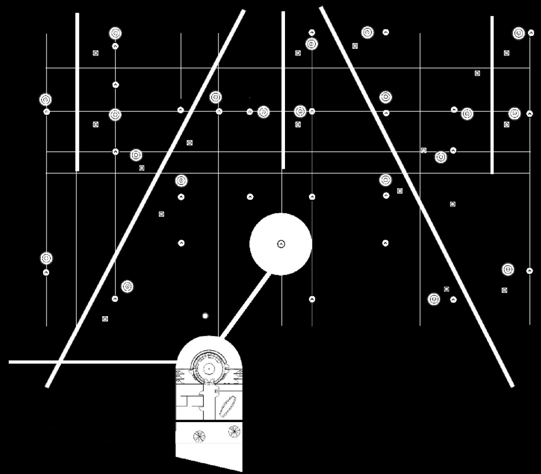
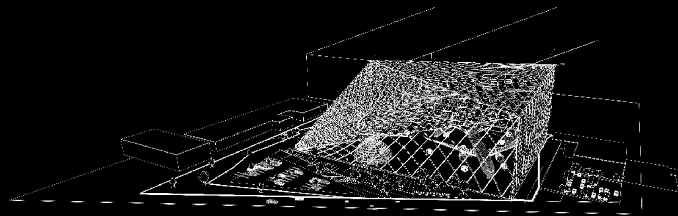
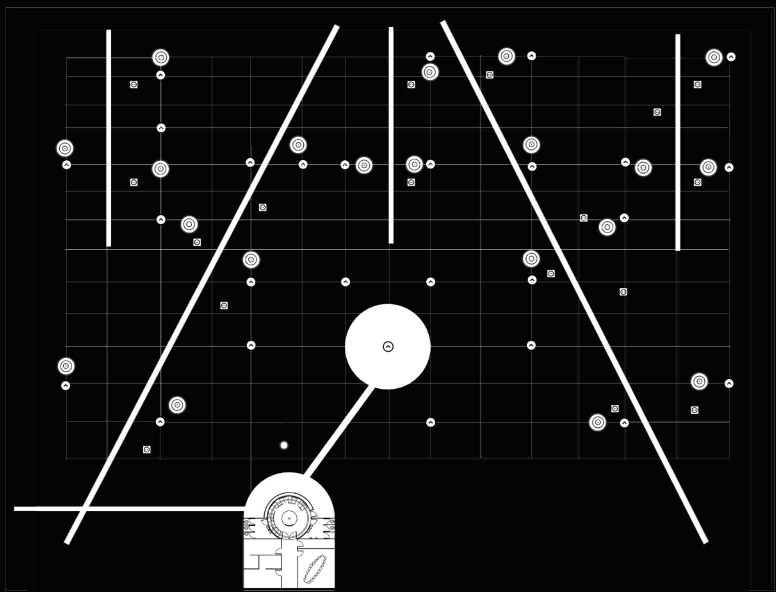


Graduation Thesis Jasmijn Kok TU Delft – KLM

# Hangar of the Future

Graduation Thesis
TU Delft Faculty of Architecture
KLM Engineering and Maintenance
22-01-2016





# General information

| | |
|---|---|
| **Student** | Jasmijn Kok |
| **University** | Delft Technical University |
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| **Supervisory team KLM** | dhr. C. Swaanenburg |

# Contentlist


VERBODEN TE ROKEN
KLM

# CHAPTER 1. ASSIGNMENT

# 1.1 Introduction

This research is performed for KLM Royal Dutch airlines and is executed by two students from the disciplines of Architecture respectively Industrial Design Engineering at the University of Technology Delft.

Starting oktober 2015, a new type of aircraft will be added to the KLM fleet. This new type of aircraft is called the "Boeing 787-9 Dreamliner." This innovative airplane exists for a large part out of composite materials and has a  system that is more electric then other models. It therefore  requires a different type  of maintenance. The maintenance of the B787 will take place in Hangar 12 at Schiphol Oost.

KLM has decided to close Hangar 10. because the frequency of it's use is not high enough to be feasable. Hanger 12 will take over part of the functionalities of Hanger 10 including the small maintenance checks (A-checks) of the Boeing 737 and the Boeing 787-9. Hangar 12  is ready for an upgrade and will be transformed to be able to support the new functionalities that are required in the future use.

The arrival of this new airplane opens up many opportunities and the arrival can be used as leverage to implement new ideas.. We will investigate how we can transform both the hangar itself and products and processes inside the hangar to improve the functionality. The goal is not to optimise the current systems, but to look at different possibilities in a new and refreshing way, with the goal to create a state of the art  hangar suitable for the new Boeing 787.

## INDUSTRIAL DESIGN ENGINEERING

An analysis of the work processes of the mechanics and the processes involved in the maintenance of the airplanes in Hangar 12 will determine which current and upcoming innovations can best contribute to the support of the processes.

Examples of such innovations are the use of Ipads, Google Glass or wearables by the mechanics to improve the efficiency of the checks using task cards. Improvements in this field could lead to an even safer and faster way of checking and controlling the maintenance process.

Another direction could be designing a moving platform or tool in order to comply to the new way of component exchange of the Boeing 787. This direction, when finalized, could be a new step in line with the "lean" production method.

Also the financial aspects of the design play an important role. Investements can be made when they can pay themselves back.

## ARCHITECTURE

Hangar 12 offers many opportunities to design the hangar of the future. Starting point for the design is the current situation since the construction will be fully preserved.

From there the different design options will be explored with an " out of the box" approach. A thorough investigation of both Hangar 12, other existing hangars and maintenance spaces of other fields than aviation will determine how and on which specific points the work environment in the hanger can be improved best.

Examples of such improvements are a new design for the daylight supply, an artificial lighting plan and the use of innovative materials for the facade.

Also the interior of Hangar 12 can be designed to optimally support the maintenance processes and create an inspiring work environment for the mechanics working there. Next to the work environment also the sustainability of the hangar will be an important aspect of the design. The possibility to create an energy generating aspects in the building will be explored. Next to this the architectural and spatial quality will be taken into consideration. The design will have to support the corporate identity and will have to contribute to the corporate image and branding of KLM.

## 1.2 Problem definition

The arrival of the Boeing 787 in October requires preparation. Staff need to be educated, equipment needs to be bought and the network and infrastructure should be made compatible and functioning before the airplane enters the hangar.

Hangar 12 is an old hangar and will be transformed in the summer of 2015 to become the "Hangar of the Future" The arrival of the new aircraft will be used as leverage to make changes in the production process and environment. The change to a paperless process is an example of such a large change.

KLM has invited students to join this process of transforming hangar 12 in order to think more out of the box. It has proven to be difficult to forget the problems from the "as is" world (he worls in which we live today) and to think in innovative, out of the box ideas. This is necessary in order to create a design that not only meets the standard of today but crosses that border into the future world.

We will however not only work on this renovation but as well focus on the future that is not immediately reachable.

## 1.3 Research Question

Design a state-of-the-art hangar that anticipates on the arrival of the Boeing 787 Dreamliner and supports the hangars maintenance processes and functionality in an innovative way.

# 1.4 Methodology

## Process

### Historical analysis
- Schiphol
- Schiphol Oost
- Hangar 12

### KLM
- Internal analysis
- Problems hangar 12
- Maintenance H12
- Hangar regulations

### Literature
- Maintenance
- Large span buildings
- Design 4 emotion
- Offices
- Context in Aviation
- External Analysis

### Case studies
- 10 hangars

### Anlysis H12
- Functions
- Construction
- Lights
- Position aircraft
- Wind
- Facade
- Materials
- Hangar doors
- Noise
- Position in hangar
- overview numbers

## Method

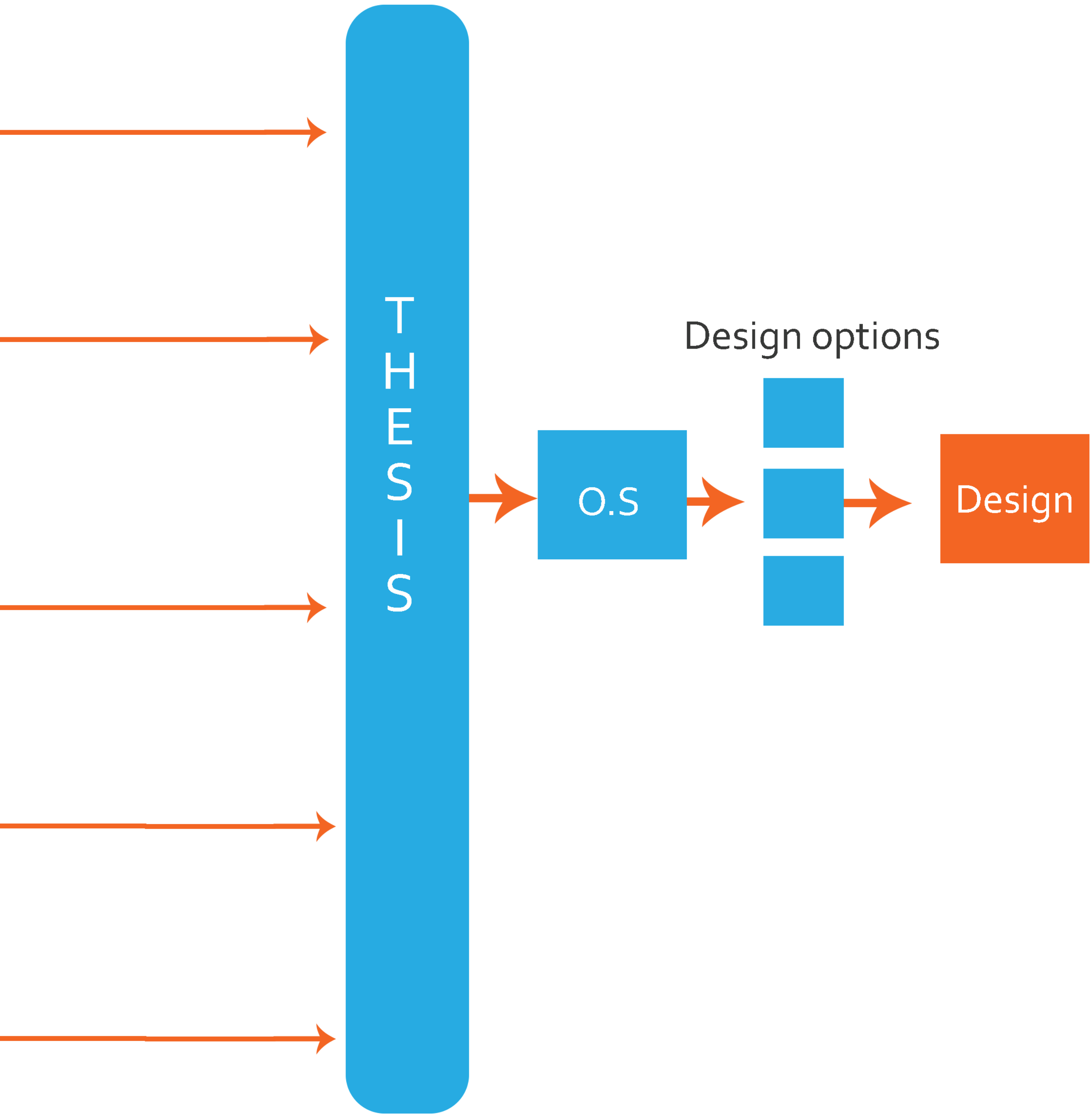
- Analize KLM archive documents
- Read research from library TUDelft + Eindhoven
- Read online articles + books
- Foto study of online archive research group Schiphol
- Analyse Map-data development Municipality Amsterdam

- Look at KLM website + strategy and regulation documents
- Take interviews with people of different hierarchy levels to learn what the current difficulties are and learn more baout how a hanar functions. Also make use of the expertise that is available in KLM> Sustainability, safety etc.
- Participate in brainstorms with management and mechanics
- Join lean sessions with innovation group
- Participate in design renovation H12

