, high landing fees at the three major airports of the Netherlands and the high call out costs for low flight amounts. These three costs are the main driving costs of the aerial network and they prevent the project from being profitable in the short term. The expected developments, in the long term, of these costs are mentioned in this section. After that, the possibility of being profitable in the long term is discussed.

10-1-1 Cost development

The cost issues identified in section 9-1 make the project unprofitable in the short term. However, in the long term these costs might change. Possible reductions to these costs in the long term might make the project profitable. Below, the three main costs are discussed. These are maintenance costs, airport charges and call out costs. Furthermore it defines scenarios, used to investigate the profitability.

Maintenance costs
Even though the Eurocopter EC135 is one of the lowest maintenance cost demanding heli-

copters currently on the market, the costs are still one of the dominant cost drivers of the operating costs. The average maintenance costs of the EC135 are estimated to be 475 euro per flying hour [83]. In the short term, these costs will not significantly decrease, hence the business model will not become more profitable. The future focus should therefore be on decreasing these costs. The design of an aerial vehicle for future operations should have low maintenance costs as a design requirement.

Airport charges
The three identified locations to fly to and from are the three major airports of the Netherlands. All three airports have suitable facilities for a helicopter service. However, the costs involved are high. These airports are not suited for a helicopter service, as they aim at other types of traffic, and therefore charge high prices. The aim should be to find alternative heliport locations with high passenger demand. If new heliports are developed, a passenger service to and from Gorinchem could be profitable, because landing fees will drop when more landing spots are in use.

Call out costs
Since only a couple of daily operations are expected in the short term, the call out costs for such services could be very high. A low amount of operations also requires a small amount of vehicles, which further increases the call out costs. In order to prevent this, the initial focus should be on a single route with a single helicopter. New routes can be added when they are becoming profitable enough to pay for an additional helicopter. With increasing passenger demand on the routes, a scheduled service becomes possible that reduces the call out costs to zero.

10-1-2 Profitability development

Figure 10-1 shows the break-even point for the ideal scenario, using the cost development described above. There are two scenarios: one where the maintenance costs are halved and another one where the airport charges are halved. The required amount of flights to Rotterdam and Eindhoven exceeds the predicted demand of flights calculated in section 6-2. The routes to Rotterdam and Eindhoven are infeasible as a consequence of the high required amount of flights. For Amsterdam, both scenarios have unrealistic break-even points, as they are well above 3500 flights per year. The combination of both scenarios does provide a reasonable break-even point for Amsterdam. Therefore, the service to Schiphol or close by should be provided, if these scenarios are becoming reality. One should keep in mind that this break-even point is calculated without taking into account the other fixed costs except the depreciation of the helicopter and the salary of the pilot. Call out costs are not incorporated. If new markets can be found in other locations with high passenger demand, these could also be an option to make the aerial network profitable.

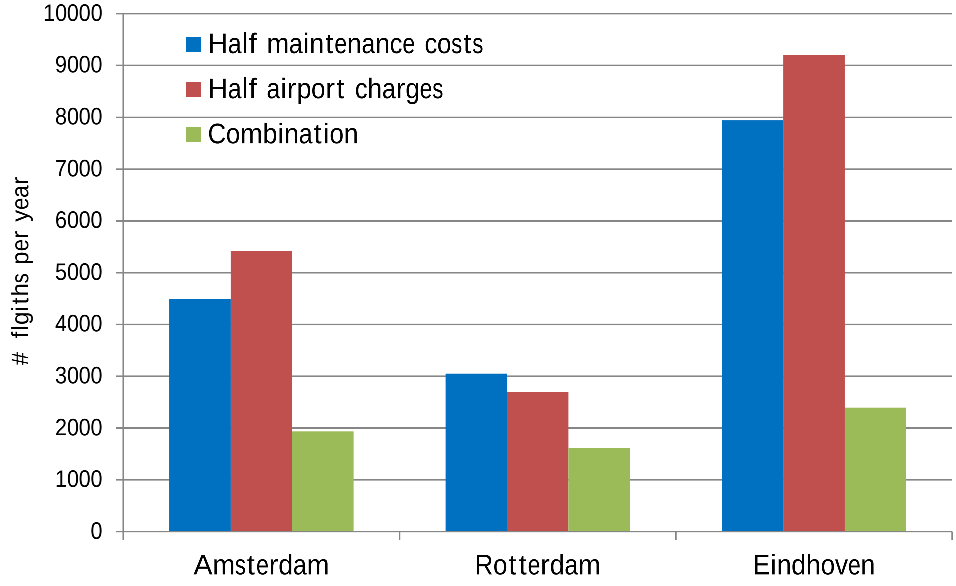


Figure 10-1: Break-even point per helicopter

10-2 Market development

A requirement for the project is to be profitable. The developments in the amount of customers determine the future income, which influences the profitability of the project. Therefore, the future changes in the amount and types of customers is analysed in this section.

Expected growth in market segments

To be able to forecast the amount of travellers in the period after implementation an expected growth is set. Since the civil helicopter segment will be liable to conjunctural influences, it is difficult to predict the growth. It is assumed that the growth is equal to the average expected inflation, because of the coupling with the economic situation. The average expected inflation in the Netherlands is around 2% [88]. Therefore, the growth of the number of customers is set to be 2%.

It is likely that a direct connection to the airports in the Netherlands will increase the attractiveness of Gorinchem for companies. Therefore, more companies will be located around Gorinchem and the growth will be higher. Because it is not possible to obtain any numbers for this, it will not be taken into consideration.

Additional market segments

An interview with the chairman of the foundation Behoud Erfgoed De Vries Robbé situated in Gorinchem has pointed out that a potential growth in the amount of emergency operations is likely. The river Boven-Merwede and the surroundings of Gorinchem could be served by a fast possibility for fire control and medical assistance. This brings a future opportunity for the network to serve this niche-market.

When the price per flight will decrease, the individual use of the helicopter for commuter traffic will be the first additional market segment. They are the first additional market segment because the willingness to pay for reduced travel time is higher than other market segments, like leisure travellers. A line connection, comparable to trains, can be developed to serve commuter traffic with a fast and high quality transfer around the Netherlands. Gorinchem can be the centre in this national aerial network.

10-3 Product developments

In the long term, developments can be expected on aerial vehicles and ATM. For the aerial vehicle, noise reduction, emission reduction and a decrease in the maintenance costs are desired for the project. The possibility of providing night operations and the adaptation towards instrument flight rules (IFR) might help in increasing utilization. Both developments influence the heliport design.

10-3-1 Aerial vehicle development

During the analysis and design phase of the Gorinchem Heliport project, the Eurocopter EC135 helicopter is selected as the aerial vehicle. The design of a future aerial vehicle should focus on three aspects: reduction of noise emission, reduction gas emissions, and reduction of maintenance costs.

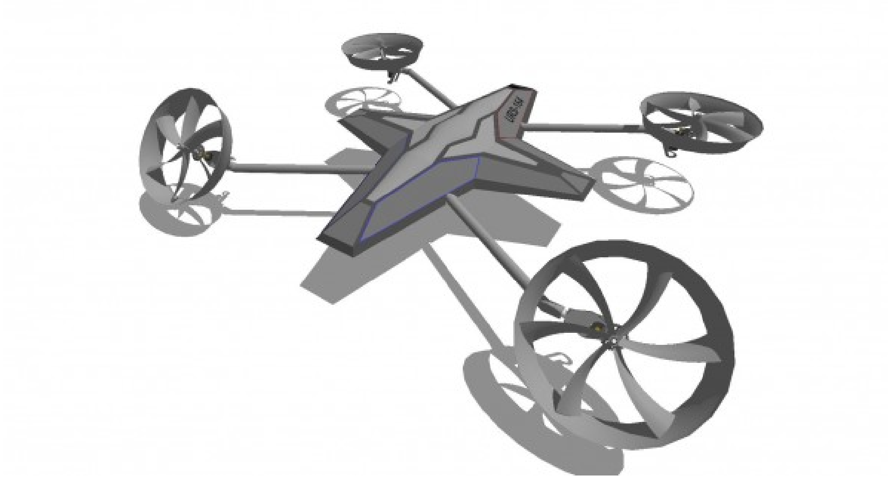


Figure 10-2: A possible layout for the future vehicle

Aerial vehicle requirements

To identify the future vehicle in more detail, requirements for the aerial vehicle have been set. Every aerial vehicle is possible, as long as it is VTOL. A possible lay-out for a future design of the aerial vehicle can be seen in figure 10-2.

As explained in section 7-1-5, the Eurocopter EC135 produces 79 dBA. The aim should be to reduce this with 10 dBA. Besides, there is a need to reduce the environmental impact of the vehicle throughout its entire life cycle from manufacturing, operation and disposal. The design focus should be fuel efficiency, low fuel consumption and reduction in gas emission. Various organisations have ambitious goals for the future, and the most influential ones are International Civil Aviation Organization (ICAO) and the European Union (EU). The specific goals of the EU are to reduce the carbon emission by 60% in 2050 compared to 1990 levels and to increase the percentage of sustainable low carbon dioxide fuels to 40% of the total used fuels [89]. Therefore, these goals set the guidelines for the long-term vision of the aerial network.
Furthermore, the operating costs should be minimised as much as possible in order to make a profitable business model. Thus the design and manufacturing of the new aerial vehicle should incorporate reduction of maintenance costs. In line with these three aspects, the requirements for the aerial vehicle are as follows.

- **Maximum take off weight:** should be smaller than 2,700 kg.
- **Noise level:** shall be less than 69 dBA for overflight.
- **Take-off:** the vehicle should be VTOL.
- **Fuel use:** the vehicle should be low fuel consuming and using alternative fuels.
- **Range:** of 500 km.
- **Cruise speed:** of 200 km/hr.
- **Emissions:** 60% less CO_2 emission (2012 EC135 baseline is 612 kg of CO_2 per hour).
- **Safety:** EASA CS-27 (certification specifications of European Aviation Safety Agency for small rotorcraft) certifiable.
- **Redundancy:** two engines.
- **Implementation:** the vehicle should be available in 2030.
- **ATM:** the vehicle should be able to fly IFR.
- **The maintenance costs:** should be halved compared to the 475 euro an hour calculated in subsection 9-1-4.

Implementation of the new vehicle in the project
A new aerial vehicle can be used to serve the additional line connections for commuter traffic, as explained in section 10-2. If the Eurocopter EC135 is already operating, it should be replaced by the new aerial vehicle, otherwise, the operations can start when the new aerial vehicle is there.

10-3-2 Air traffic management development

Developments in the ATM are expected to focus on the increase of the utilisation of the heliport, when additional operations for the line connection service are provided. One option is to change the national legislation with respect to flying VFR at night. As NACA (the National Advisory Committee for Aeronautics) indicated, the current rules are not clear [46]. Furthermore, in surrounding countries as Germany, Belgium and the United Kingdom, it is already allowed to fly VFR at night.

Another option is to allow instrument flight rules (IFR) operations. This will allow pilots to fly with low visibility and at times outside the universal daylight period. As explained in subsection 7-2-2, the main reason for not using IFR in the short term is due to the high investment costs. As described in 7-2-2, flying IFR means that pilots might not be able to ensure separation between vehicles. This can be solved by offering air traffic control or limiting the amount of operations per hour by providing air traffic flow management locally.