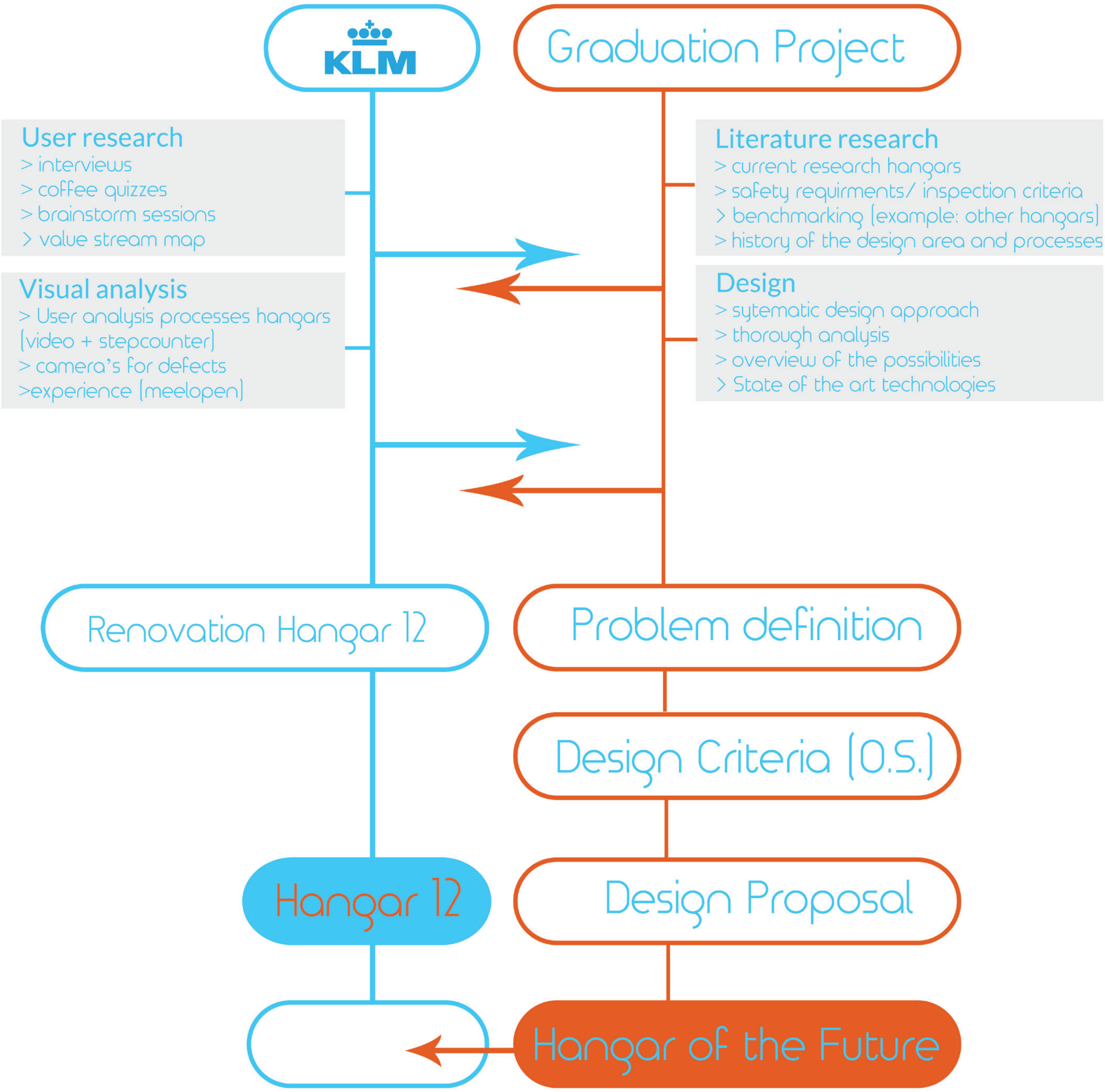
- Read books and articles on airplane maintenance, office environments, the aviation industry and large span buildings.
- Follow classes + training excersises and read books on how to use Design for emotion as a design tool
- Read about developments in aviation industry and follow the news to stay up to date.
- Read documents on aircraft maintanence and data.
- Visualize findings

- Read about hangars to find examplary interesting types
- Search online on hangars from all over the world
- read aviation and industrial architecture magazines
- Compare the hangars on 6 different criteria

- Look into the archive of KLM to find drawings
- Read articles, books and magazines about H12
- Analyse these drawings and text
- Talk to KLM experts on the different topics for example light
- Look at location data such as wind and sun
- Visualize all data and findings


THESIS
O.S
Design options
Design

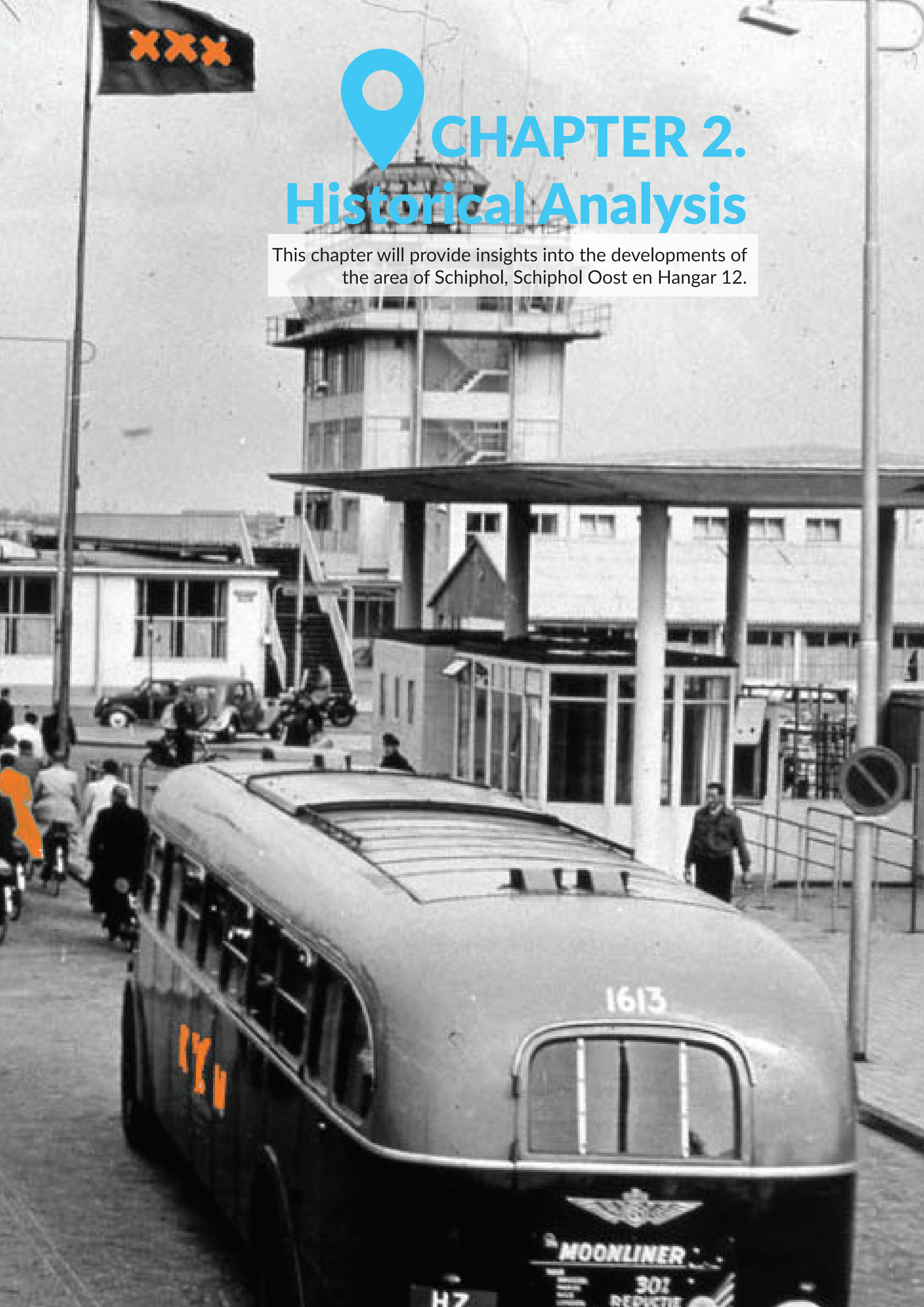
# 1.5 KLM-TU DELFT




Flying Dutchman
PANELEN
FWD. CARGO COMP
SKYDROL ONLY

# CHAPTER 2.
# Historical Analysis

This chapter will provide insights into the developments of the area of Schiphol, Schiphol Oost en Hangar 12.




Left: Location of Schiphol with respect to the former Haarlemmermeer, ca. 1840 image courtesy Ed Stavemaker. Right: 17th century map of Rijnland with Haarlemmermeer on it, image courtesy Ad van


# 2.1 Description Schiphol

Schiphol Airport  is the main international airport in the Netherlands and plays an important role in Europe. In 2014 it was the fourth largest airport in Europe, transporting 55 million passengers that year. Only Heathrow (London)  Charles de Gaulle (Paris) and Frankfurt were responsible for an even larger amount of passengers.  40% of the passengers at Schiphol are transfer passengers, they transfer from one flight to another at Schiphol.

### LOCATION

Schiphol is located in the south of the province Noord-Holland, in Haarlemmermeer, about 15 kilometers south-west of Amsterdam. Haarlemmermeer is a municipality that was made by draining the lake between 1848 and 1852. Schiphol is therefore positioned 4 meters below sea level. It has seven runways and is  the primary hub for KLM as well as for Arkefly, Corendon Dutch Airlines, Martinair, and Transavia. Also Easyjet and Delta Air lines frequent Schiphol as does Vueling, for them Schiphol serves as a base. The airport is owned by Schiphol Group and has several shareholders: The Dutch government, municipalities of Amsterdam and Rotterdam and Aéroports de Paris.

### NAME SCHIPHOL

The origin of the Dutch airport's name has three interesting stories. Schiphol is built on a lake, the Haarlemmermeer. This lake had several shallow areas, and the story goes that in heavy storms many ships stranded in this place. In Dutch the name was Scip Hol, meaning "Ship's Grave". However,  when the lake was drained no shipwrecks were found. Another explanation could be that it was derived from the Dutch word "Scheepshaal". This words referred to a narrow lake that was used to move ships from one lake to another. The third explanation is based on the words "scip""  and "hol". Scip meaning ship and hol referring to a low lying area (as in Holland) of land where wood was derived from.

# Expansion and sprawling structures

**TERMINAL EXPANSION**
The surface area of Schiphol has grown explosively since 1916. After the inauguration in 1967 the terminal area kept expanding quickly.  The area around the startingpoint of Schiphol is urbanised. Especially after WWII the expansion increases expansively.

"In 2012 the terminal surface was 650.000m2. 2787 hectares of the airport are used for the runways that the airport has at it's disposal."

The maps show the ground owned by Schiphol in grey, the buildings and the runways and their expansion over the years.

In 1988 the maps show that new land was purchased in order to be able to built the polderbaan, visible on the top map.

**SPRAWLING STRUCTURES**
The runways that were built just after 1916 tunred out to be positioned in a difficult position. The direction of the wind was not optimal for take off and landing. This was the reason that new runways were built

The oldest runway , the Oostbaan is today only used in emergencies and extremely bad weather. The reason for this is again the wind and the urbanised area that the aircraft have to cross in order to land on this runway.

The runways of the design from the 1950´s was made based on the idea that the landing routes should not cross over urban area´s.  The built area however grew expansively and it became difficult to find routes that would not conflict with the urban area´s

The grey area on the maps is the Haarlemmer polder and the orange blocks show the expansion of Amsterdam and the other urbanised area´s.

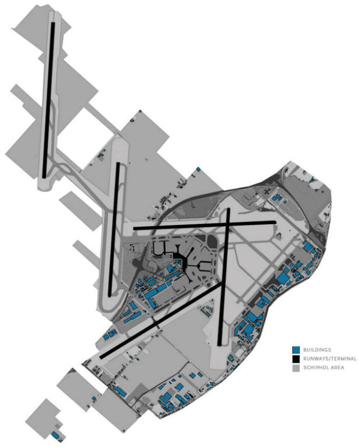
source: megastructures 2012

2012

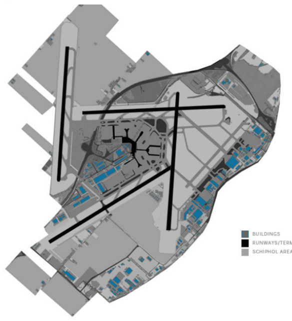
1988

1975

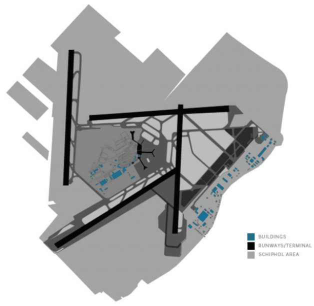
1967



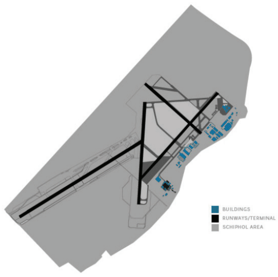

2014




2003

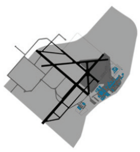



1994

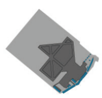



1975


1967



1934



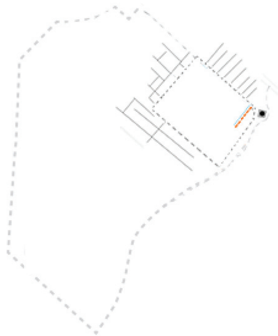
1928

1916

# History Schiphol

## 1916 - Opening military airport

In 1916 the minister of War authorized the realization of a military airport next to Fort Schiphol in Haarlemmermeer. On an  area of 16.5 hectare the military airport was built and the first airplane landed here on 19 September that same year. By the end of World War I  in 1918 the area had already extended to 76 hectare.



*1916*
*Opening of the military airport*

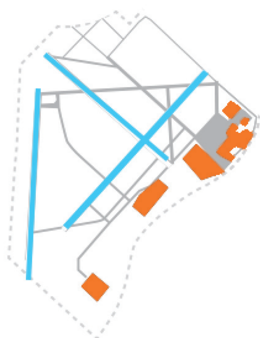
## 1919- Dutch Royal Airline founded

In 1919 the KLM was founded, the Royal Dutch Airline. In 1920 the first commerical aircraft landed on Schiphol and KLm started flying frequently from Amsterdam to London. For Schiphol the military function became less important. The number of civil flights however increased largely and became more and more the main function of Schiphol.
On the first of April  1926 the municipality of Amsterdam became the owner of the airport. They started a large drainage project  to increase the quality of the runways since the planes often got stuck in the muddy Dutch grounds.

*1919*
*KLM founded*

## 1940 - Schiphol bombed in WWII

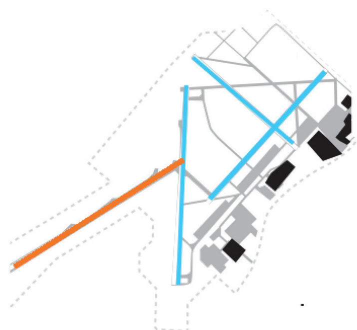
During the second World War Schiphol was bombed by both the Germans and the Allies.



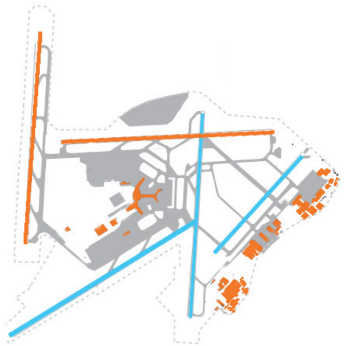
*1940*
*Schiphol bombed in WWII*

## 1945 - First airplane lands again

Schiphol was rebuilt after the bombing and on 28 July 1945 the first airplane landed again on the partly restored airport. Since then Schiphol has been extended enormously. In order to be able to finance the renovations and extensions the government became the largest stakeholder with over 75% of the shares.