10-3-3 Heliport development

The new aerial vehicle and the possibility of flying at night, influence the heliport design. With the possibility of night operations, additional rules apply. The new aerial vehicle would possibly be electrical, which requires recharging facilities. As stated in section 7-3, the heliport area will be sufficient when the number of flights increases in the future.

Electrical charging
Ideally, a switch to electrical helicopters is made. In that case, the amount of electrical power required would increase. A new facility could be implemented as an expansion on the site, in order to provide electricity for the batteries. The company Better Place already launched the first electric taxi project in Amsterdam, which uses a new battery switching technology. Better Place could be considered as a stakeholder for the future plan in order to make a smooth switch to the new technology [90].

To provide energy for the electrical aerial vehicles, the use of pumping high altitude wind power plant (PHAWPP) might be an option. PHAWPP could be another alternative for generating electricity, using kites. It has a smaller structure and carries less material than conventional wind turbines, thereby making it more sustainable. Based on the research conducted in one of the Test-Analysis and Validation projects in TU Delft [91], the new findings show that up to 12,8 MJ of net energy per hour can be produced. The main problem is the automation of the steering of the kite and the performance of the entire system. Nevertheless, having kites nearby the heliport could cause risks for the operation of the helicopters. In a follow-up project, more research should be done on the elements that could minimise the risks of the implementation of PHAWPP around a location nearby the heliport.

Night operations
ICAO Annex 14 gives different guidelines for night time operations than for day time operations for certain functions or elements of the heliport [58]. The major difference in day

and night operations for the surfaces is that for night operations the width of the inner gate is wider than for daytime operations. This difference is to give the pilot more airspace for conducting the approach and take-off manoeuvres. The heliport operator should monitor the obstacle free surface for night operations so that the surface area will stay clear. Additional, night operations requires multiple lights at the heliport.

To be able to fly IFR in the long term, the heliport should install instruments to provide the desired information. An example of such instruments is the Instrument Landing System, where an approach path towards the runway is provided. A detailed description of the heliport function that should be provided to fly IFR, is given in Annex 14 of the ICAO regulations [58].

10-4 Long-term sustainability

In section 10-2, it is already mentioned that the design should be profitable. However, the impact on the environment is important as well. Chapter 8 deals in great detail with carbon emissions, alternative energy generation and noise. As explained in section 10-3, the design for the new aerial vehicle aims to reduce emission and use alternative fuels. Therefore, this section will only discuss the effect of noise in the long term. The influence of the increased amount of operations on the noise contour is given below.

Noise impact with doubled amount of operations
The additional operations for line connections influence the noise impact from the design. To predict the future noise level, a noise contour with an increased amount of operations has been created. Again, Integrated Noise Model (INM) is used, as described in section 8-3. The similar assumptions as mentioned in that section have been used. Figure 10-3 shows the noise contour map with the double amount of operations.
Compared to the noise of the designed amount of operations, an increase in the area of the 48 L_{den} noise level can be seen. Nevertheless the impact on the populated area is still small. With the improvements ahead in the development of less noise producing aerial vehicles, the noise level is assumed to stay within the acceptable level of 48 L_{den} in populated areas, even when the amount of operations doubles, compared to the amount of operations in the short-term design.

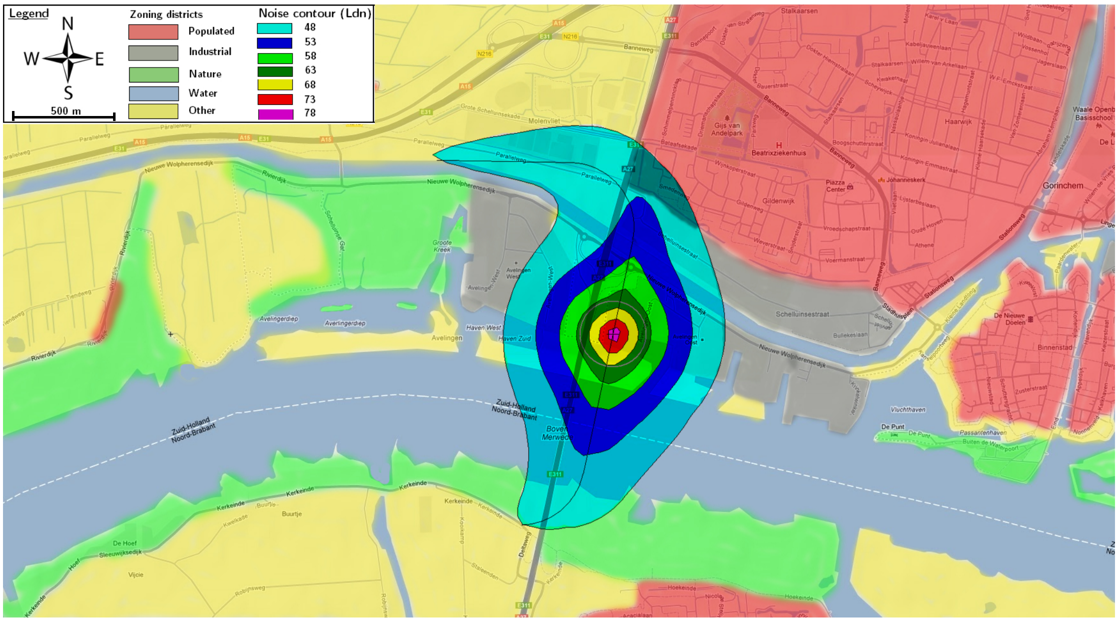


Figure 10-3: Noise contour in a scenario where the amount of operations is doubled

Chapter 11

Verification, validation and sensitivity analysis of the design

A verification and validation of the design is performed to find out if the design complies with the requirements and to check if this project has achieved its goal. In this chapter, the requirements defined at the start of the project are checked for achievement or failure. This check is part of the verification and is further elaborated in section 11-1. In section 11-2, the validation process of this project is briefly described. The validation is an assurance that the customer and other identified stakeholders get the product they need. Finally, a sensitivity analysis is executed in section 11-3. This analysis determines if the outcome of the design is sensitive to different inputs.

11-1 Verification of final design

The requirements for an aerial network are defined at the start of the project. This is described in chapter 2. These requirements are based on the initial project description and on a meeting with a member of the municipality of Gorinchem. A second meeting with another member of the municipality has lead to a modification of the vision of the project. This can be read in chapter 5. Here, an additional requirement is added, i.e. the design must be profitable. Solving the traffic problem for Gorinchem has become beyond the scope of the project. In subsection 11-1-1, the requirement check is further discussed. A verification of the calculations in the previous design chapters is performed in subsection 11-1-2.

11-1-1 Requirements check of final design

In section 2-4, the requirements discovery tree (RDT) can be found. It is divided into two parts. The first part consists of the requirements that the network should have, based on the functions like passenger transport, cargo transport and other services. The second part consists of the constraints in terms of costs, customer demands, legislation, schedule and location.
First, the requirements check of the functional part of the RDT is investigated. This can be seen in the paragraphs below.

Design must be profitable
This is not met in the short term. However, there is high potential in the long term if sufficient funding is found. From the calculations in chapter 9, it has become clear that the

design is not profitable in the short term. Nevertheless, many opportunities exist in the long term in case the maintenance costs and landing fees decrease significantly as mentioned in 10-1.

Provide passenger transport
This is met. Even though it is not profitable to start a transport service to certain locations at a reasonable price per ticket, the implementation of the heliport is recommended. Therefore, passenger transport will be provided as soon as the heliport begins its operations.

Provide cargo transport
This is not met. From the services analysis in chapter 6, it has become clear that there is no market for cargo transport in the short term. However, as new companies are being established in Gorinchem, a need for cargo transport might arise therefore this market requires reconsideration in the long term.

Always available for use by authority
This is met. Governmental flights can be performed from the heliport at all time.

Private use only
This is not met. However, this requirement does not carry any significance to the project since the heliport will be a commercial open heliport.

Subsequently, the constraints requirements check is performed. It can be seen in the paragraphs below.

No financial risk for municipality
This is partially met. The financial risk for the municipality will be reduced to a minimum and companies will invest in the project, as can be read in section 12-4.

Engineering budget competitive with electric cars
This requirement is not investigated, because the aerial vehicle has not been compared with electric cars. The requirement is not applicable any more.

Beneficial for economy
This is met. A heliport in Gorinchem will be beneficial for the economy. There will be an increase in tourism, governmental use of the airspace and business aviation. The assumption that the presence of tourist flights are beneficial for the economy is verified during the second meeting with the municipality of Gorinchem.

Payload constraints
This is met. The helicopter that will be used can carry six passengers and a cargo of more than 350 kg. This can be read in section 7-1-2.

Transport by air
This is met. Transport services will be performed by air.

Reduce traffic-jam time
This is not met in the short term. However, in the long term, transport by air could reduce the amount of traffic jams.

Design complies with legislation
All the different subrequirements related to legislation are met. Every design part is developed according to the regulations and legislations. Although, a risk contour is not provided due to its complexity. However, risk indications for landing and take-off procedures are available.

Implementable within five years
This is partially met. The implementation time is extended until 2020 to guarantee the availability of a hybrid helicopter and to have all the sufficient resolutions and clearance from both the province and the municipality.

Sustainable for 30 years
This is met. The implementation of new technologies and the growing customer markets indicate that the aerial network is sustainable and even will continue to develop for the next 30 years and longer.

Location does not disrupt protected city view
This is met. The aerodrome will be located on an industrial estate and it will not disrupt the existing city view.

In general, the system complies with the functional requirements of the aerial network. At this moment, it is not profitable to start a passenger service however as soon as the heliport is implemented, the transport operations can begin. Only the customer demand to reduce the loss in time due to the traffic problem is not met in the short term. An overview of the requirements which are met for both parts can be found below in table 11-1 and table 11-2.

Table 11-1: Overview of the functional requirements that are met

	Design profitable	**Provide passenger service**	**Provide cargo service**	**Can be used by authority**	**Private use only**
Met	No	Yes	No	Yes	No

11-1-2 Verification of the calculations

In the previous subsection, a requirements check is performed for the design. Next to that, a verification of the individual calculations can be done to check if the calculated values are correct. An overview of the different verifications is given in the paragraphs below.

Table 11-2: Overview of the constraint requirements that are met

	No financial risk municipality	**Engineering budget competitive**	**Beneficial for economy**	**Payload**	**Transport by air**
Met	Maybe	Not applicable	Yes	Yes	Yes
	Reduce traffic jam time	**Legislation**	**Implementable within 5 years**	**Sustainable for 30 years**	**Location**
Met	No	Yes	Maybe	Yes	Yes

Customers

Multiple companies are contacted to ask if they could provide data on charter flights, tour trips and inspection flights. Unfortunately, there has been no response. Therefore, the amount of customers that can be served is not verified yet.

Product design

The determination of the location and design of the heliport is based on all the different regulations. These regulations are, although extensive, very clear. The verification of these calculations is therefore not needed. For the research on the helicopter, different sources are used. The values and estimations for the future come from EADS and Eurocopter. These values can assumed to be correct.