*1945*
*First airplane lands again*



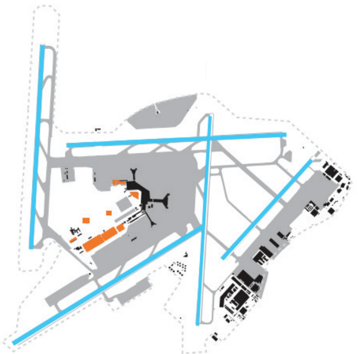
*1967*
*Opening Schiphol Centrum*

## 1967 - Opening Schiphol Centrum

The realization of the new station building of Schiphol started in 1963 and the reconstructed airport was festively opened by Dutch Queen Juliana in 1967. This buildings would later become Schiphol Centrum.

When Schiphol Centrum was built, the building ideology was “a single terminal concept” meaning that the airport was built as a large terminal split into three large departure halls. The airport kept growing and needed more space. This was the reason that around 1990 Architectural office Benthem and Crouwel designed a new master plan for Schiphol.

This plan was realized and the station building was doubled in size.  A new terminal hal (number 3) was built and the lounge area was extended. A new train station under Schiphol was built and the tracks were extended from three to six.. This would still not be enough to transport the passengers, so next to this a new tunnel was built with two tracks.

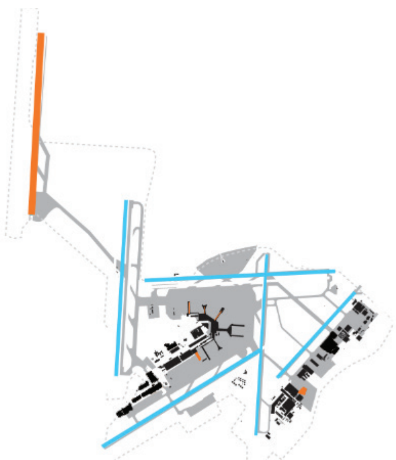


*1992*
*Opening new control tower + runway*

## 1992 - New tower and runway

In the seventies the type of airplanes that landed on Schiphol changed. Instead of propeller aircraft more jet aircraft were used. These airplanes were faster and more efficient since they could transport more passengers. This innovation in aviation industry made flying cheaper and more accessible.

Queen Beatrix opened the new control tower in 1992, at that moment this was the highest control tower in the world. Schiphol kept growing, In 2003 the fifth runway was opened

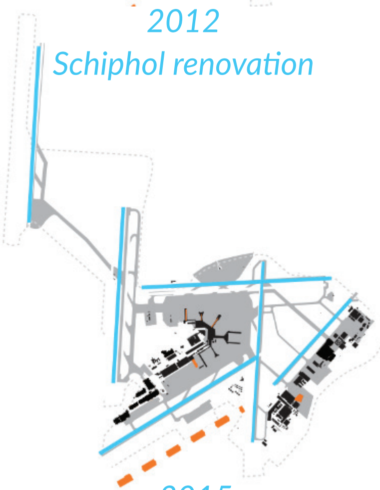


*2012*
*Schiphol renovation*

## 2012 -  Start Schiphol renovation

In 2012, Schiphol Group announced a big expansion of Schiphol, featuring a new Pier, new central security system, an expansion of the terminal and a new parking garage. Also a new Hilton hotel was built .

Schiphol has started the first phase of this renovation that should prepare them for the future and enables them to compete with London, Paris and Frankfurt.



*2015*
*Start nieuw masterplan 2020-2025*

## 2015 - Start nieuw masterplan 2020

In 2010 a new masterplan was designed by Benthem and Crouwel architects. Schipol wants to grow to 65 miljon passengers and reserved ground for a new landingtrack that would run parrallel to the Kaagbaan

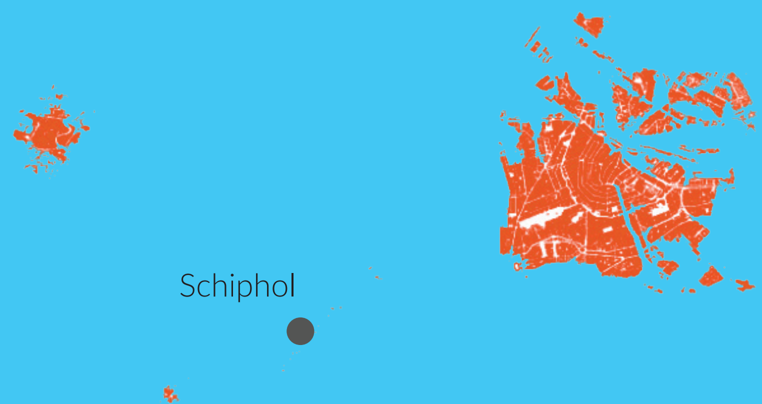
source: Edited illustrations, source Bosma. (2012). Megastructure Schiphol. Design in Spectacular Simplicity. NAI.

# Urbanisation Amsterdam

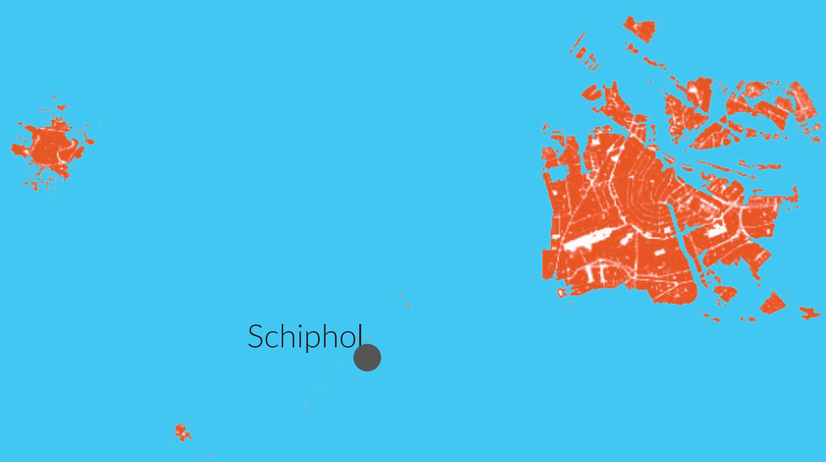
**1900**

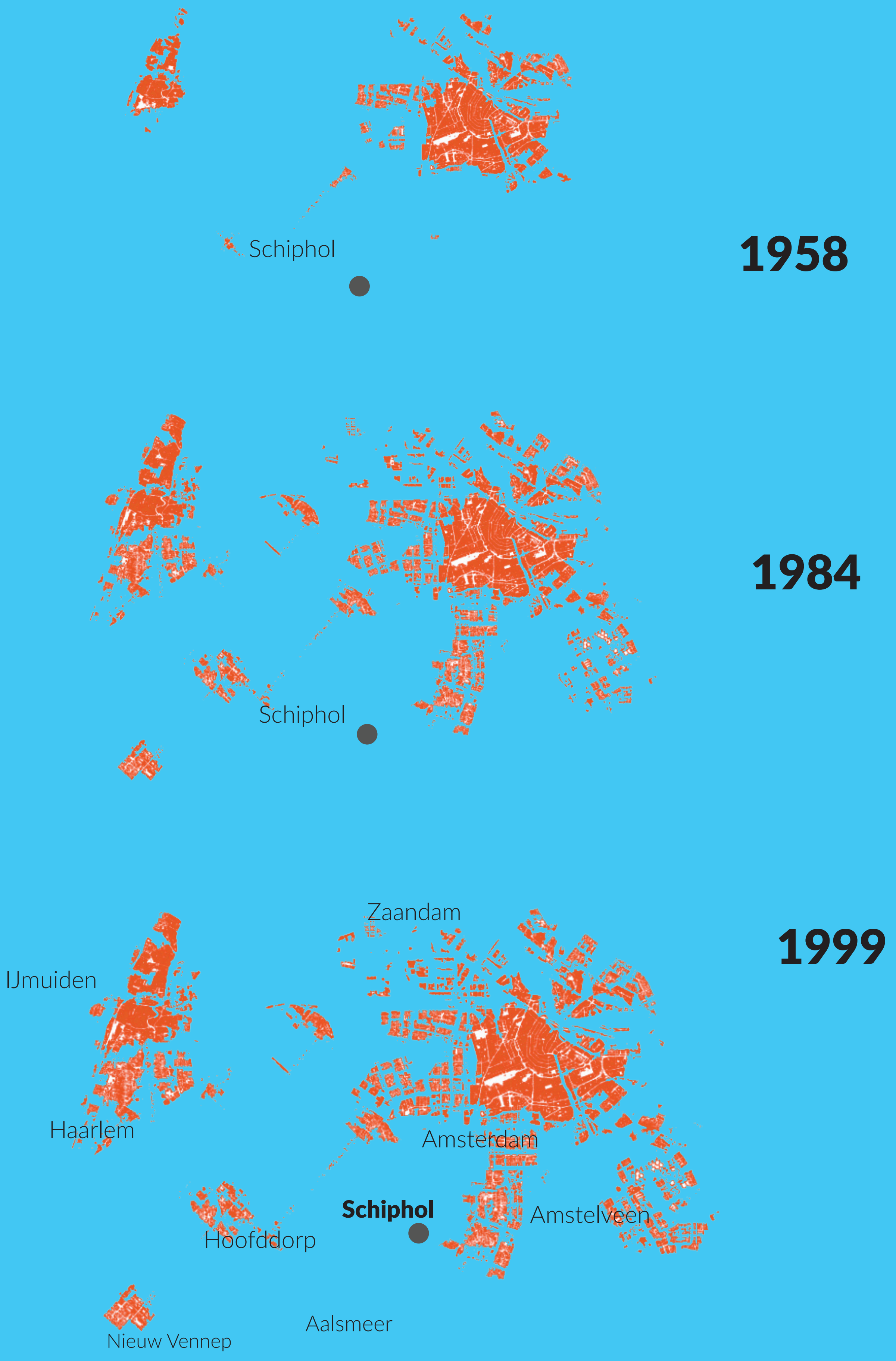

**1929**


**1939**



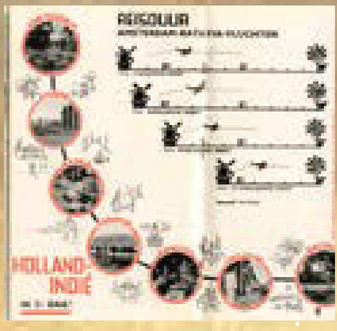

**1945**






Source: Edited illustrations, source Bosma. (2012). Megastructure Schiphol. Design in Spectacular Simplicity. NAI.

# TIMELINE HISTOR




Land for a Military airport was bought

KLM starts with the first intercontinental schedule on the Dutch Indies

Schiphol registers more than a million visitors

Jet engines introduced

The military turn the airfield over to the City of Amsterdam

The German occupational troops inflict great destruction on the

Commercial aviation sees introduction of economy class

1916 1919 1926 1928 1929 1940 1945 1950 1955 1957 1959

KLM founded in 1919,

Opening of first semi-permanent terminal building and Jan Dellaert accepts position as Director of Schiphol

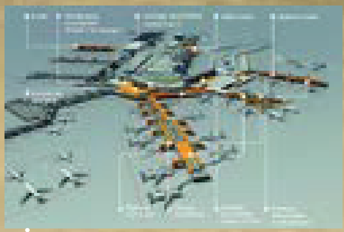
Many improvements completed at Schiphol to prepare for the Olympic Games that will take place in Amsterdam

Start op tax-free shops at the airport

Schiphol becomes a commercial airport

Schiphol falls into the hands of the Germans and becomes a Fliegerhorst

# RY OF SCHIPHOL



Schiphol-Centre is opened by Queen Juliana

Runway 18R/36L ("Polderbaan") becomes opera-tional

Decision on wether to built a new air-strip parrallel to the Kaagbaan

Schiphol registers more than a mil-lion travellers

Railway connection to the airport is established

Start first phase large renovation an innova-tion project

1963 1967 1970 1978 1991 2003 2006 2012 2015 2023

In 1960 Jan Dellaert retires and dies.

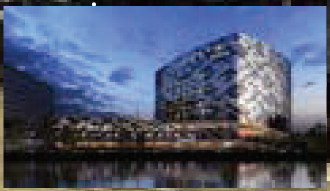
Major expansion, in-cluding new runways, is started

A new ATC-tower becomes opera-tional

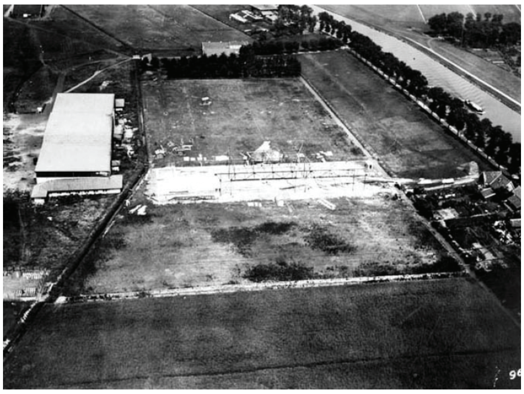
First Boeing 747 (Pan Am) lands at Schiphol, july 2nd

Schiphol cel-ebrates 60th anniversary

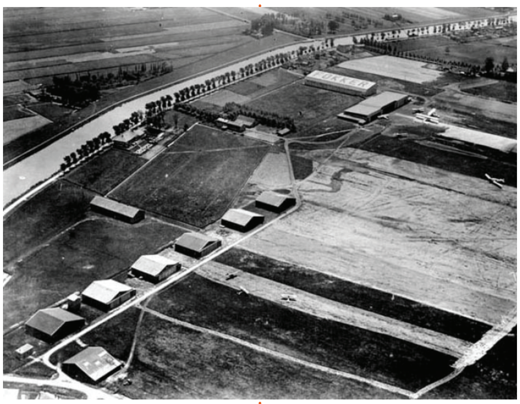
New Hilton hotel is finished + Implementation of central secu-rity



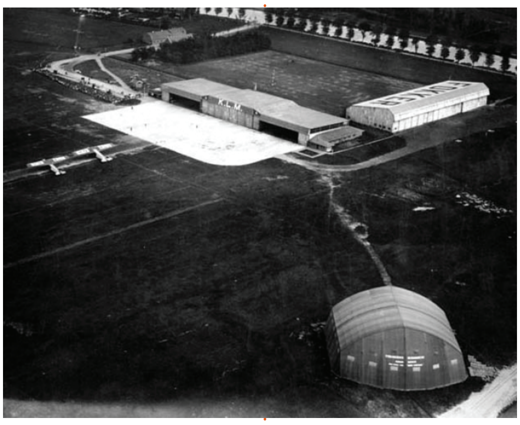
# Areal Timeline Schiphol 1916–2015



**1924**
First building of Schiphol



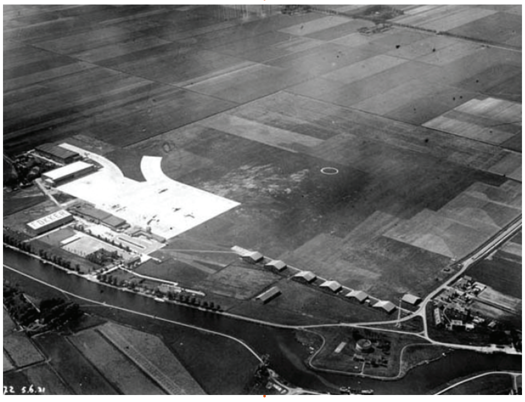
**1924**
Overview of the early Schiphol



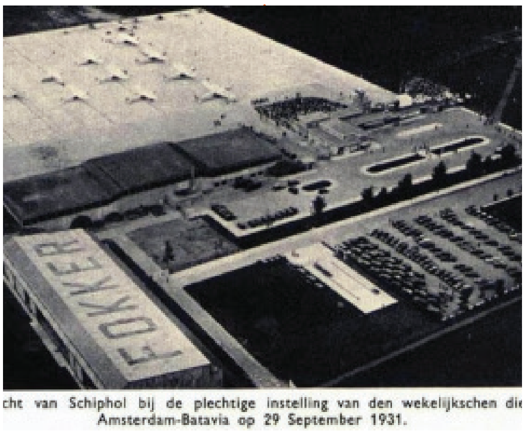
**1926**
Bessonneau tent KLM


**1927**
Fly-in hangar Fokker

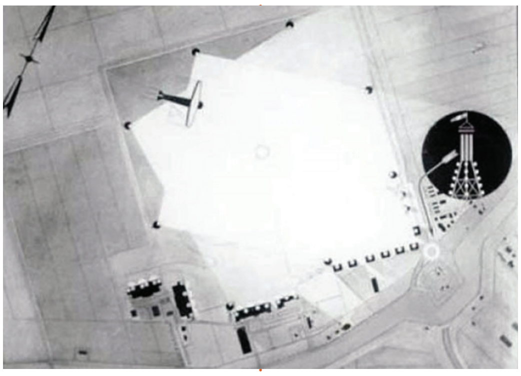
**1928**
Station building under construction



**1931**
Bigger platform and B hangar

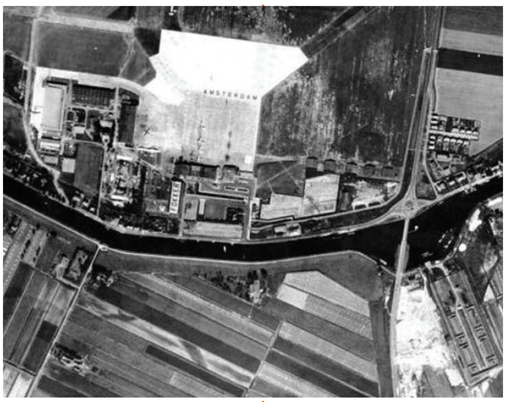



**1931**
Schiphol at the start of the line service Amsterdam–Batavia



**1934**
Terrain lights

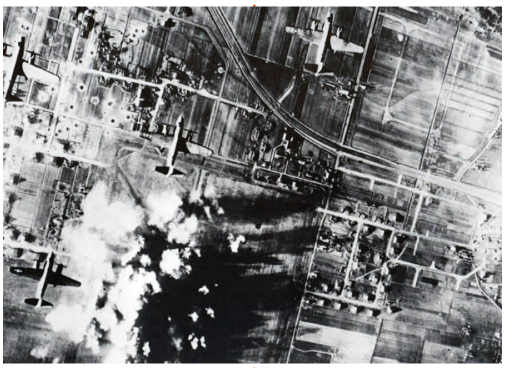
**1934**
**Demolishing of Fort Schiphol**



**1936**
**Bridge over the ringvaart**

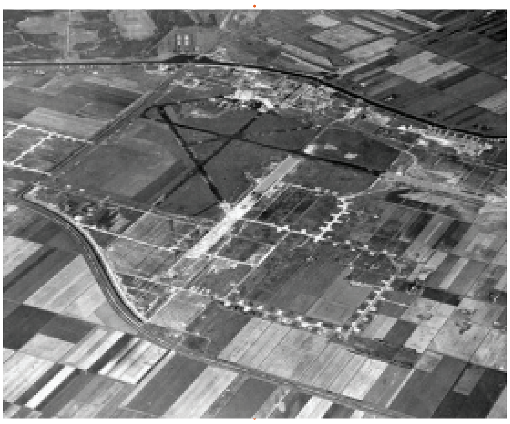
**1938**
**Schiphol: the second airport in Europe to install a runway system**

**1940**
**RAF bombs Schiphol**



**1945**
**Bombing of Schiphol**

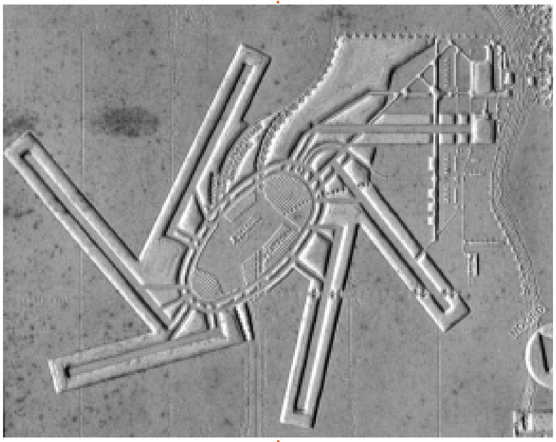
**1946**
**Rebuilding Schiphol after WWII**



**1947**
**Consruction of new run-way**

**1950**
**Three runways are ready**

http://www.urbannebula.nl/?datatype=visualization&req=keyword&id=schiphol



1950
Original tangential system of Schiphol

1953
Hangars 7 and 8 built between 1948 and 1953

1955
View on the platform from the control tower

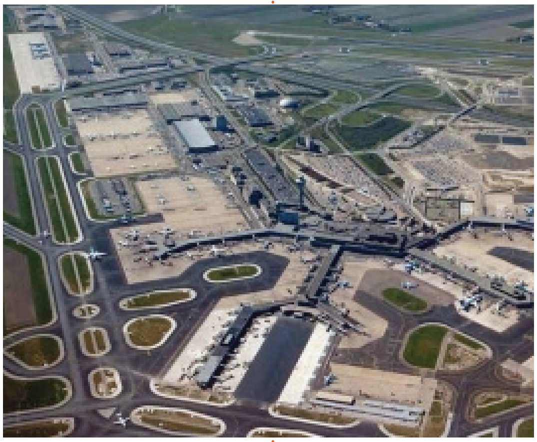
1964
Technical area

1967
Schiphol Centre and freight area

1967
Schiphol is called `Schiphol Oost`

1986
Development of E-Pier (former C-Pier)

1988
Development of Schiphol-South



**1989**
**First leg of D pier finished**

**1992**
**Schiphol in de Haarlemmer-meer**

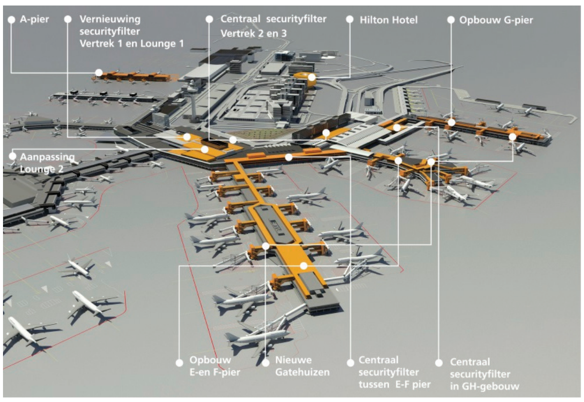
**1992**
**Terminal West and G-Pier**

**1992**
**Construc-tion of West Terminal, G-Pier and train tunnel**

**1993**
**Schiphol Plaza under construc-tion**

**2003**
**`Polderbaan ` Runway**

**2014**
**New Hil-ton Hotel finieshed and start renova-**




**Future**
**new security sys-tem and piers**

# Highlights Timeline

**Start Schiphol**

Schiphol is located in the Haarlemmermeer, a municipality that was founded in 1855 after the Haarlemmermeer was drained in 1952. Here a military airport was realised in 1916. Schiphol existed only out of **four simple wooden hangars** in the beginning. This construction was chosen because it was a cheap and simple way of building a shed for the airplanes. This type of construction construction was also relatively light, which was a desirable characteristic considering the drained muddy ground of Schiphol. In 1926 a **Bessoneau hangar** was built. This type of hangar can be easily moved because it consists of again a light construction and canvas.

**Civil airport**

During the war the airport was extended, adhecent grounds were bought and new hangars were built to meet the needs of the military airport. The Bessoneau Hangar was used by KLM in 1926, before this, the wooden **Fokker fly-in hangar was built without doors** so that the aircraft could easily enter.

After the war the total area had expanded from 16,5 to 76 ha. But the airfield was not used anymore, the airplanes were just standing on the ground. Albert Plesman saw an opportunity here to move passengers and freight. The first planes started flying passengers from Amsterdam to London and Schipol becomes a civil airport in 1920. This lead to quite some changed at Schiphol, the civil airport required **new facilities.** For example in 1921 a complete hangar was transformed to be used by passengers and new hangars were built.

**Municipal airport**

The number of passegers kept growing, and Schiphol started to take in an important position as a civil airport. But the runway system on the drained Dutch ground was not designed to carry the rising number of airplanes and often airplanes got **stuck in the mud.** The municipality of Amsterdam bought the airport and started a large renovation project to improve Schiphol. The **Olypic games** that would be held in 1928 will have played a role in this decision since visitors from abroad would need to land here.. The renovation included a new drainage system, a new concrete platform of 50x100 meters and on the built area of 30 meters a station building was completed in time for the games. In 1935 the landing area was 180 ha., contained **200 km of drainage pipes** and had **four asphaltic concrete runways** with **nightlandingsystem.**

**The war**

In 1940 the Germans bombed Schiphol, took over the airport and **extended the runwaysystem**. The Allies bombed Schiphol several times and damaged Schiphol severely. Schiphol was rebuilt in 1945 after the Germans left and in that same year on the 8th of July a Douglas DC-3 could already land again on Schiphol. After the war Schiphol grew so fast that the space was not big enough anymore so that **new land had to be bought in the South.**

**Rotterdam airport?**

Behind the scenes there was a battle going on: **Rotterdam wanted her own airport.** A plan was presented by Plesman for a central airport in the South of the Haarlemmermeerpolder but the municipality of Amsterdam strongly opposed. Then Jan Dellaert presented his plan for **a tangential Schiphol** with a stationbuilding in the centre located on the other side of the Haarlemmermeer. In 1949 werd the decision was made that Schiphol would remain the main airport of the Netherlands. That same year the tangential design was approved by the board of Amsterdam and would form the base of the urban design of Schiphol. The start of the project was in 1963 and it was finised in 1967.

**Jet engines**

In 1955 the first Jet engine aircraft landed on Schiphol. This new type replaced the propellor aircraft, is faster and can carry more passengers. Another advantage is that they can reach destinations that are further away. The prices of the tickets went down and **more people were able to afford to fly** > passenger numbers increased largely. These jet engines were an important change for the development of Schiphol as they are heavier and require long, strong runways and had a large impact on the number of passengers. This all lead to **a request for new terminals, runways and facilities.**

**Schiphol City**

Around 1977 Schiphol Centrum showed clear grow. South of the station building the first offices started and the station office had dubbled in size. Slowly a change became visual, Schiphol became Schiphol City, a place with offices, shops, hotels and café's. This developemt was very important for the extension of Schiphol. Schiphol becomes a centre of economy. The one terminal concept is chosen to support this **growing hub of economic activity** and to

**Hub position**

From 1970-1980 there is a change in the grow of passengers to the Asian countries. Due to liberalisation and deragulation of the airtraffic in Europe from 1983 there is space for a different type of businessfroms. For Schiphol this meant that for example the number of transfer passengers started growing faster then the regular flights from 1980. Eventually the **one terminal concept had to be changed** due to the quickly growing number of

**The Boeing 747**

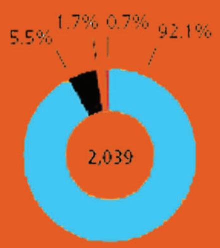
This new aircraft was developed in 1970 and this was the first wide body airplane. It could transport 2.5 times as many passemgers as the in that time popular 707 model. From the introduction in 1970 until the launch of the Airbus 380 it was the biggest airplane and therefore received the nickname Jumbojet. In 1970 the A pier was transformed to be able to link to these Jumbojets. This is also the year that Pier D became operational. **The names of the piers had to be changed** since they were not in logical order anymore after the realization of two new piers below the previous A pier. The concept of the "one terminal" is abandoned for practical reasons and new piers are built.