Sustainability approach

Well documented data provided by car and helicopter manufactures is used for comparison of carbon emissions. A quick snapshot of the heliport building footprint has been made using the life cycle impact assessment tool Athena EcoCalculator. However, the obtained values are not verified with a third party. The noise contour map is checked by a PhD student at the faculty of Aerospace Engineering at Delft University of Technology (TU Delft), ir. S. Hartjes. The basic calculations of the noise contour seem to be reasonable. The final part on alternative energy generation however, is not verified. Although the numbers are based on well documented data, it is recommended to do further investigation on the exact outcome of the calculations.

Financial plan

The determination of the costs is based on different sources, but these sources are scarce. The calculations on maintenance costs are compared with other helicopters and other calculations and assumptions. They look reasonable. However, it must be mentioned that there is no verification of the calculation with an expert in the field.

11-2 Validation of final design

A validation is needed to check if the customer and other identified stakeholders get what they need and demand. It is hard to have a good validation process, because the amount of customers and stakeholders is large. A meeting with Mr P. van der Werff of the municipality of Gorinchem has been performed to have a validation of the design. A visit to the actual location Avelingen has resulted in a preliminary check on safety, noise problems, estimated landing approach routes and unforeseen costs. Although this visit is part of a verification process, it is described in this section as part of the visit to Gorinchem.

The response of Mr P. van der Werff has brought that there is a potential for a heliport in Gorinchem. However, it depends on the amount of investors that can be found to agree with the development of a heliport. The requirements of the constraints seem to be valid, but more detailed research is necessary to admit a heliport project into a policy. Furthermore, the disturbance of motorway users due to helicopter activities must be investigated in the future. Mr P. van der Werff has made the suggestion to get in contact with the appropriate alderman of the city and to present this final report to the municipality of Gorinchem.

A visit of the location Avelingen has made it clear that there is enough space for a heliport. A part of the existing infrastructure can be retained to save costs. In terms of safety, a radio mast must be removed to guarantee a safe clearance zone. The same holds for big billboards along the motorway. The landing approaches and take-off routes are well defined, as can be seen in figure 7-17. However, one remark must be made. There are situated a couple of ten storeys high flats in the north of the Avelingen. Flight paths need to be adjusted to modify the noise contour. This could avoid complains of residents and violation of provincial regulations.

11-3 Sensitivity analysis of final design

In this section, a general sensitivity analysis is performed. The outcome of the design should be a heliport with a profitable aerial network.

A complete sensitivity analysis whereby every element is changed to see the effect on the outcome is not possible. The complexity of this heliport project is too large to complete such an analysis. Still, a general sensitivity analysis can be performed by changing some major aspects and estimating what effect it has on the profitability. The aerial network is profitable if the incomes are higher than the variable and fixed costs together. The variable costs do have a larger influence on the profitability than the fixed costs, as can be found in chapter 9. Below, a sensitivity analysis on customers (revenue), vehicle selection (variable costs) and location (fixed, investment costs) is done.

Amount of customers

This has major sensitivity. The income is entirely dependent on the amount of customers. The profitability of the network and a heliport is highly sensitive for a change in the amount of customers.

Type of customers

This has moderate sensitivity. If there is a change in customers, the impact on the outcome will have a moderate effect. The total revenue should have the same percentage per customer type. A business to business flight creates a higher revenue, but the variable costs, e.g.

landing fees are higher compared to the cost of tour flights. The impact on the outcome would only be significant in a case that an entire customer type would disappear.

Vehicle selection
This has major sensitivity. The vehicle has a direct effect on the maintenance and fuel costs. In figure 9-3, it can be seen that the maintenance cost has a large effect on the total variable costs per flight. Therefore, a different vehicle with modified maintenance costs will have a major influence on the profitability.

Location
This has minor sensitivity. A different location will have an effect on a part of the investment costs. However, the overall effect on the profitability will be of minor influence because it has no effect on the variable costs. In chapter 9, it is explained that the variable costs are the main costs drivers.

Based on these elements, it can be concluded that the sensitivity to have a different outcome in terms of profitability is moderate to high.

Part III

Implementation phase

Chapter 12

Implementation strategy

From chapter 9, the conclusion is drawn that the current business model is not profitable. Still, chapter 3 has shown that there is the need to improve the accessibility of Gorinchem and the findings in section 6-2 have shown that several market segments for a heliport exist. This means that there is a potential market for a heliport in Gorinchem. Therefore, this chapter will elaborate on the implementation strategy for a heliport in Gorinchem.

Section 12-1 will explain the business strategy. The business strategy explains what steps should be taken at the moment, to realise a profitable heliport in Gorinchem. Section 12-2 will elaborate on the market strategy. The market strategy explains how the identified markets will be attracted to use the heliport. To prepare for the implementation of the heliport, section 12-3 will deal with a competitor analysis for both the short and the long term. In order to guarantee a successful business model, it is smart to keep possible competitors into account. Finally, section 12-4 elaborates on a risk analysis for the implementation strategy of the project.

12-1 Business strategy

At the moment, the business model is not profitable, but there are several identified markets that are interested in the use of a heliport in Gorinchem. Therefore, the business strategy proposes to start with the construction of a heliport in the short term, with the aim to develop a profitable business in the long term.

The construction of the landing site in the short term will increase the accessibility and connectivity of Gorinchem. Local business can fly in their customers by using either their own helicopter or by using a commercial helicopter. It is also expected that the government and the municipality are willing to make use of the heliport for medical assistance, law enforcement and inspection flights. The operational service cannot be offered yet by Heliport Gorinchem, because the current business model is not profitable, as shown in chapter 9. Therefore, only the landing site is constructed and the user is responsible for other arrangements itself, like the helicopter for instance.

To get the business model profitable, the business strategy aims to decrease operating costs in the long term. This can for instance be done by a decrease in maintenance costs or by developing other heliports near the destinations, in order to avoid the expensive landing fees. This is explained in section 10-1. Once it will be possible to realise a profitable business model, Gorinchem already has its heliport and operations can start immediately. Gorinchem can take the leading role in developing an aerial network in the Netherlands.

The construction of the heliport will take a limited investment of 750,000 euro. Investors will be necessary to realise the heliport, because the municipality of Gorinchem has indicated that there is no money available for the heliport project in the short term. A good market strategy might ensure that the municipality only has to provide the location of the land site. This would limit their financial risk.

To give an indication of the future planning, a Gannt chart for the business strategy is included in appendix E.

12-2 Market strategy

This section elaborates on the market strategy for each identified market for the heliport. The market strategy describes how the heliport will attract the targeted niche-markets. The section will elaborate on the market strategy for respectively the business to business market, tourism, emergency services and the government and other third parties.

Business to business

One of the identified markets for the heliport is the business to business market. Especially the larger, international orientated companies are willing to pay for this service. The two largest ones are Damen Shipyards and Van Oord. To make sure that these companies will make use of the services of the heliport, they should be bound to the project from the start. The companies that are interested in the services of the heliport, should invest in construction of the land site of the heliport. Damen Shipyards should be contracted as the launching customer, while others should invest shortly after. By letting companies invest in the project, they become financially involved and carry part of the risk involved in such a project. The involvement of these companies will also ensure that they will make use of the heliport. The investors for the heliport should be found in this market. Damen Shipyards and Van Oord should have a leading roll in this. The heliport can then be realised and the use of the heliport will thereby be guaranteed.

The business strategy indicates that it will not yet be profitable to offer the planned services to business travellers in the short term. Until then, the companies that already want to make use of the heliport have their own responsibility to lease or invest in a helicopter themselves. It should be made clear that there is the possibility to already make use of the heliport although Heliport Gorinchem is not yet offering the helicopter service. The market is expected to grow in the long term and that the service will be offered when a profitable business model can be realised.

Tourism

Another identified market is tourism. Visiting tourist attractions in the region of Gorinchem by helicopter is an exclusive way of sightseeing. As explained in chapter 6, the willingness to pay for a trip by a helicopter is not that high with the moderate tourists. Therefore, it should be made clear that this market is not very promising for the short-term business strategy. Once it is possible to realise a profitable business model, this market should be attracted as well. In that case the helicopter tours should aim for tourists from other continents. These tourists are more willing to pay for an exclusive Eurotrip, including sightseeing tours by helicopter. The helicopter tours should also be promoted on a national and European scale, although the expectations are not that good as for the intercontinental tourists. The fact that not many tourists have ever travelled by helicopter should be used. Tourists should be made curious to know how it would be to fly by helicopter. Promotion of the new heliport should be outsourced to a number of marketing companies. Also tourist offices like the Vesting3hoek and the Tourist Information Office of Gorinchem should be approached. These offices can present the helicopter tour to tourists as being "the most exclusive way to fly back to the past". The fact that it is better to attract tourism in the long term, gives the opportunity to better investigate this market.

Emergency services

A heliport could support the hospital of Gorinchem in supplying extra emergency services. Also the connection with other hospitals in the Netherlands will be improved. It is advised to anticipate on this market by offering the use of the heliport to the municipality of Gorinchem. A positive side to this market segment is the contribution to the social importance and social acceptance for a heliport of the inhabitants of Gorinchem. The municipality and the hospital of Gorinchem should be convinced of the importance of the implementation of a heliport by presenting all opportunities in terms of medical assistance, connectivity to other hospitals in the Netherlands and law enforcement.

Government and third parties

As explained in chapter 6, half of the helicopter flights in the Netherlands is related to governmental services and inspections. Therefore, another market segment is the government. The same strategy as for the business to business market can be used for this niche-market. The government should be convinced by the benefits of a heliport in Gorinchem and invest in the project. The government should invest in the project, because of the fact that it can use the services for inspections and other governmental issues in the region. If it turns out that the government is not willing to invest in the heliport because of financial issues, then the government should only be considered as a possible client.

12-3 Competitive analysis

The following section will focus on assessing the strengths and weaknesses of current and potential competitors, for respectively the short- and long-term business strategies. Such an analysis will provide insight in the opportunities and threats to the use of the heliport. These are caused by alternative ways of transportation that provide the same service. In order to perform a competitor analysis, it is of importance to clearly define the service, competitors, customers and key success factors. These can then be used to construct a competitor array as can be seen in subsections 12-3-1 and 12-3-2.

Service

The essence of the aerial network is to transport passengers from heliport to heliport in a quick, luxurious and dependable way. Although, other niche-markets have been identified, the main objective of the aerial network is to offer a transportation service. In the short term, this market will be small, due to high operating prices of the helicopter. However, in the long term, these prices are expected to decrease, thereby opening up a larger market segment.

Customers

The service of transportation offered by the heliport will be expensive in the short term. The customers are therefore identified to be customers and employees of either Damen Shipyards, Van Oord or other companies in Gorinchem that are willing to invest. People with high incomes and the willingness to pay, are also identified as a niche-market. This customer group is however fairly small due to the high operating prices of the helicopter. In the long term, the lower operating costs will allow this customer group to expand, since more people will be able to afford the heliport service.

Competitors

Competitors that offer a similar service to that of the helicopter are identified to be the taxi, public transport and the private car. These modes of transport offer a comparable service and are capable of reaching the same destinations. In the long run, these competitors are expected to develop. However, it is not expected that new competing modes of transport will be created.

Key success factors

The key factors that determine the success of the aerial network are defined to be the follow ones.

- **Costs**: the average cost of one trip.
- **Travel time**: the door-to-door travel time.
- **Comfort**: the level of comfort experienced by the passenger.
- **Traffic sensitivity**: the sensitivity to traffic congestion during peak hours.
- **Flexibility and reliability**: the degree of responsiveness to change and the capability of being dependable.