**Prize fighters**

In 2005 the H-pier was opened especially for the cheaper airlines, To keep the costs at a minimum this pier **does not have any shops, café's or toilets.** Also the gangways do not have roofs because this will save time in linking them tot he airplane.

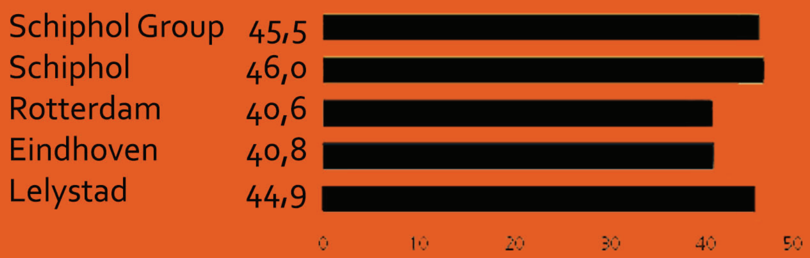
# Employees Schiphol

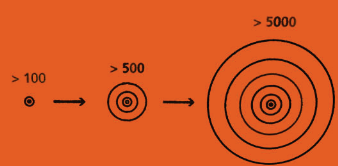
**Total Workforce** In FTEs and % per location




65.000 Schiphol employees

## Average age of employees




**50%** **of all passengers**

**71%** **of employees**

**Go to Schiphol by car**

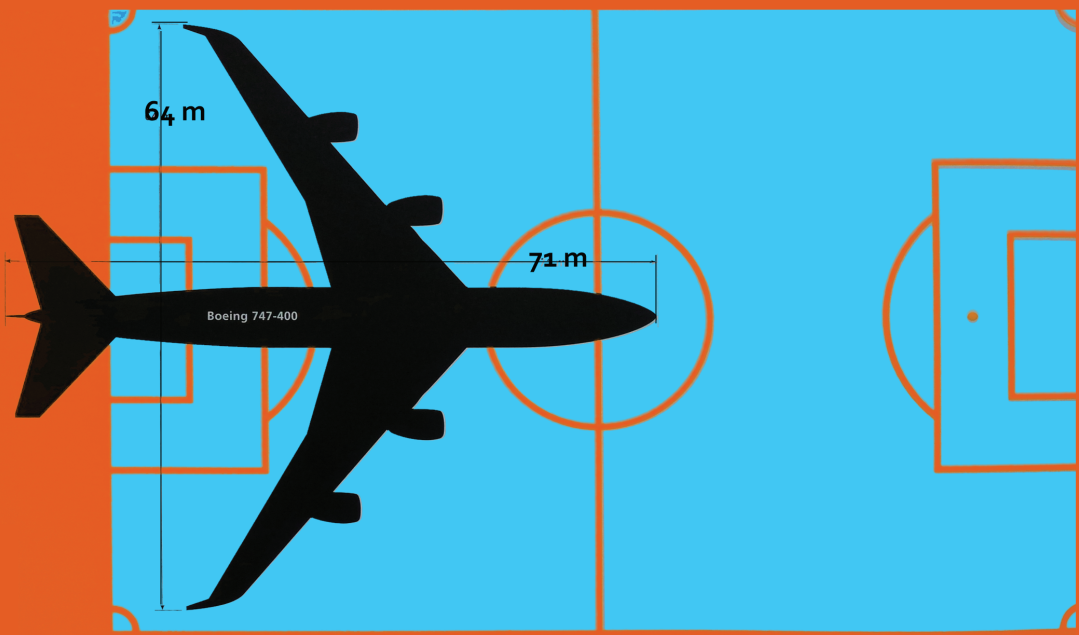
**Where do Schiphol employees live?**

Most Schiphol employees live near the airport, in Amsterdam, Haarlem, Almere Hoofddorp and Amstelveen.
A large number also lives in The Hague, Rotterdam, Lelystad and even in Eindhoven

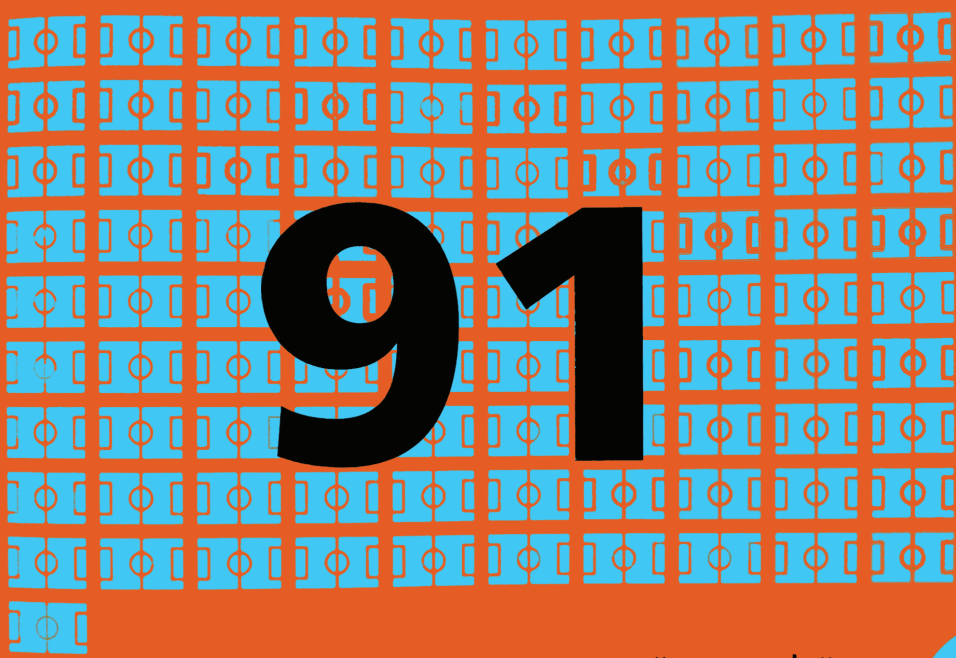
Source: Megastucture Schiphol p.182

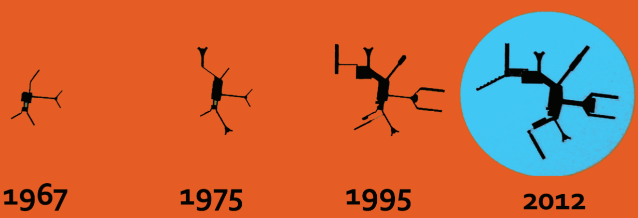
# Size

**71 x 64 meters = Boeing 747**
**105 x 86 meters = UEFA footbal Pitch**



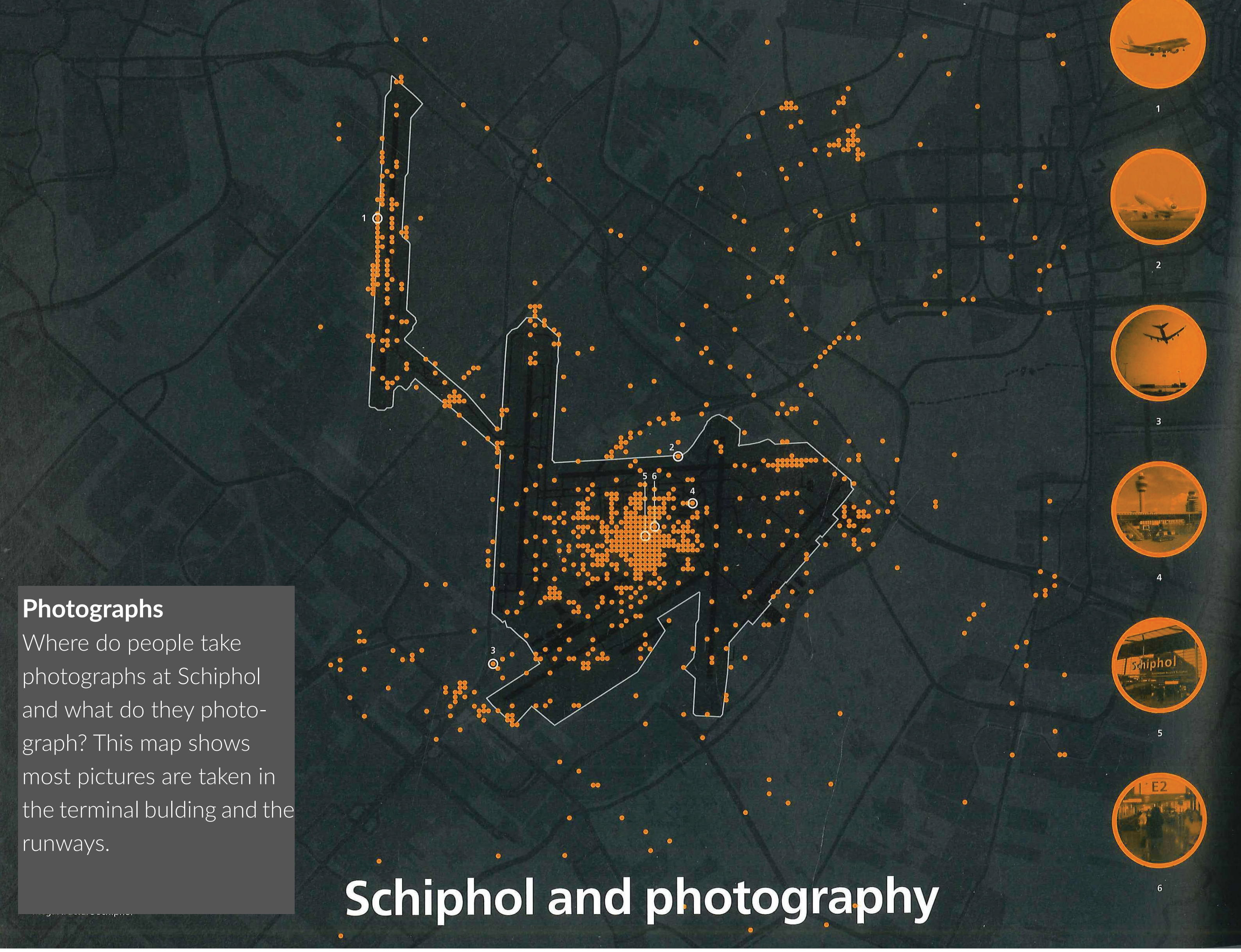

**7140 m2 per football pitch**
**650.000 m2 terminal floor surface area**




**Floor surface area**
The current surface area of
Schiphol is as big as 91 foorball pitches.
Source: Megastructures Schiphol

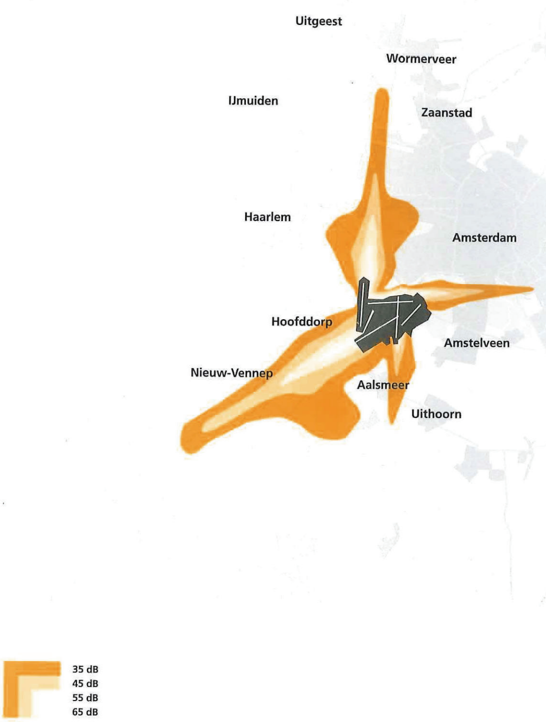
# 50,000 photographs




**Photographs**
Where do people take photographs at Schiphol and what do they photograph? This map shows most pictures are taken in the terminal bulding and the runways.

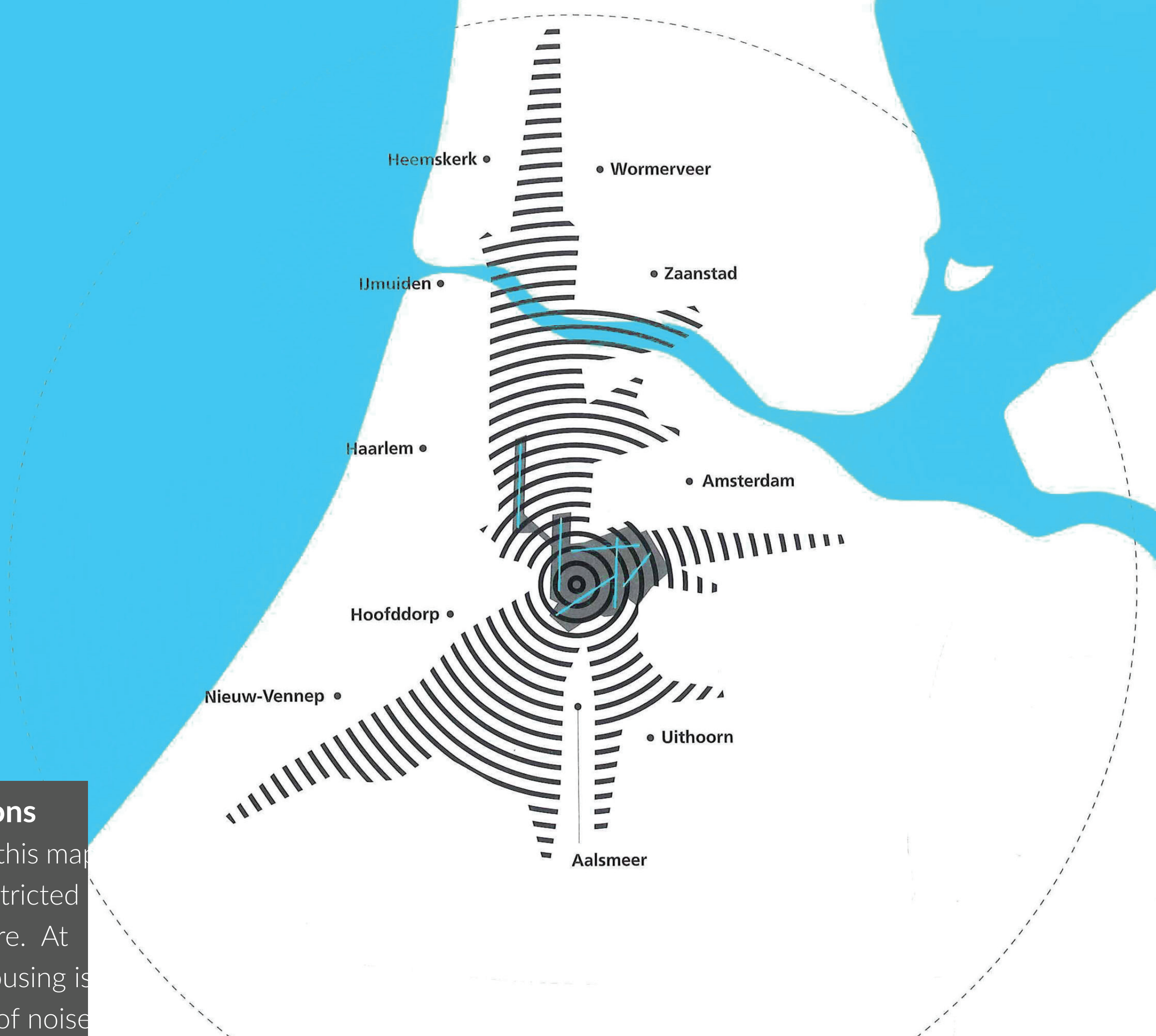
# Schiphol and photography

# Schiphol and noise barrier





*Source data Bosma. (2012). Megastructure Schiphol. Design in Spectacular Simplicity. NAI.*



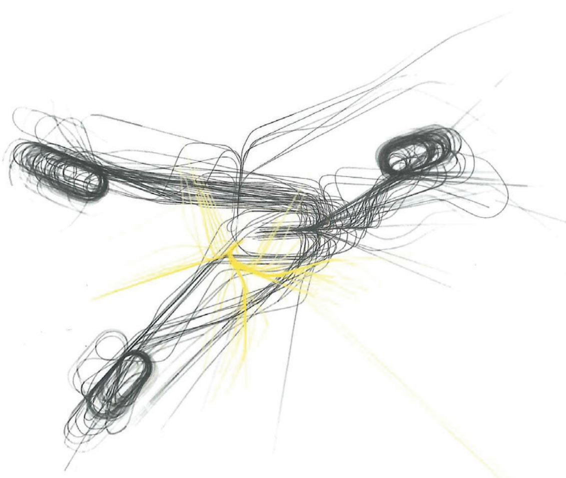

**Building restrictions**

The black cicles on this map show where the restricted area's for housing are. At the dark lines no housing is permitted because of noise nuisance. Aalsmeer clearly shows that the area's are arranged around the urban area's.



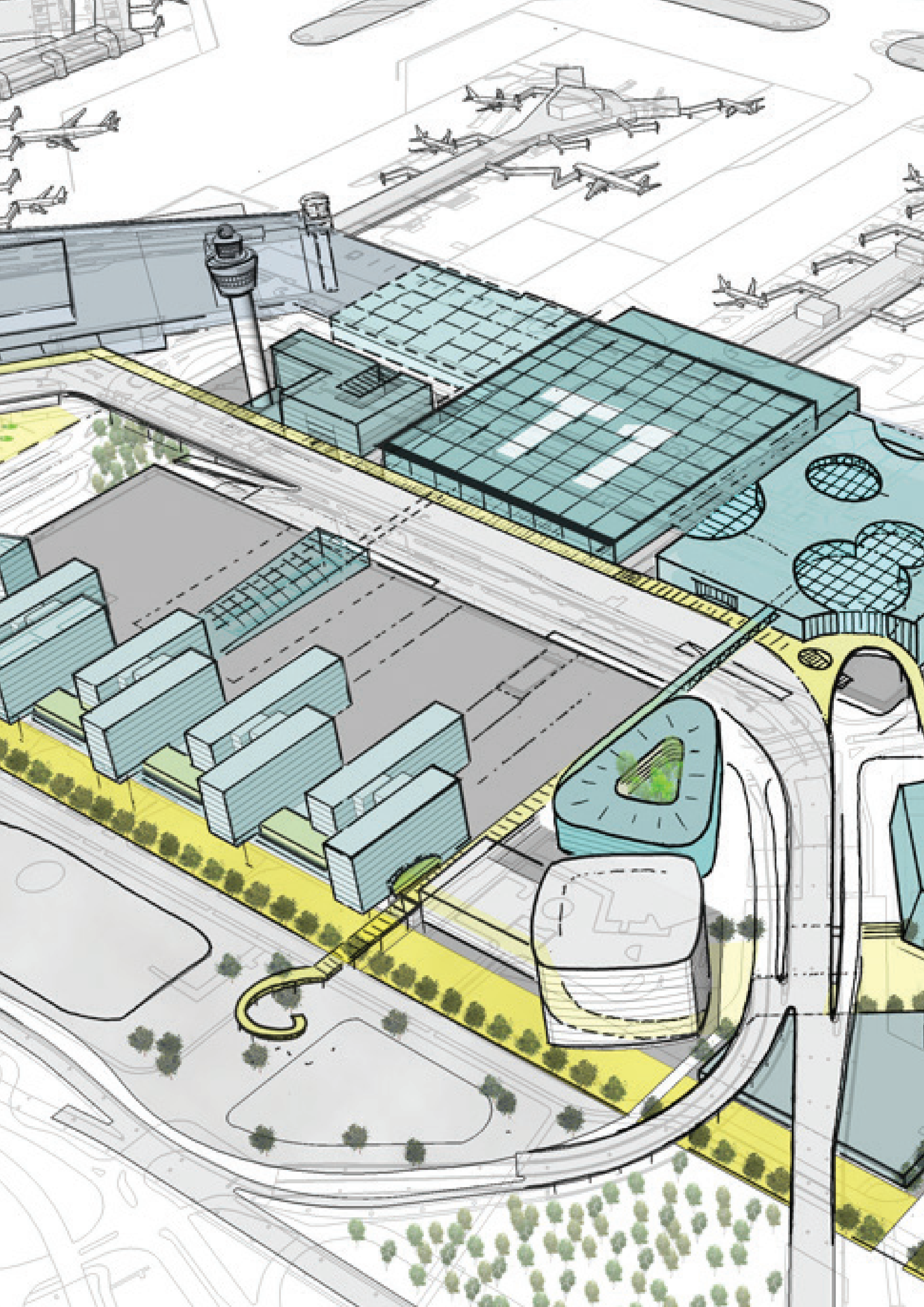
# Schiphol and Building restrictions

# Schiphol and airmovements



Map 1.
This map shows 4 januari 2012, a day with much fog. The airplanes had to circle before they could land.

Map 2.
This map shows 5 januari 2012, the fog has dissolved. The Polderbaan used by most planes for landing.



## Future Plans Schiphol

Schiphol plans to expand their capacity up to 65 million passengers and between 600.000 and 650.000 flights per year. In order to be able to compete with the larger airports and to keep supporting the growing stream of passengers constantly new plans were developed such as the plans to build the new A-bay.  Schiphol now developed a future vision for 2020 - 2025. In this plan the extension of the bays south of the B bay and a new departure/arrival hall are discussed.

Schiphol will keep on focussing on the hub function for KLM and the skyteam airlines but will also grow in the low-cost airlines segment. Long-term view is that several charter flights (point-to-point) will be transferred to the regional airports Lelystad and Eindhoven

Schiphol also reserved ground to build a new runway that runs parallel to the Kaagbaan in order to be able to compete with London, Paris and Frankfurt. They need to keep growing and adapting to changes in aviation industry such as larger planes that fly larger distances. This could lead to losing their strong hub position since no in-between stop is necessary anymore with the newer planes.

The decision about whether or not to build this runway will be taken after 2023. Schiphol confirmed  at the 12th of August 2014 that they reserved half a million for realizing a new terminal and a new bay on the south side of the airport.  The first fase of the renovation project is displayed on the picture.

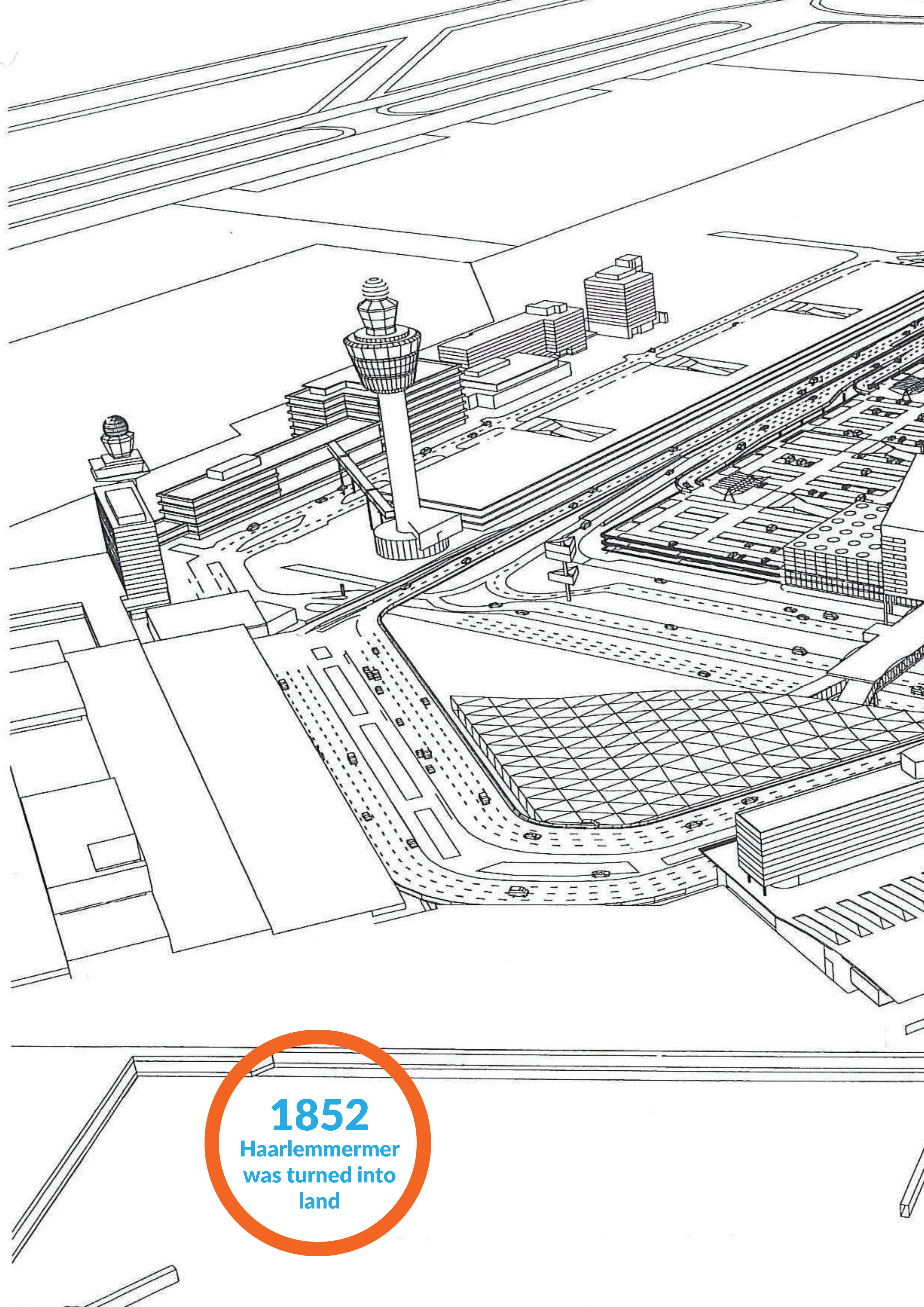
*Renovations Schiphol 2015 fase one, retreived klm.com on 23/03/2015*