The weight assigned to each key success factor differs for the short and long term, since other market segments are aimed at. Different market segments have different priorities and preferences, hence some factors become more important than others.

12-3-1 Short-term competitors

In the short-term competitor array, the competitors and the heliport services are scored on each of the key success factors. Each of the transportation modes are given a score, as described in table 12-1.

Table 12-1: Scale of scores given the key success factors

Score	Definition
1	Poor
2	Unsatisfactory
3	Satisfactory
4	Good
5	Excellent

Each of the key success factors is also given a weighting, in order to describe the importance of that certain key success factor for the customer. The weightings for the short-term situation are discussed in table 12-2. One must keep in mind that the customer group for the short term are identified to be customers and employees of either Damen Shipyards or Van Oord and people with high incomes and the willingness to pay.

Table 12-2: Weighting key success factors in the short term

Key success factor	Weight	Reasoning
Costs	15	The ability and willingness to pay is present for the identified customer group.
Travel time	25	Time is of the essence for businesses and high income customers and hence has high priority.
Comfort	20	The identified customer group expects a high level of comfort and are willing to pay for this.
Traffic sensitivity	15	Less sensitive to traffic since travelling occurs mostly off peak hours.
Flexibility and reliability	25	Transportation mode should be highly flexible according to wishes of customer and above all reliable.

Now that the key success factors have been identified and weighted, each of the transportation modes are examined by each of the key success factors. The scores are then multiplied by the weights to get a final total score. The short-term competitor analysis can be found in table 12-3.

From the competitor analysis, it becomes clear that helicopter use for the specified customer group is the best transportation mode. The strengths of an aerial network are the low travel times and the high flexibility and reliability. These factors are considered to be of utmost

Table 12-3: Short-term competitor analysis

Key success factors	Weight	Taxi	Public transport	Private car	Helicopter
Costs	15	3	5	4	1
Travel time	25	3	2	3	4
Comfort	20	4	2	3	5
Traffic sensitivity	15	2	4	2	4
Flexibility and reliability	25	4	2	4	4
Total	**100**	**330**	**245**	**325**	**375**

importance to the identified customer group. The level of comfort of the helicopter is also one of the biggest strengths of the helicopter in comparison to the other modes of transport. As expected, the weaknesses of the helicopter are the high operating costs and hence high prices.

The major competitor threats are presented by taxi services. This service allows high comfort levels and flexibility and reliability, while charging lower costs for service. The opportunities of the helicopter service in comparison with that of the taxi service are the faster travel times and the insensitivity to traffic congestion. The second threat to the helicopter service is the private car which allows for far lower costs. However, it is very sensitive to traffic congestion.

12-3-2 Long-term competitors

In the long term, the customer group that is initially identified will be expanded by lowering the costs of the helicopter service. In order to successfully carry out a competitor analysis for the long term, it is important to identify the main assumptions of the long term. Three of the main assumptions made about the future situation are as follows.

1. Helicopter operating costs will decrease, allowing for lower prices;
2. Public transport network in Gorinchem will expand making it faster, more reliable and more flexible;
3. Traffic situation in and around Gorinchem will not improve or worsen.

While keeping the above stated assumptions in mind, the key success factors can again be weighted according to the situation in the long term. The weights assigned to each key success factor can be found in table 12-4, while keeping in mind that the customer group has been expanded to people with a lower ability and willingness to pay.

Each transportation mode is again examined by each key success factor. The scores are multiplied by the weights to reach a final total score for each transportation mode. The competitor analysis for the long term can be found in table 12-5.

In the long term, the high operating costs of a helicopter are expected to decrease. However, the weighting of this key success factor is expected to increase. The strengths of the helicopter service remain in comparison to the other modes of transport.

Table 12-4: Weighting key success factors in the long term

Key success factor	Weight	Reasoning
Costs	30	Costs have become a crucial factor, since the overall ability and willingness to pay has decreased.
Travel time	20	Travel time becomes less important since the aim is to make the heliport also accessible for the moderate class, for which time is not that important as compared to the business to business market.
Comfort	15	Level of comfort should still be high but is not as important as in the short term.
Traffic sensitivity	15	Traffic sensitivity is considered to be equally important in the long term as in the short term.
Flexibility & reliability	20	Reliability remains important however the flexibility is less of a concern.

Table 12-5: Long-term competitor analysis

Key success factors	Weight	Taxi	Public transport	Private car	Helicopter
Costs	30	3	5	4	2
Travel time	20	3	3	3	4
Comfort	15	4	2	3	5
Traffic sensitivity	15	2	4	2	4
Flexibility and reliability	20	4	3	4	4
Total	**100**	**320**	**360**	**335**	**355**

However, the main threat that will arise in the long term, is that the public transport network will expand. This expansion will offer faster travel times, more flexibility and reliability, in comparison to the short term. Therefore, public transport becomes a considerable threat to the helicopter service. The only real opportunity is the comfort level of the transportation mode. Where public transport is considered to be at a relative low comfort level, the helicopter is at a very high comfort level. Taxi services and private cars are still a threat, however the main opportunity for an aerial network exists due to the insensitivity to traffic congestion.

12-4 Risk analysis

A risk analysis is done to identify the risks for the implementation of the heliport and its market and business strategies. First, the risks need to be identified. When the risks are identified, the consequences of the risks should be clear and then it is possible to think of actions to reduce the risk. The risk analysis is divided into two parts. In subsection 12-4-1, the risks are identified and analysed. In subsection 12-4-2 a strategy is determined to monitor and control the different risks. The approach for the risk analysis is the same as used for the risk analysis of the conceptual design in the midterm report [1].

12-4-1 Risk identification

The identified risks are risks that can influence the implementation strategy of the heliport. Below, the identified risks are listed.

1. **Heliport is built, but not used:** this will be a waste of money and a waste of the heliport. The heliport can be taken in use by a company like Damen Shipyards for business travellers and clients. The services are not offered yet, but that does not mean that a company like Damen cannot use the heliport. This will not have a lot of impact on the project, since implementation of the heliport prepares Gorinchem for the future to create a profit making heliport.

2. **Companies are not willing to invest:** companies are not convinced of the use of a heliport and are therefore not willing to invest in the project. This will have large influence on the project. Since the municipality of Gorinchem is not willing to invest because of financial issues, the project is dependable on main investors. Besides that, this will make it more difficult to approach the business to business market.

3. **Heliport Gorinchem is not profitable in the long run:** for instance, when maintenance cost decrease but salaries increase in the near future. These costs will cancel each other out and this will not improve the profitability of the heliport. If the long term will not be profitable either, there is a high chance of not executing the project.

4. **Technological developments take more time than expected:** technological developments should aim for a decrease in costs in order to make the heliport profitable. For instance, the development of the hybrid engine of the helicopter. The current plan already incorporates the use of a hybrid engine in the business model. This development is really necessary to realise the project. It will have a catastrophic impact on the project.

5. **Maintenance cost will not decrease in the long run:** this will make it a lot harder to make the heliport profitable. It turns out that the maintenance cost need to be decreased in order to make the heliport profitable. It will have major impact on the project since this will make it a lot harder to gain profit out of the heliport.

6. **The aerial logistic network cannot expand in the long run:** this can endanger the profitability of the heliport services. It turns out that the landing fees of the airports are an obstacle in making the heliport profitable. A way to get around this, is to expand the network with other heliports near the airports. No expansion of the aerial network will have major impact on the project, because it will be even harder to make the heliport services profitable.

7. **Market for tourism not as strong as expected:** it might turn out that the demand for helicopter tours is not big enough to gain profit out of this market. Since also other markets are identified, this risk will have moderate impact on the project.

8. **Public transport is more popular than the heliport in the long term:** the public transport is an important competitor in the long run. It might threaten the possibility to expand aerial network of the heliport, because there is no demand for travelling more by helicopter. This risk will have moderate impact on the project, since it will affect only in the long run. This means that the heliport is operational in the short term and therefore, has to look for other market segments if there is a demand for the use of a helicopter network.

9. **There are other ways to make Gorinchem more accessible:** by building a second bridge next to the Merwedebrug or by building a large train station it is possible to improve the north-south connection from Utrecht to Breda. This might result in the fact that the cost of a helicopter flight does not outweigh the amount of travel time saved. It will therefore have a major effect on the heliport. However, due to financial concerns of the Dutch government, the projects related to reducing the traffic problem via ground or rail transportation is unlikely to be realised, thus such a risk is unlikely.

10. **No social acceptance of the community and municipality of Gorinchem:** this is necessary to implement a heliport in the city. Previous projects on heliports are not executed, because there has been no social acceptance of the community. It is therefore considered to be a show stopper of the project that will have a catastrophic effect on the project. Nevertheless, the noise contour is within the limit of the legislations. Therefore, this risk is unlikely.

Of course there are also opportunities. For instance when the heliport attracts more companies to Gorinchem. This will stimulate the economic growth of the city and brings more potential clients that might be willing to make use of the heliport services. Above listed risks only contain threats, because the risk analysis in this chapter is meant to identify the risks that form a threat for the implementation of a heliport. The opportunities are emphasised in the vision statement in chapter 5.

The identified risks can be inserted into the risk matrix. Two axis are used: one states the probability for the risk to occur and the other states the consequences it has on the implementation strategy in case of occurrence. On the probability axis a distinction is made between rare, unlikely, possible, likely and almost certain. On the consequence axis a distinction is made between insignificant, minor, moderate, major and catastrophic. The risk is then classified as being a negligible risk, low risk, medium risk, high risk or a critical risk. Figure 12-1 shows the risk matrix for the implementation strategy.

12-4-2 Risk assessment

The risks are identified in the previous subsection. The following step is to perform the risk assessment. In case one of the risks occurs, it is important to know what actions should be taken.

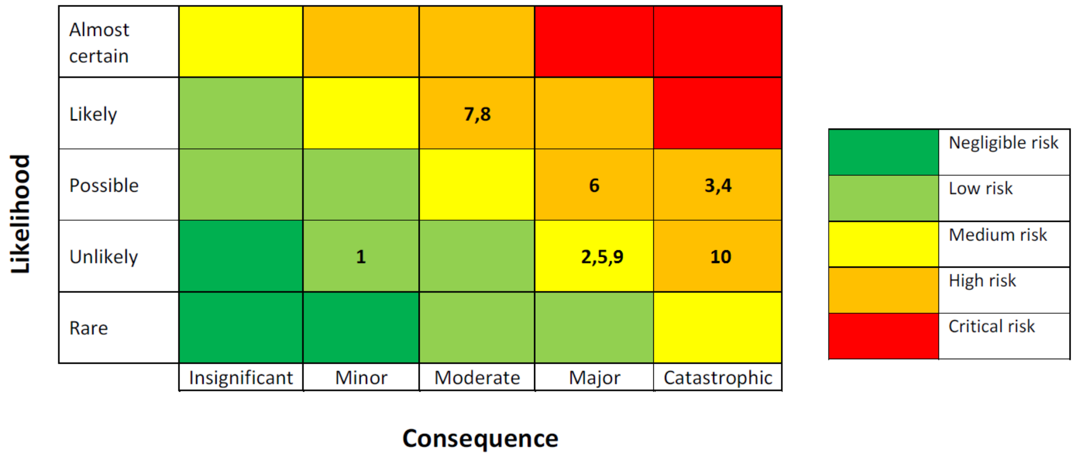


Figure 12-1: Risk matrix for the implementation of the project

High risks with catastrophic consequences should be avoided. These risks show that it is actually not worth to invest in a heliport in Gorinchem. For example, without investors it is not possible to realise the heliport. Therefore, extra research or preparation should be done to make sure that these risks can be avoided. The probability of occurrence should be decreased as much as possible. High risks that will have catastrophic consequences are risk 3, 4 and 10.

The risks that will have major consequences should be avoided as well. If one of these risks fails there is still a possibility to make the heliport profitable. But if more of these risks occur it becomes impossible to gain profit out of the project and the project will fail. Therefore, also for the risks that will have major consequences concerning the implementation of the heliport should be avoided. These are risk 2, 5, 6 and 9.

Risks with moderate consequences should be managed in case they occur. In case the heliport will not be successful as being a tourist attraction, it is better to focus more on the other markets. It is possible to try to identify other markets for the use of helicopter flights. The same holds for the fact that the public transport becomes more attractive for the moderate civilian in stead of taking a flight by helicopter. Preferably, more people can afford themselves a trip by helicopter in the long run. But if these people give preference to make use of the public transport, the heliport should focus more on offering its services to other niche markets.

Finally, there is the risk that the heliport is built, but not used. Because this risk is very unlikely to occur, this risk is accepted.

Chapter 13

Conclusions and recommendations

The purpose of the Heliport Gorinchem project is to investigate an innovative approach to tackle the current accessibility problem of Gorinchem. This chapter gives the conclusions both for the short and the long term. The short-term period contains the first ten years after implementation in 2020 and focused on operating a profitable aerial network. The long-term period start in 2030 and focused on serving additional market segments and implementing an improved aerial vehicle. Furthermore, this chapter gives recommendations to further develop the design of the Heliport Gorinchem and to investigate the feasibility of the long-term vision.

13-1 Conclusions for the short term

Research of the detailed design aspects indicates that it is technically feasible to implement an aerial network in Gorinchem and thereby improve the accessibility of the city. From investigation during the project, it is clear that there is a demand for aerial transportation in Gorinchem. Business to business travellers, and tourists are willing to pay for an aerial transport or tour. The final design consists of the following aspects:

- A new model of the Eurocopter EC135 has been selected as the aerial transport vehicle. The helicopter will contain the Blue Edge and Blue Pulse technology to decrease noise. Furthermore, it will contain a hybrid engine to reduce emissions. The new technologies will be available in the next five to seven years. Therefore, the implementation time is extended to seven years to guarantee the availability of the vehicle at the start of operations.

- Due to high investment costs, flights will be performed under visual flight rules, in an uncontrolled airspace. Therefore, flights are only allowed during daylight and when visibility is sufficient. To ensure safe operations, it is decided to provide an aerodrome flight information surface officer at the heliport.

- Industrial estate Avelingen is the selected location for the heliport. It is near the inner city of Gorinchem and complies with regulations stated in the provincial policy plan. Finally, the approach and departure routes have been designed such that no populated areas will experience noise hindrance.

However, the business model shows that this design will not be profitable in the short term. The main reasons for this are the high maintenance costs of the vehicle, call out costs, and airport charges. The income of the business model is based on the 10% of business travellers with the highest income that would use the aerial vehicle. Their willingness to pay is estimated on 60 euro per saved hour on travelling time.

By constructing a heliport, it is possible to increase Gorinchem's accessibility in the short term. It will accommodate the economic and urban development of the city. This will be the first step in implementing an aerial network that eventually helps reducing traffic congestion. However, such a network alone cannot solve the traffic congestions entirely.

Investors should be found to construct the heliport, because the municipality of Gorinchem has financial difficulties. By involving multinational companies, the use of the heliport is guaranteed. They will become leading customers and can fly in their clients by using either their own helicopters or a commercial helicopter. It is expected that also the government and the municipality are willing to make use of the heliport for medical assistance, law enforcement, and inspection flights.

13-2 Conclusions for the long term

In the long term, the heliport can be the first and innovative step in the development of a national aerial network in the Netherlands. This aerial network can connect cities in a high quality and fast manner. With this connection, the additional market segment of commuter traffic can be served. Changes with respect to the short-term design are:

- The design of the aerial vehicle should be adjusted in order to reduce costs. Furthermore, it should decrease noise and gas emissions.
- To increase the amount of operations, the aerial vehicle should be allowed to fly at night. Furthermore, by operating under instrument flight rules, it is also possible to fly with bad visibility. Either an air traffic flow management system or an air traffic controller should be used to ensure separation between vehicles.
- The location is long-term sustainable, as the distance to populated areas is sufficient. Even when expanding operations with a factor two, assuming a more silent vehicle, no populated areas will experience noise nuisance exceeding the provincial policy plans.
- New flight destinations should be explored. These should have a high passenger demand and low landing charges.

13-3 Recommendations for the heliport project

Due to time constraint of the project, not every aspect has been elaborated to the desired level of detail. Therefore, this section will give further recommendations to the heliport project. The recommendations aim to further develop the design of the heliport in Gorinchem and the feasibility of the long-term vision.

Design of the aerial vehicle
An existing helicopter is chosen for the short-term use. This helicopter makes use of a hybrid engine and Bluechopter technology to reduce noise. For the long-term development it is recommended to design a new aerial vehicle. The new aerial vehicle must help in making the heliport profitable. It is recommended to set the following requirements for the design of the aerial vehicle:

- **Maximum take off weight:** should be smaller than 2,700 kg.
- **Noise level:** shall be less than 69 dBA for overflight.
- **Take-off:** the vehicle should be VTOL.
- **Fuel use:** the vehicle should be low fuel consuming and using alternative fuels.
- **Range:** of 500 km.
- **Cruise speed:** of 200 km/hr.
- **Emissions:** 60% less CO_2 emission (2012 EC135 baseline is 612 kg of CO_2 per hour).
- **Safety:** EASA CS-27 (certification specifications of European Aviation Safety Agency for small rotorcraft) certifiable.
- **Redundancy:** two engines.
- **Implementation:** the vehicle should be available in 2030.
- **air traffic management (ATM):** the vehicle should be able to fly IFR.
- **The maintenance costs:** should be halved compared to the 475 euro an hour calculated in subsection 9-1-4.

Expansion of the aerial network
It is recommended to investigate the possibility of expanding the aerial network. Therefore, research should aim to find alternative locations with low landing charges. Building heliports near the three major airports of the Netherlands could have potential. In this way, the high fees at the airports can be avoided and the possibility to make the aerial network profitable will increase. Besides this, research should investigate the possibility to apply the heliport concept to other cities in the Netherlands. The implementation of heliports in other cities would expand the aerial network.

Detailed design of the heliport
The project includes a first design of the land site of the heliport. Further research could elaborate on the detailed design of the land site. For instance, the rejected take-off area within the final approach and take-off area (FATO) requires further research and the obstacle free area could be optimised according to the performances of the (new) aerial vehicle. It is also

recommended to do further research on possible transport modes to improve the connection from and to the heliport. For instance, buses or ferry services are possible options to improve the public transport connection with the heliport.

Flying at night
It is recommended to investigate the possibility of flying at night. This would increase the flexibility of the flight services. Research should aim to investigate instrument flight rules (IFR) and the consequences it would have on the current design of the heliport.

Willingness to pay
The income from ticket sale for a helicopter flight is based on an estimation of the customers willingness to pay. It is recommended to perform a market analysis on the willingness to pay of the future business travellers and other markets. This will have influence on the income of the business model. In the best case scenario the design can even become profitable in the short term.

Appendix A

Project defintion tools

The figures in this appendix are related to chapter 2 and illustrate the organisation, overall planning and functionality of the project. In this appendix, the work flow diagram can be found in figure A-1, the work breakdown structure can be found in figure A-2 and the Gannt chart can be found in figure A-3. It is also contains the different tools used to describe the functionality of the system using the functional flow block diagram (FFBD) and the functional breakdown structure (FBS). The FFBD can be found in figure A-4. In this figure, the flow of functions is given by two main parallel branches, depending on whether it is the transportation of either cargo or passengers. This is indicated by the presence of the "OR" in the diagram. Lastly, the FBS can be found in figure A-5.