## Schiphol mission and values

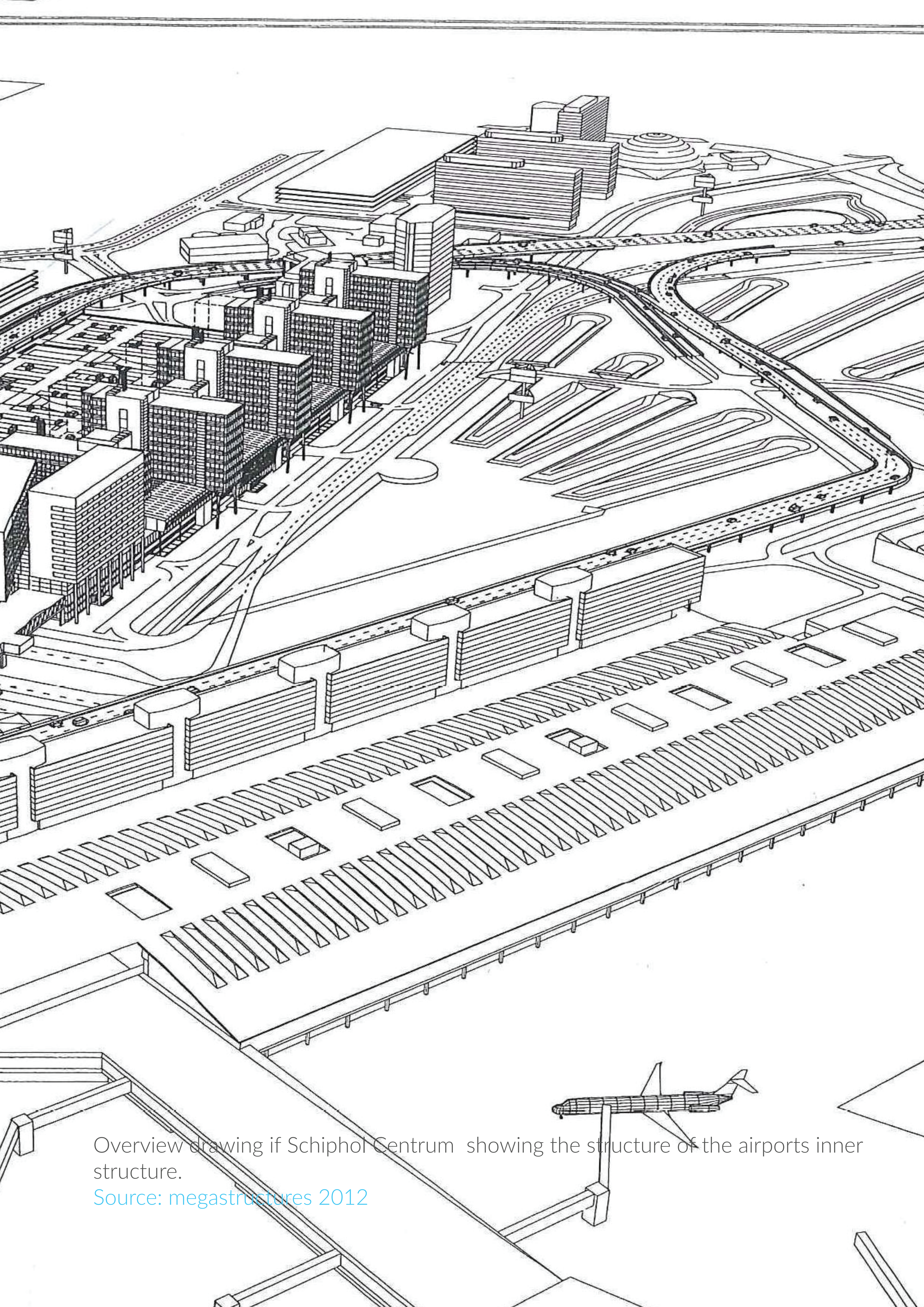
The mission of Schiphol is to connect the Netherlands with important cities and regions in the world. They do not have the ambition to be the biggest airport in Europe but do want to be a preferred airport.

This means: Being an airport that is more attractive than others by quality of the network, the service to passengers and ailrlines while keeping a good balance between price and quality. Main values of Schiphol are: Reliable, Efficient, Sustainable and Inspiring.


Polderbaan
Buitenveldertlaan
Zwanenburglaan
Oostbaan
Kaagbaan
Aalsmeerbaan



**1852**
**Haarlemmermer was turned into land**



Overview drawing if Schiphol Centrum  showing the structure of the airports inner structure.
Source: megastructures 2012

# 2.2. Schiphol Oost

Schiphol Oost, area of Hangar 12, is located in the municipality Noord- Holland and is part of Airport Schiphol. It is located between the canal of the Haarlemmermeerpolder and the Oostbaan. In the South the hamlet called "Oude Meer"is located, in the north hamlet "Nieuwe Meer. "

Before the current Schiphol-Centrum opened in 1967, the platform, the control tower and the terminal hall were all located in this area. The only architecture that still exists of that time is the former control tower, which is now used as a restaurant. Currently the buildings at Schiphol Oost are mainly new offices, hotels and hangars. In the hangars the technical maintenance for the airplanes takes place. This is also the place where KLM Engineering and Maintenance has her hangars for the technical maintenance of aircraft engines and aircraft components. The Fokker Factory moved to Schiphol (now Schiphol-Oost) in 1951. Also part of the air traffic control that supports the air traffic in the Dutch airspace is located in Oost

This is also the place where KLM Engineering and Maintenance has her hangars for the technical maintenance of aircraft engines and aircraft components. The Fokker Factory moved to Schiphol (now Schiphol-Oost) in 1951. Also part of the air traffic control that supports the air traffic in the Dutch airspace is located in Oost

Since 2003 a judicial complex with a court and a detention centre located are located next to Schiphol Oost in Oude Meer. In this detention a major fire raged in October 2005 which killed eleven detainees and wounded fifteen.

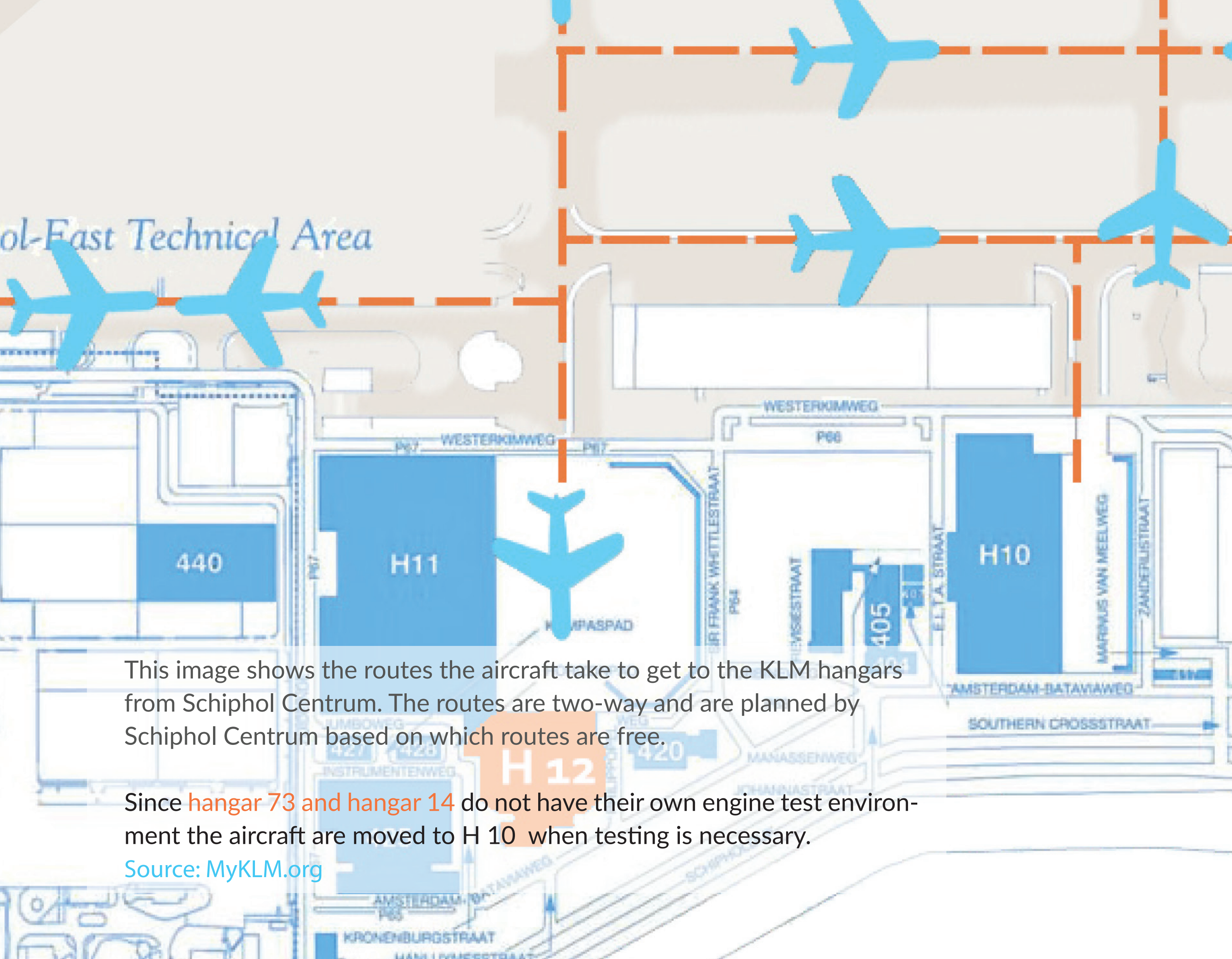

1613
MOONLINER
30%
REDUCTIE
HZ
82803
NL

# KLM in Schiphol Oost

The maintenance buildings of KLM are located in Schiphol Oost. Meaning that for example hangars are located here, just like the engine workshop and component shops are. Schiphol Oost is a secured area, you need to have a pass to be able to access the area.

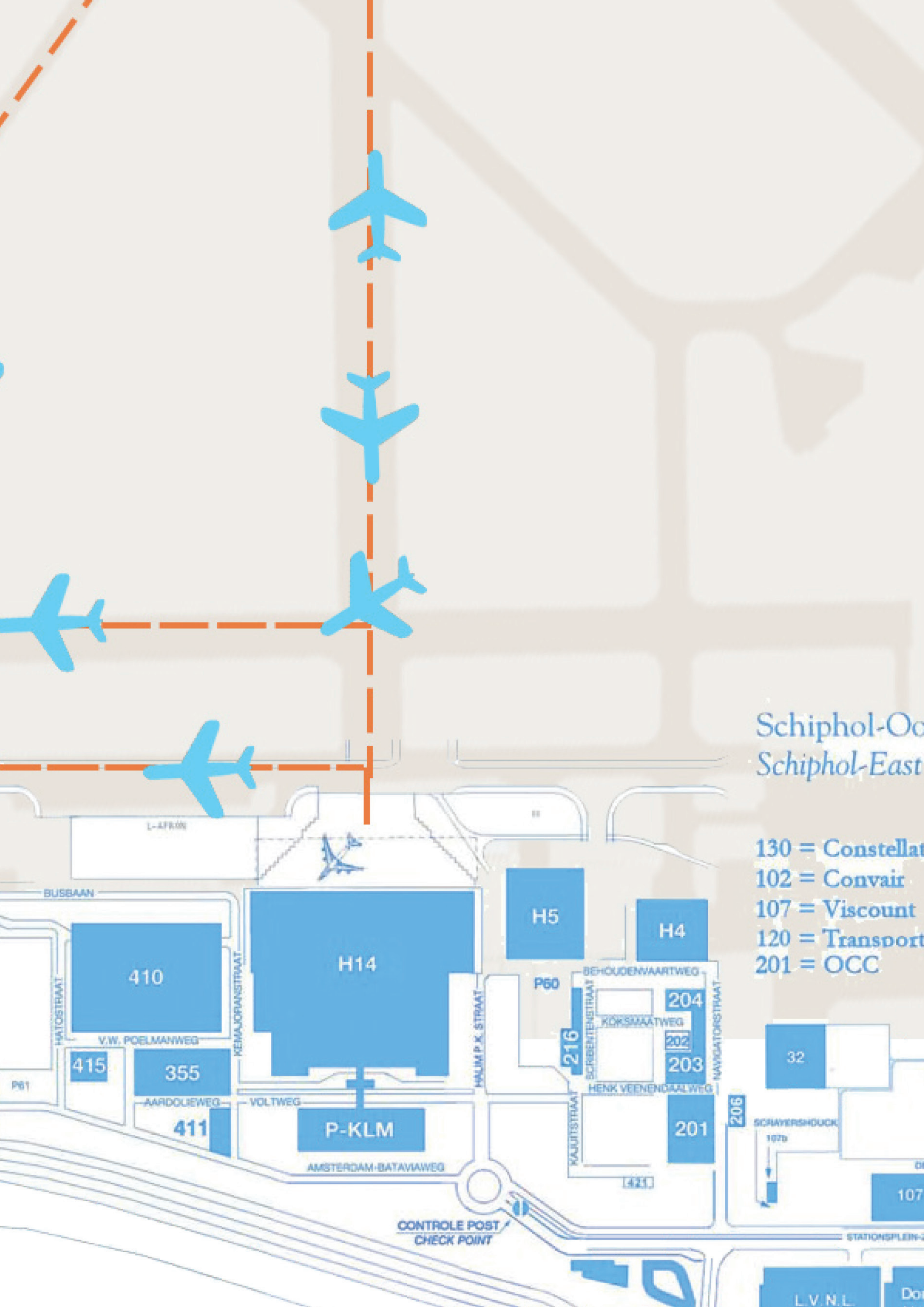
The KLM Hangars are located in buildings 11, 12, 10 and 14 on the map. In between these Hangars you can find the supporting functions: IRA in building 425 ( electrical components shop) and the engine shop in building 410. Building 411 is an educational building and the buildings next to H10 are offices and storage. The empty areas connected to the Hangars are used as test areas. These area's are surrounded by high heavy concrete walls to reduce noise, waste and wind released at the engine tests.

source: interview Gerald van Baars KLM 05032015
KLM Schiphol Hangar 10




This image shows the routes the aircraft take to get to the KLM hangars from Schiphol Centrum. The routes are two-way and are planned by Schiphol Centrum based on which routes are free.

Since hangar 73 and hangar 14 do not have their own engine test environment the aircraft are moved to H 10 when testing is necessary.
Source: MyKLM.org



Schiphol-Oo
Schiphol-East
130 = Constellat
102 = Convair
107 = Viscount
120 = Transport
201 = OCC
L-AFRON
BUSBAAN
H5
H4
H14
410
P50
BEHOUDENVAARTWEG
204
KOKSMAATWEG
202
203
216
HATOSTRAAT
V.W. POELMANWEG
KEMAJORANSTRAAT
HALIM P.K. STRAAT
SCRIBENTENSTRAAT
NAVIGATORSTRAAT
HENK VEENENDAALWEG
415
355
P61
32
AARDOLIEWEG
VOLTWEG
411
P-KLM
KAJUITSTRAAT
201
206
SCRAYERSHOUCK
107b
AMSTERDAM-BATAVIAWEG
421
107
CONTROLE POST
CHECK POINT
L.V.N.L.

Every Hangar has each own workspace and tool warehouse except for H 11 and H 12 because they have the possibility to share since they are connected. Different parts of the airplane are transported from the hangars to the supporting buildings when they cannot be repaired at the Hangar itself. Small objects are transported with vans from shop to Hangar and vice versa, but the engine for example is too large and requires a special transport.