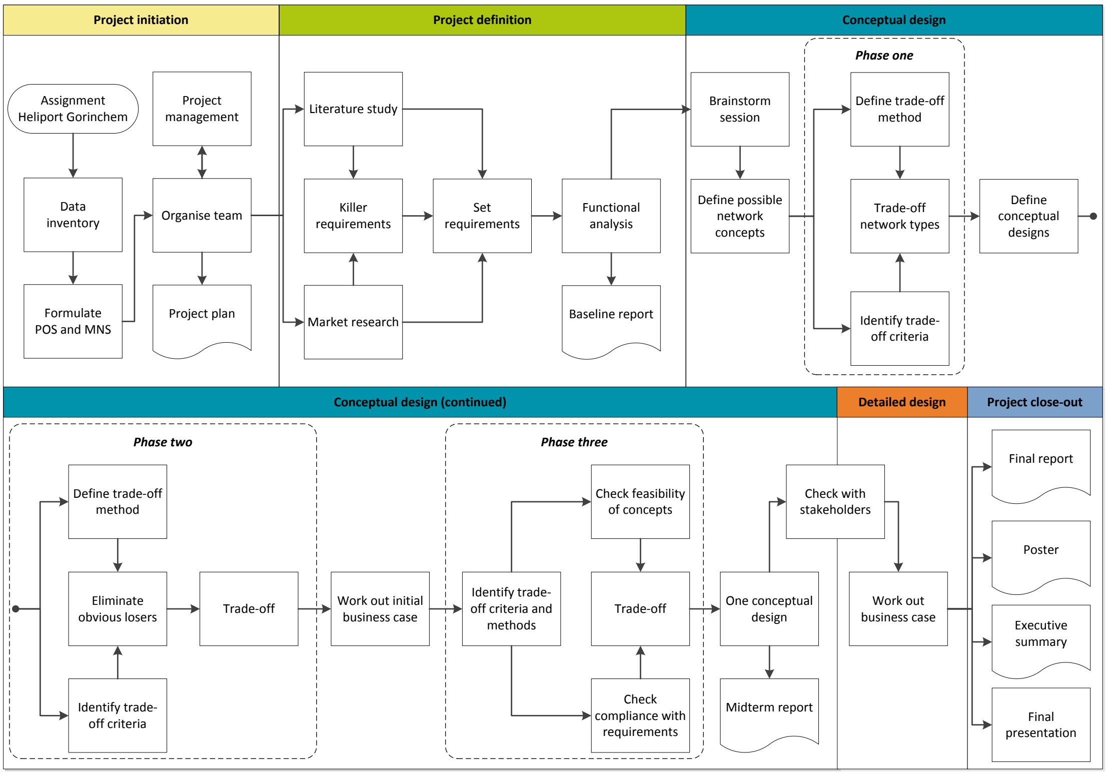


Figure A-1: WFD of project

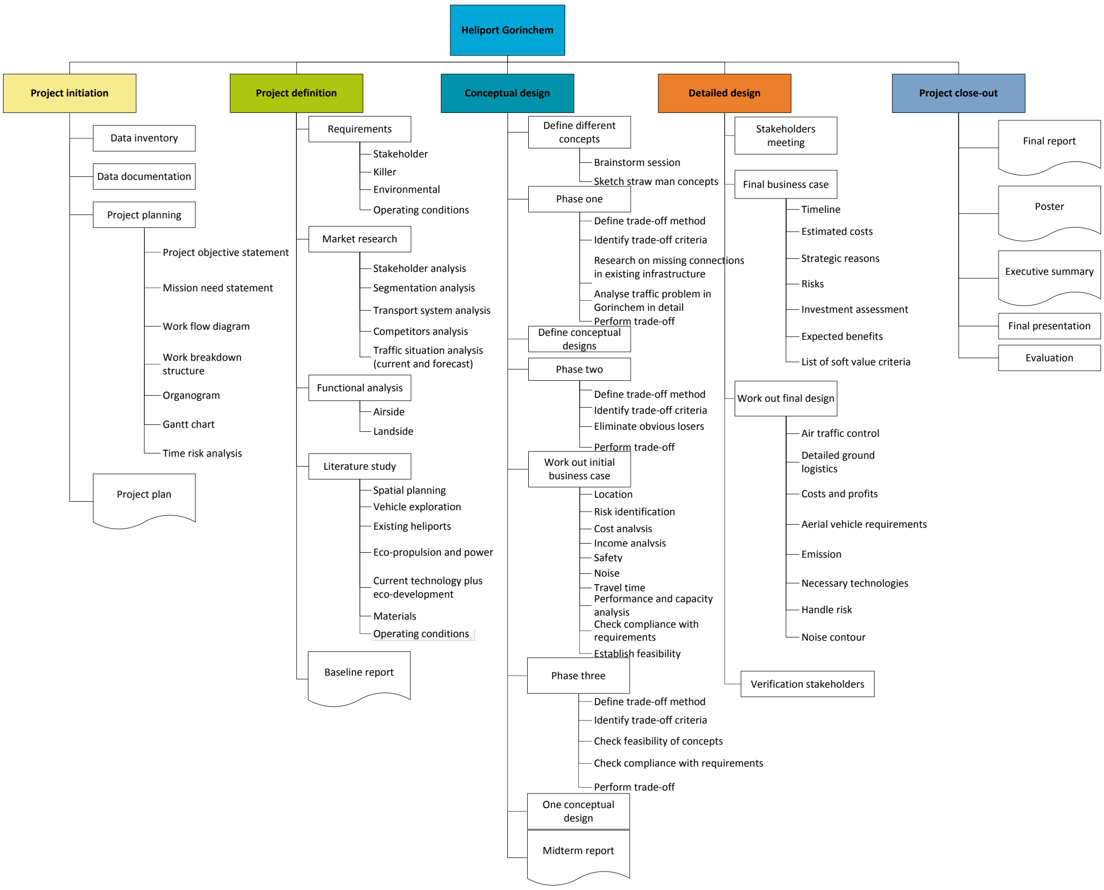


Figure A-2: WBS of project

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Assignment Heliport Gorinchem**	**60 days**	**Mon 12/11/12**	**Fri 01/02/13**		
2	**Project initiation**	**5 days**	**Mon 12/11/12**	**Fri 16/11/12**		
3	Data inventory	3 days	Mon 12/11/12	Wed 14/11/12		
4	Data documentation	3 days	Mon 12/11/12	Wed 14/11/12		
5	**Project planning**	**5 days**	**Mon 12/11/12**	**Fri 16/11/12**		
6	Organise team members	2 days	Mon 12/11/12	Tue 13/11/12		
7	Project objective statement	2 days	Mon 12/11/12	Tue 13/11/12		
8	Mission need statement	2 days	Mon 12/11/12	Tue 13/11/12		
9	Work flow diagram	3 days	Tue 13/11/12	Thu 15/11/12		
10	Work breakdown structure	3 days	Tue 13/11/12	Thu 15/11/12		
11	Gantt chart	2 days	Wed 14/11/12	Thu 15/11/12		
12	Organogram	1 day	Thu 15/11/12	Fri 16/11/12		
13	Finish project plan	1 day	Fri 16/11/12	Fri 16/11/12	7,8,9,10,12,11	
14	Hand in project plan	0 days	Fri 16/11/12	Fri 16/11/12	13	
15	**Project definition**	**7 days**	**Mon 19/11/12**	**Tue 27/11/12**	**2**	
16	**Market research**	**5 days**	**Mon 19/11/12**	**Fri 23/11/12**		
17	Stakeholder analysis	5 days	Mon 19/11/12	Fri 23/11/12		
18	Segmentation analysis	5 days	Mon 19/11/12	Fri 23/11/12		
19	Transport system analysis	5 days	Mon 19/11/12	Fri 23/11/12		
20	Competitor analysis	5 days	Mon 19/11/12	Fri 23/11/12		
21	Traffic situation analysis	5 days	Mon 19/11/12	Fri 23/11/12		
22	**Literature study**	**5 days**	**Mon 19/11/12**	**Fri 23/11/12**		
23	Spatial planning	5 days	Mon 19/11/12	Fri 23/11/12		
24	**Vehicle exploration**	**5 days**	**Mon 19/11/12**	**Fri 23/11/12**		
25	Current technology and development	5 days	Mon 19/11/12	Fri 23/11/12		
26	Propulsion and power	5 days	Mon 19/11/12	Fri 23/11/12		
27	Materials	5 days	Mon 19/11/12	Fri 23/11/12		
28	Existing heliports	5 days	Mon 19/11/12	Fri 23/11/12		
29	**Functional analysis**	**2 days**	**Mon 26/11/12**	**Tue 27/11/12**		
30	Airside	2 days	Mon 26/11/12	Tue 27/11/12		
31	Landside	2 days	Mon 26/11/12	Tue 27/11/12		
32	Set requirements	2 days	Mon 26/11/12	Tue 27/11/12	16,22,29	
33	Finish baseline report	1 day	Wed 28/11/12	Wed 28/11/12		
34	Hand in baseline report	0 days	Wed 28/11/12	Wed 28/11/12	32	
35	**Conceptual design**	**13 days**	**Wed 28/11/12**	**Fri 14/12/12**	**15**	
36	Brainstorm session	2 days	Wed 28/11/12	Thu 29/11/12		
37	Define possible network concepts	2 days	Wed 28/11/12	Thu 29/11/12		
38	**First trade-off**	**1 day**	**Thu 29/11/12**	**Thu 29/11/12**		
39	Define trade-off method	1 day	Thu 29/11/12	Thu 29/11/12		
40	Identify trade-off criteria	1 day	Thu 29/11/12	Thu 29/11/12		
41	Research on missing connections in existing infrastructure	1 day	Thu 29/11/12	Thu 29/11/12		
42	Analyse traffic problem in Gorinchem in detail	1 day	Thu 29/11/12	Thu 29/11/12		
43	Perform trade-off	1 day	Thu 29/11/12	Thu 29/11/12		
44	Document first trade-off	1 day	Fri 30/11/12	Fri 30/11/12		
45	Define conceptual designs	1 day	Fri 30/11/12	Fri 30/11/12		
46	**Second trade-off**	**2 days**	**Fri 30/11/12**	**Mon 03/12/12**		
47	Define trade-off method	1 day	Fri 30/11/12	Fri 30/11/12		
48	Identify trade-off criteria	1 day	Fri 30/11/12	Fri 30/11/12		
49	Eliminate obvious losers	1 day	Mon 03/12/12	Mon 03/12/12		
50	Perform trade-off	1 day	Mon 03/12/12	Mon 03/12/12		
51	Document second trade-off	2 days	Tue 04/12/12	Wed 05/12/12		
52	**Work out initial business case**	**2 days**	**Thu 06/12/12**	**Fri 07/12/12**	**46**	
53	Location	2 days	Thu 06/12/12	Fri 07/12/12		
54	Risk identification	2 days	Thu 06/12/12	Fri 07/12/12		
55	Cost analysis	2 days	Thu 06/12/12	Fri 07/12/12		
56	Income analysis	2 days	Thu 06/12/12	Fri 07/12/12		
57	Safety	2 days	Thu 06/12/12	Fri 07/12/12		
58	Noise	2 days	Thu 06/12/12	Fri 07/12/12		
59	Travel time	2 days	Thu 06/12/12	Fri 07/12/12		
60	Performance and capacity analysis	2 days	Thu 06/12/12	Fri 07/12/12		
61	Check compliance with requirements	2 days	Thu 06/12/12	Fri 07/12/12		
62	Establish feasibility	2 days	Thu 06/12/12	Fri 07/12/12		
66	**Final trade-off**	**1 day**	**Mon 10/12/12**	**Mon 10/12/12**		
67	Define trade-off criteria	1 day	Mon 10/12/12	Mon 10/12/12		
68	Define trade-off method	1 day	Mon 10/12/12	Mon 10/12/12		
69	Perform trade-off	1 day	Mon 10/12/12	Mon 10/12/12		
70	Check feasibility of concept	1 day	Mon 10/12/12	Mon 10/12/12		
71	Compare concepts & business models	1 day	Mon 10/12/12	Mon 10/12/12		
63	Describe concept	1 day	Tue 11/12/12	Tue 11/12/12		
64	Hand in preliminary midterm report	0 days	Tue 11/12/12	Tue 11/12/12		
72	Finish midterm report	2 days	Wed 12/12/12	Thu 13/12/12		
65	Hand in midterm report	0 days	Thu 13/12/12	Thu 13/12/12		
73	Make midterm review presentation	1 day	Fri 14/12/12	Fri 14/12/12		
74	**First detailed design**	**5 days**	**Mon 17/12/12**	**Fri 21/12/12**		
75	**Detailed design**	**6 days**	**Mon 07/01/13**	**Mon 14/01/13**		
76	**Business case**	**6 days**	**Mon 07/01/13**	**Mon 14/01/13**		
77	Infrastructure	6 days	Mon 07/01/13	Mon 14/01/13		
78	Cost structure	6 days	Mon 07/01/13	Mon 14/01/13		
79	Customers	6 days	Mon 07/01/13	Mon 14/01/13		
80	Revenue streams	6 days	Mon 07/01/13	Mon 14/01/13		
81	Value proposition	6 days	Mon 07/01/13	Mon 14/01/13		
82	**Final Design**	**6 days**	**Mon 07/01/13**	**Mon 14/01/13**		
83	Air traffic control	6 days	Mon 07/01/13	Mon 14/01/13		
84	Costs and profits	6 days	Mon 07/01/13	Mon 14/01/13		
85	Noise contour	6 days	Mon 07/01/13	Mon 14/01/13		
86	Emission	6 days	Mon 07/01/13	Mon 14/01/13		
87	Risks	6 days	Mon 07/01/13	Mon 14/01/13		
88	Aerial vehicle requirements	6 days	Mon 07/01/13	Mon 14/01/13		
89	Ground logistics	6 days	Mon 07/01/13	Mon 14/01/13		
90	Necessary technologies	6 days	Mon 07/01/13	Mon 14/01/13		
91	Verification stakeholders	1 day	Fri 11/01/13	Fri 11/01/13	76,82	
92	**Project close-out**	**14 days**	**Tue 15/01/13**	**Fri 01/02/13**	**75,91**	
93	Finish final report	5 days	Tue 15/01/13	Mon 21/01/13		
94	Finish poster	5 days	Tue 15/01/13	Mon 21/01/13		
95	Evaluation	2 days	Thu 17/01/13	Fri 18/01/13		
96	Hand in final report	0 days	Mon 21/01/13	Mon 21/01/13	93,95	
97	Hand in poster	0 days	Mon 21/01/13	Mon 21/01/13		
98	Make presentation	6 days	Tue 22/01/13	Tue 29/01/13	93	
99	Rehearsal	1 day	Thu 31/01/13	Thu 31/01/13		
100	Symposium	1 day	Fri 01/02/13	Fri 01/02/13		
101	Finish DSE	1 day	Fri 01/02/13	Fri 01/02/13	96,98	

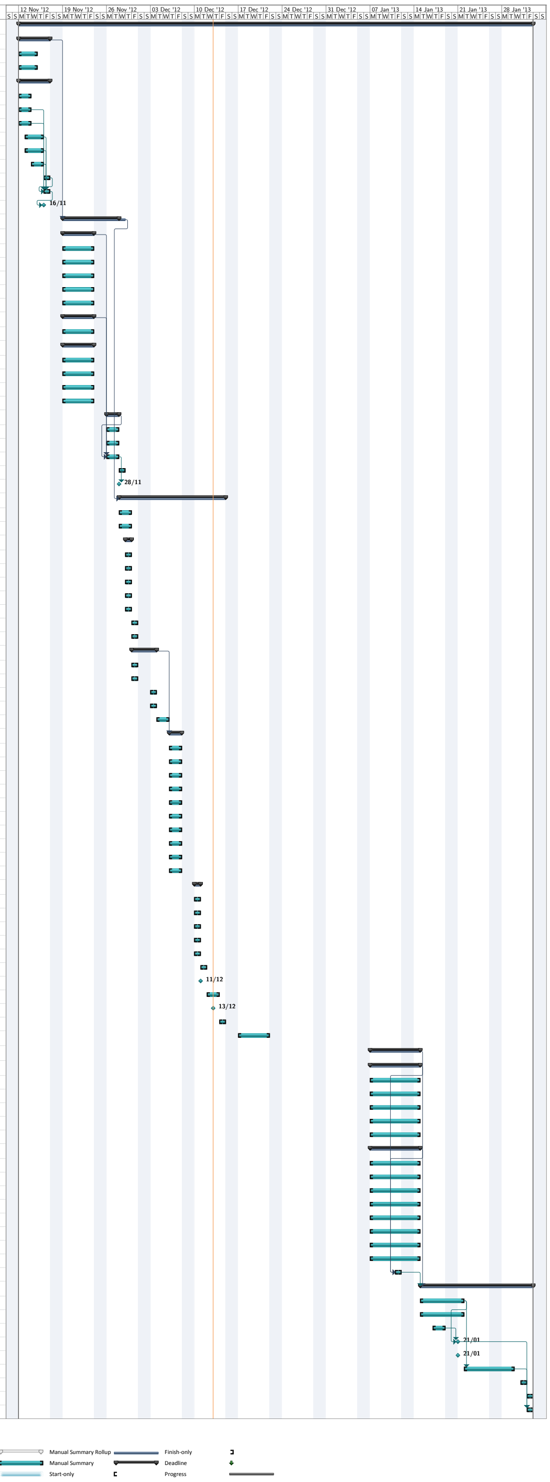


Figure A-3: Gantt chart of project

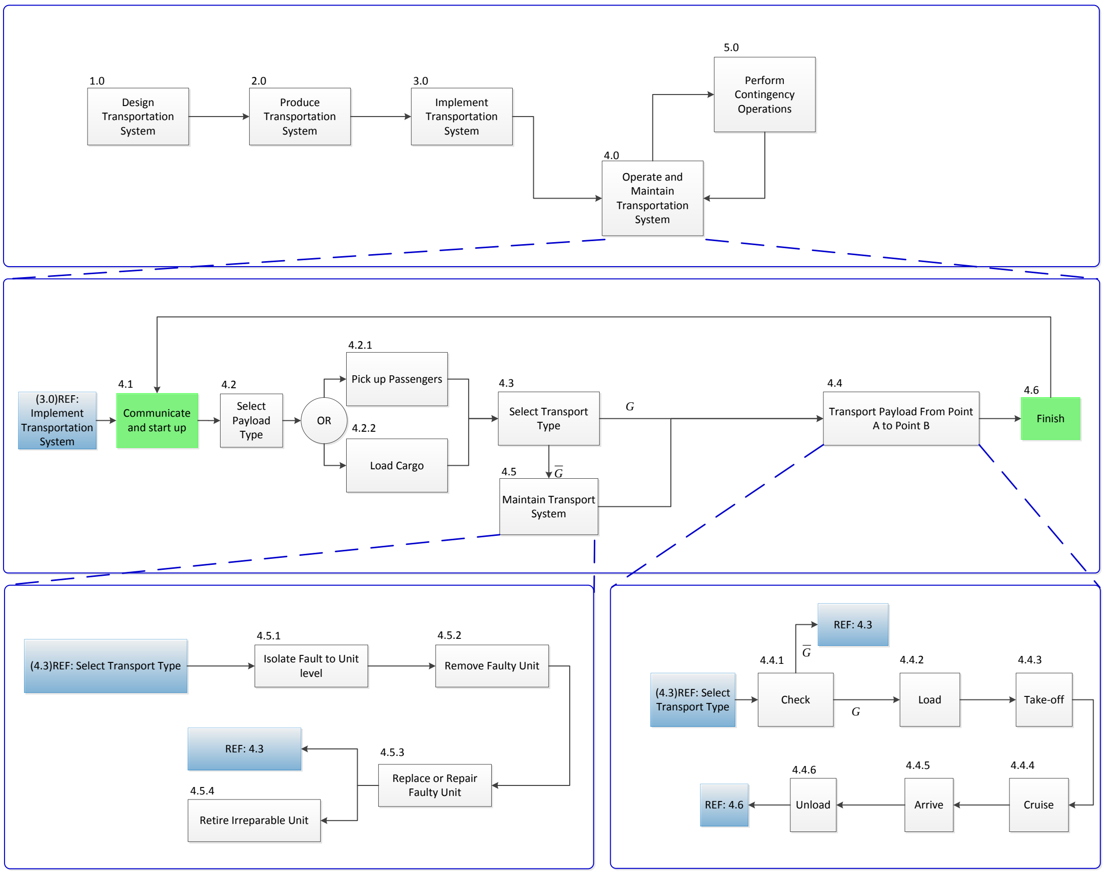


Figure A-4: FFBD of project

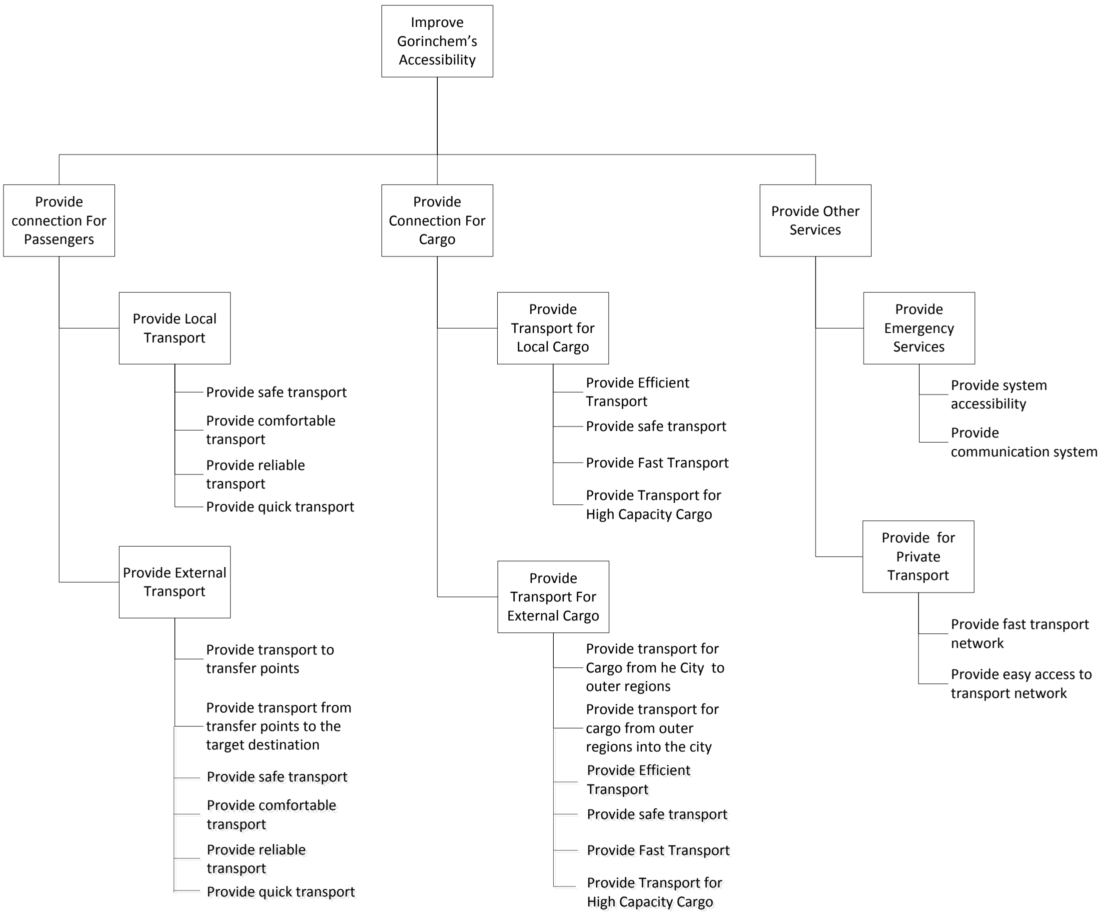


Figure A-5: FBS of project

Appendix B

Trade-off of remaining concepts

The trade-off method of the remaining concepts can be seen in table B-2. The highest score possible for a design option is 500 points. The scale of the scores is given in table B-1. An elaboration on the choice of the criteria and their weight is given in the midterm report.

Table B-1: Scale of scores

Score	Definition
1	Poor
2	Unsatisfactory
3	Satisfactory
4	Good
5	Excellent

Table B-2: Trade-off table of conceptual design

		Local linear			Local radial			Local circular			Local linear and regional			Local radial and regional			Local circular and regional			Regional linear		
		City centre	Suburbs		City centre	Suburbs		City centre	Suburbs		City centre	Suburbs		City centre	Suburbs		City centre	Suburbs		City centre	Suburbs	
Selection criterion	**Weight**	VTOL	VTOL	STOL	VTOL	VTOL	STOL	VTOL	VTOL	STOL	VTOL	VTOL	STOL	VTOL	VTOL	STOL	VTOL	VTOL	STOL	VTOL	VTOL	STOL
Operating cost	9	2	2	3	1	1	1	1	1	1	4	4	4	3	3	4	3	3	4	5	5	5
Investment cost	7	3	4	2	1	2	1	1	2	1	2	2	2	2	1	2	2	2	1	3	4	3
Traffic impact	11	3	3	3	4	4	4	3	2	3	4	4	4	5	4	4	4	3	3	2	2	2
Noise	13	2	3	3	1	2	1	1	2	2	2	3	3	2	3	3	4	3	3	2	3	3
Travel time	9	4	4	3	4	4	3	3	3	2	4	4	4	4	3	3	3	3	3	4	4	4
Safety	14	3	4	4	2	3	2	2	3	2	3	4	4	3	3	3	3	3	3	3	4	4
Adaptability	8	3	4	2	3	3	2	2	3	2	3	4	3	2	3	2	2	3	2	3	4	2
Implementation time	8	3	4	2	2	2	2	1	2	2	3	4	3	2	3	2	3	3	2	3	4	2
Robustness	7	1	1	1	3	3	3	4	4	4	1	1	1	3	3	3	4	4	4	1	1	1
Integrability	10	3	3	1	2	2	1	2	2	1	3	3	1	3	3	1	1	2	1	4	4	1
Complexity	4	4	4	3	2	2	2	3	3	3	4	4	4	1	1	1	1	1	1	5	5	4
Total	**100**	277	327	257	226	260	199	201	240	203	299	342	306	287	289	269	288	282	258	307	357	284

Appendix C

Calculation amount of business to business travellers

In table C-1 the amount of business travellers is calculated. Schiphol is assumed to cover the Netherlands in total. Therefore the working labour force in Gorinchem is divided by the working labour force of the Netherlands to get the relative amount of businesses in Gorinchem. For Rotterdam airport and Eindhoven airport, it is assumed that they cover the surrounding province plus ten percent. Second, the amount of business travellers at the airports is calculated, by multiplying the amount of travellers, with the percentage of business travellers. When this is multiplied with the percentage of people with origin and destination (O&D) in the Netherlands, the amount of business travellers with O&D in the Netherlands is calculated. This is multiplied with the relative amount of businesses in Gorinchem, to obtain the amount of business travellers with O&D Gorinchem. This is corrected with the percentage of business travellers within the ten percent of largest income, to get the amount of potential users. For this estimation it is assumed that 70% of the potential users is willing to pay the service. This is because it is expected that not every potential customer is going to use the aerial network. The equation to come to the final number is:

$$T_t = T_a \cdot P_{\text{O\&D}} \cdot P_B \cdot \frac{W_G}{W_R} \cdot P_{10\%} \cdot P_W \tag{C-1}$$

The parameters of this equation can be found in table C-1.

Table C-1: Business travellers per year

	Schiphol airport	**Rotterdam airport**	**Eindhoven airport**
Working labour force Gorinchem	15,600	15,600	15,600
Reference working labour force	7,442,000	1,728,100	1,218,800
Travellers at airport (T_a)	49,680,625	1,075,000	2,664,078
Percentage O&D at airport ($P_{\text{O\&D}}$)	59	95	95
Percentage business travellers (P_B)	35	40	35
Amount of business travellers at airport O&D (W_G) Netherlands	10,207,000	409,000	886,000
Amount of business travellers with O&D (W_R) Gorinchem	21,400	3,700	11,300
Percentage of business travelling in 10% of people with highest incomes ($P_{10\%}$)	48	48	48
Amount of potential users	10,200	1,760	5,390
Percentage willing to pay (P_W)	70	70	70
Total estimated travellers (T_t)	**8,490**	**1,460**	**4,480**

Appendix D

ICAO airspace classification

This appendix gives the properties of the different airspace classes that are currently present in the Netherlands. The data in these tables is based on the Integrated Aeronautical Information Package, Part 2, ENR 1.4 [47]. Table D-1 gives these properties for visual flight rules; table D-2 gives the properties for instrument flight rules classes. For clarity's sake, KIAS is defined to be knots indicated airspeed and FL100 is defined to be flight level 100, i.e. at 10,000 ft.

Originally, airspace class G distinguishes between flights above 900 m and flights below or at 900 m. However, helicopters in the Netherlands are only allowed to fly at altitudes between 0 and 450 m, as mentioned by the Dutch Ministerie van Defensie [92]. Therefore, both tables in this appendix only include the relevant information for flights at or below 900 m in airspace class G.

* According to the International rules of the Air, in airspace class G, *"Helicopters may be permitted to operate in less than 1500 m flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision"* [61].

Table D-1: VFR properties for different airspace classes in the Netherlands

Airspace class	**A**	**B**	**C**	**D**	**E**	**G***
Service provided	n/a	ATC	ATC; VFR traffic info; traffic avoidance advice	ATC; traffic info; traffic avoidance advice	Traffic info	FIS
Separation provided	n/a	All aircraft	VFR from IFR	Not provided	Not provided	Not provided
VMC minima	n/a	8 km visibility; 1.5 km horizontal and 1000 ft vertical from clouds	5 km visibility; 1.5 km horizontal and 1000 ft vertical from clouds	8 km visibility 1.5 km horizontal and 1000 ft vertical from clouds	8 km visibility 1.5 km horizontal and 1000 ft vertical from clouds	1500 m visibility clear of cloud with surface in sight
Speed limitation	n/a	n/a	250 KIAS below FL100	250 KIAS below FL100	250 KIAS below FL100	250 KIAS below FL100
Radio communication	Continuous two-way	Continuous two-way	Continuous two-way	Continuous two-way	Not required	Not required
Flight plan	Required	Required	Required	Required	Not required	Not required
ATC clearance	Required	Required	Required	Required	Not required	Not required
Flight rules allowed	IFR only	Both	Both	Both	Both	Both

Table D-2: IFR properties for different airspace classes in the Netherlands

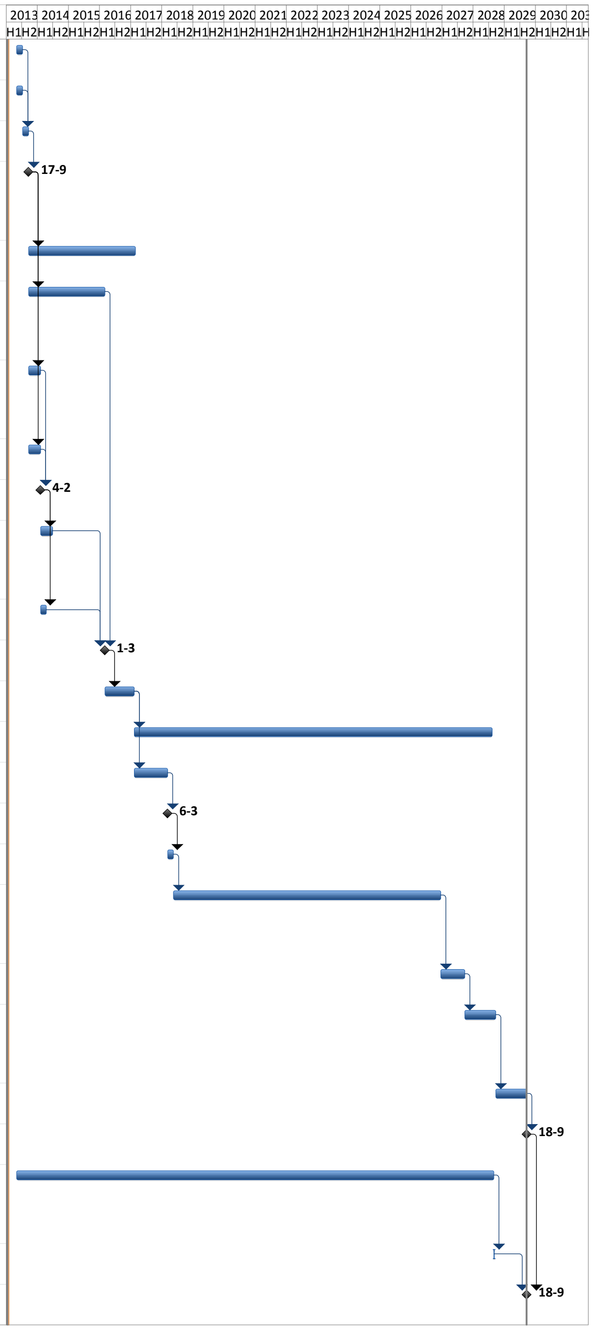
Airspace class	**A**	**B**	**C**	**D**	**E**	**G***
Service provided	ATC	ATC	ATC	ATC; VFR traffic info; traffic avoidance advice	ATC; VFR traffic info	FIS
Separation provided	All aircraft	All aircraft	IFR from IFR, IFR from VFR	IFR from IFR	IFR from IFR	Not provided
VMC minima	n/a	n/a	n/a	n/a	n/a	n/a
Speed limitation	n/a	n/a	n/a	250 KIAS below FL100	250 KIAS below FL100	250 KIAS below FL100
Radio communication	Continuous two-way	Continuous two-way	Continuous two-way	Continuous two-way	Continuous two-way	Continuous two-way
Flight plan	Required	Required	Required	Required	Required	Required
ATC clearance	Required	Required	Required	Required	Required	Not required
Flight rules allowed	IFR only	Both	Both	Both	Both	Both

Appendix E

Gantt chart business strategy

The figure in this appendix is related to chapter 12 and shows the time organisation regarding the business strategy. The time organisation is represented by a Gantt chart and can be found in figure E-1.

ID	Task Name	Duration
1	Further investigate demand for heliport	50 days
2	Further investigate willingness to invest in heliport	50 days
3	Write business model	50 days
4	Agreement by municipality of Gorinchem. Heliport is taken into zoning plan of Avelingen.	0 days
5	Attract identified markets	895 days
6	Arrange provencial order and permits for the use of the heliport	640 days
7	Make project plan for the construction of the heliport	100 days
8	Find investors	100 days
9	Investors are contracted and project plan finished	0 days
10	Arrange contracts and permits for construction of the heliport	100 days
11	Obtain chosen location in Avelingen	50 days
12	Permits, contracts and provencial orders arranged	0 days
13	Construction phase of the heliport	245 days
14	Invest in technology to decrease maintenance cost	3000 days
15	Investigate possibility to expand helicopter network	280 days
16	Go/ No Go expansion helicopter network	0 days
17	Write business model for network expansion	50 days
18	Arrange permits, contracts, provencial orders and agreements with other municipalities	2240 days
19	Develop project plan for network expansion	200 days
20	Arrange permits and contracts for construction phase of the expansion	260 days
21	Execute construction phase of network expansion	260 days
22	Construction phase finished	0 days
23	Monitor development of hybrid engine for helicopters	4000 days
24	Buy helicopters	4 days
25	Start business	0 days



Gantt chart Business strategy
Date: Tue 29-1-13

Task | Split | Milestone | Summary | Project Summary | External Tasks
External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only
Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

Page 1

Figure E-1: Gantt chart business strategy

Appendix F

List of contacts

This appendix contains the persons or companies that are contacted during this project.

- City council Gorinchem, Mr C. van der Roest
- Damen Shipyards, Mr D. van der Stel
- De Nederlandse Luchtvaart Pool, Mr A. Leemeijer
- Heliflight, Mr Ton van Kempen
- Inspectie Leefomgeving en Transport, Mr B. Fischer
- KLM Jet Center Rotterdam Operations, Mr H. van der Goes
- Luchtverkeersleiding Nederland, Mr E.M. de Both
- Municipality of Gorinchem, Mr P. van der Werff
- NLR, Mr H. van Dijk
- Foundation Behoud De Vries Robbé, prof. dr. ir. J.A.A.M. Stoop
- TU Delft, ir. S. Hartjes
- TU Delft, ir. P.C. Roling

Contacted companies, but no reply:

- Heliholland
- Helicon
- Helicentre
- Heliport Amsterdam
- Luchtvaart verzekeringen
- Van Oord

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