The activities of Hangar 10 will be moved to Hangar 12 after summer. The reason for this is that the airplanes in the KLM fleet as well in the other fleets that use the Hangar for maintenance are newer. These newer airplanes require less maintenance hours and therefore there are not enough requests to keep Hangar 10 open. In KLM language KLM has **"Too much concrete"** meaning that the amount of square meters of the hangars is too much to be feasible nowadays.

**TRANSFER H 10 > H12**

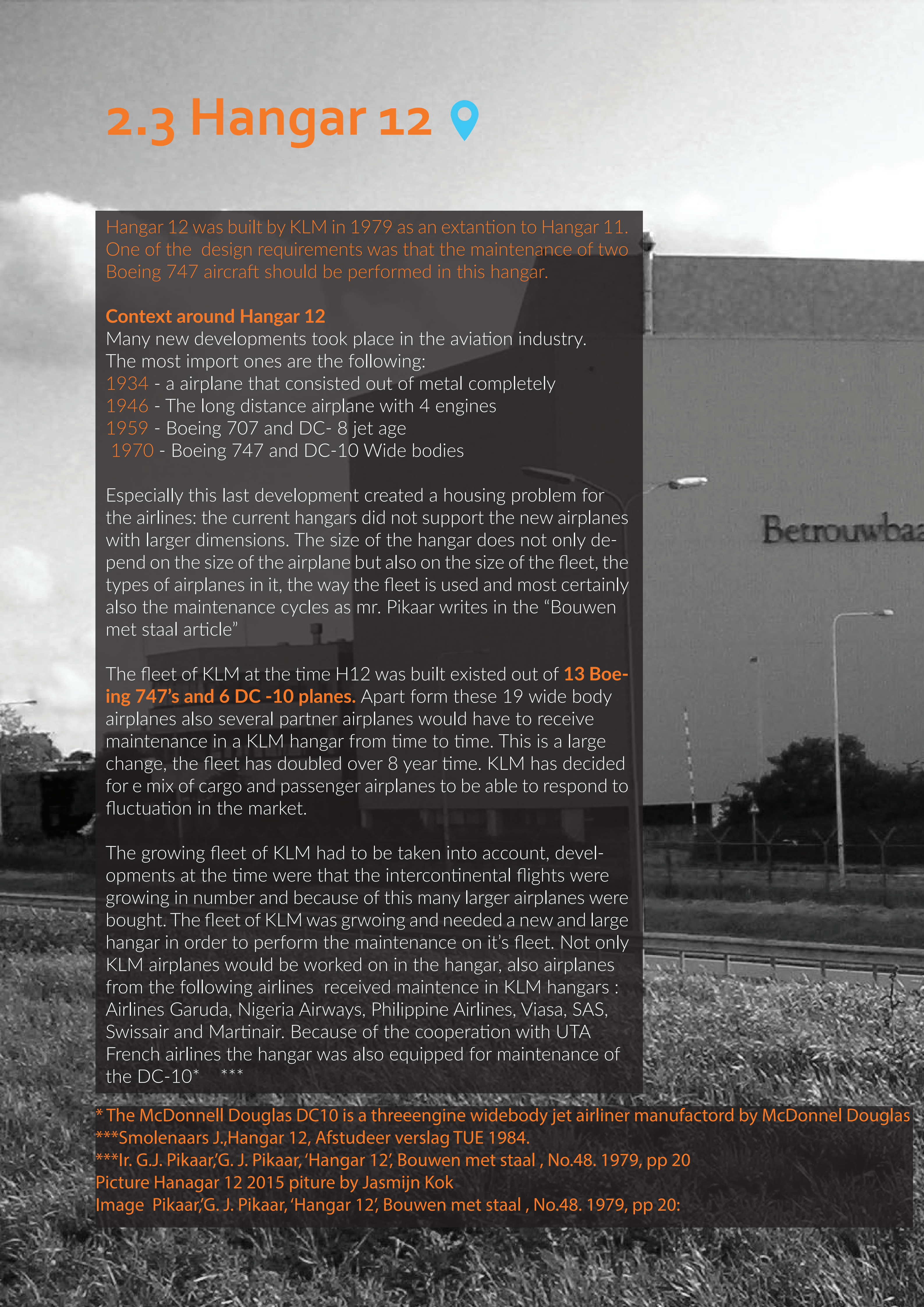
The transfer from H10 > H12 will take place after summer 2015. The reason behind this time scheme is that in summer the KLM customers and KLM planes themselves will be out in the air. The summer is the time when a large number of people want to go on vacation. The time consuming C checks are therefore all planned out of the summer season to have as many airplanes in the air as possible to increase profit.
The future plans for Hangar 10 are still unclear and depend on the developments of KLM and her customers.

**The activities differ per hanger: ****

- **Hangar 10** Maintenance B 737,767/787 A+C checks
- **Hangar 11** All airplanes except 787 A + C checks
- **Hangar 12** B787 A + C checks and B737 A checks
- **Hangar 14** Airbus330, Boeing 747 Boeing 777 A+C checks
- **Hangar 73** KLM City hoppers Fokker 70 and Embraer

**A-check takes about 160 hours finished in 13 days necessary everey 3a 4 months.. C check every few years takes between 1 3 weeks. Source interview Gerlald van baars on 05032015 facility and equipment at KLM

# 2.3 Hangar 12




Hangar 12 was built by KLM in 1979 as an extantion to Hangar 11. One of the  design requirements was that the maintenance of two Boeing 747 aircraft should be performed in this hangar.

**Context around Hangar 12**

Many new developments took place in the aviation industry. The most import ones are the following:

1934 - a airplane that consisted out of metal completely
1946 - The long distance airplane with 4 engines
1959 - Boeing 707 and DC- 8 jet age
1970 - Boeing 747 and DC-10 Wide bodies

Especially this last development created a housing problem for the airlines: the current hangars did not support the new airplanes with larger dimensions. The size of the hangar does not only depend on the size of the airplane but also on the size of the fleet, the types of airplanes in it, the way the fleet is used and most certainly also the maintenance cycles as mr. Pikaar writes in the “Bouwen met staal article”

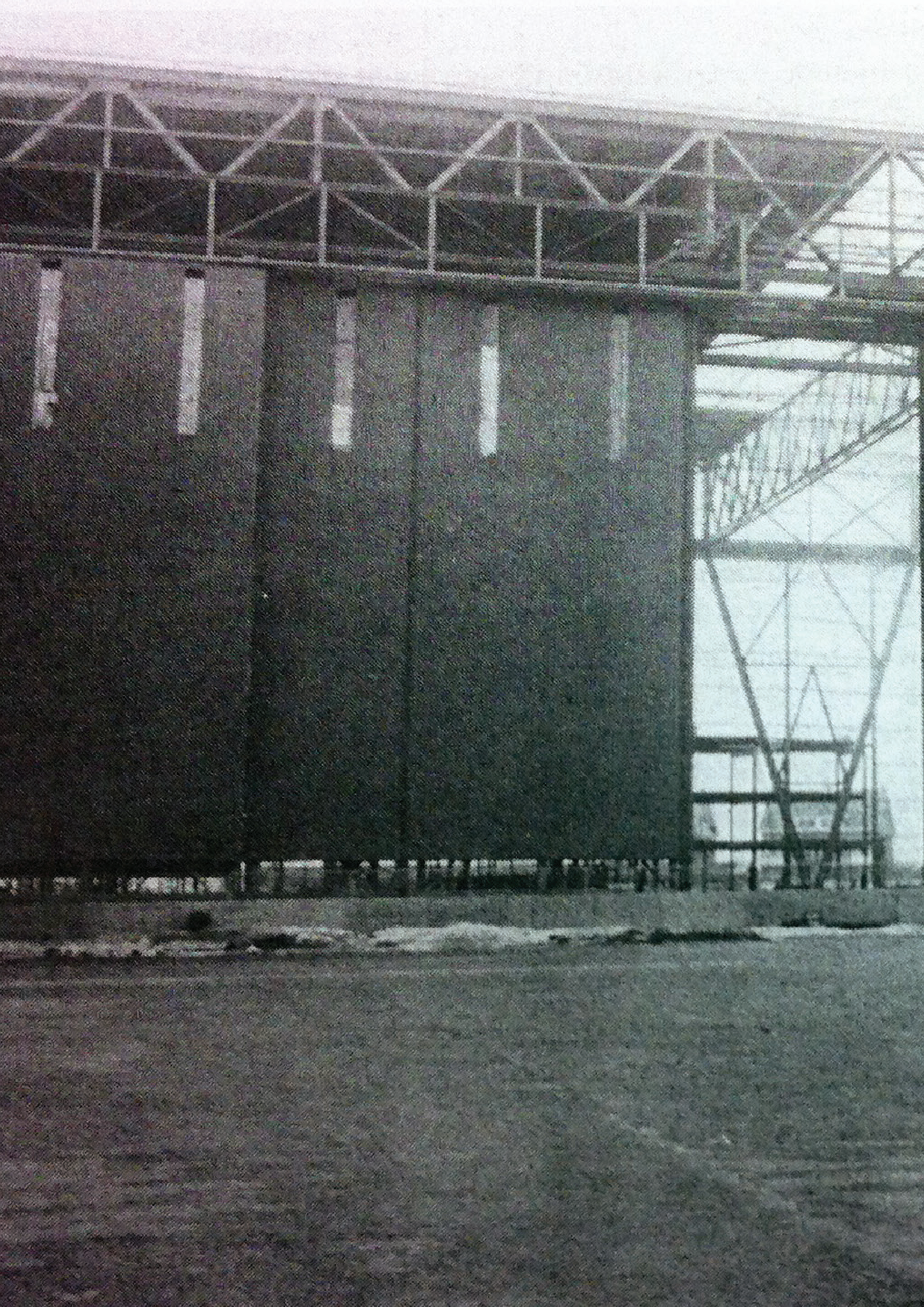
The fleet of KLM at the time H12 was built existed out of **13 Boeing 747's and 6 DC -10 planes.** Apart form these 19 wide body airplanes also several partner airplanes would have to receive maintenance in a KLM hangar from time to time. This is a large change, the fleet has doubled over 8 year time. KLM has decided for e mix of cargo and passenger airplanes to be able to respond to fluctuation in the market.

The growing fleet of KLM had to be taken into account, developments at the time were that the intercontinental flights were growing in number and because of this many larger airplanes were bought. The fleet of KLM was grwoing and needed a new and large hangar in order to perform the maintenance on it's fleet. Not only KLM airplanes would be worked on in the hangar, also airplanes from the following airlines  received maintence in KLM hangars : Airlines Garuda, Nigeria Airways, Philippine Airlines, Viasa, SAS, Swissair and Martinair. Because of the cooperation with UTA French airlines the hangar was also equipped for maintenance of the DC-10*     ***

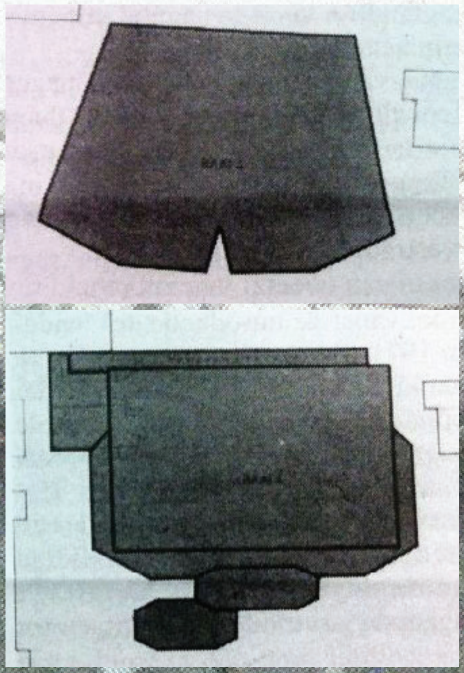
* The McDonnell Douglas DC10 is a threeengine widebody jet airliner manufactord by McDonnel Douglas
***Smolenaars J.,Hangar 12, Afstudeer verslag TUE 1984.
***Ir. G.J. Pikaar,'G. J. Pikaar, 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20
Picture Hanagar 12 2015 piture by Jasmijn Kok
Image  Pikaar,'G. J. Pikaar, 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20:

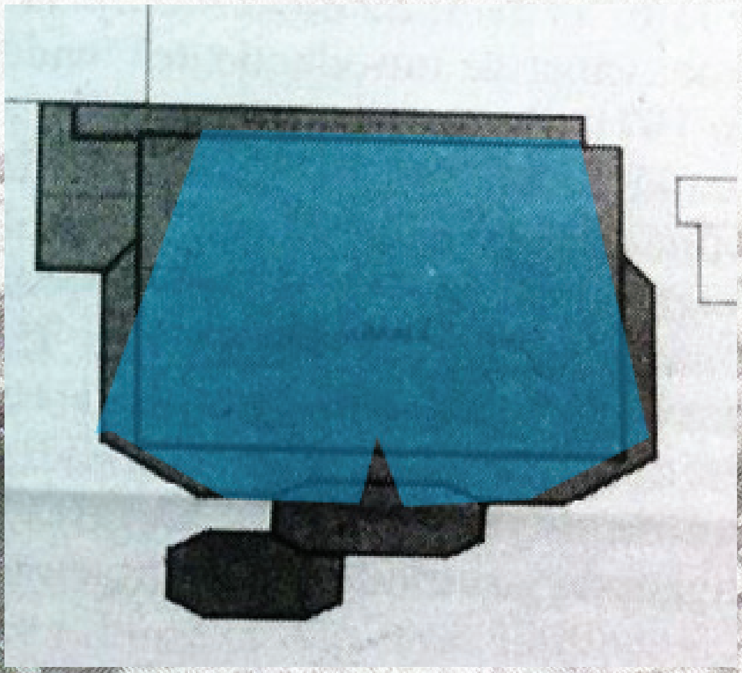
## Prediction of the growth of the KLM fleet in 1979


Image Pikaar,'G. J. Pikaar, 'Hangar 12',
Bouwen met staal , No.48. 1979, pp 20:

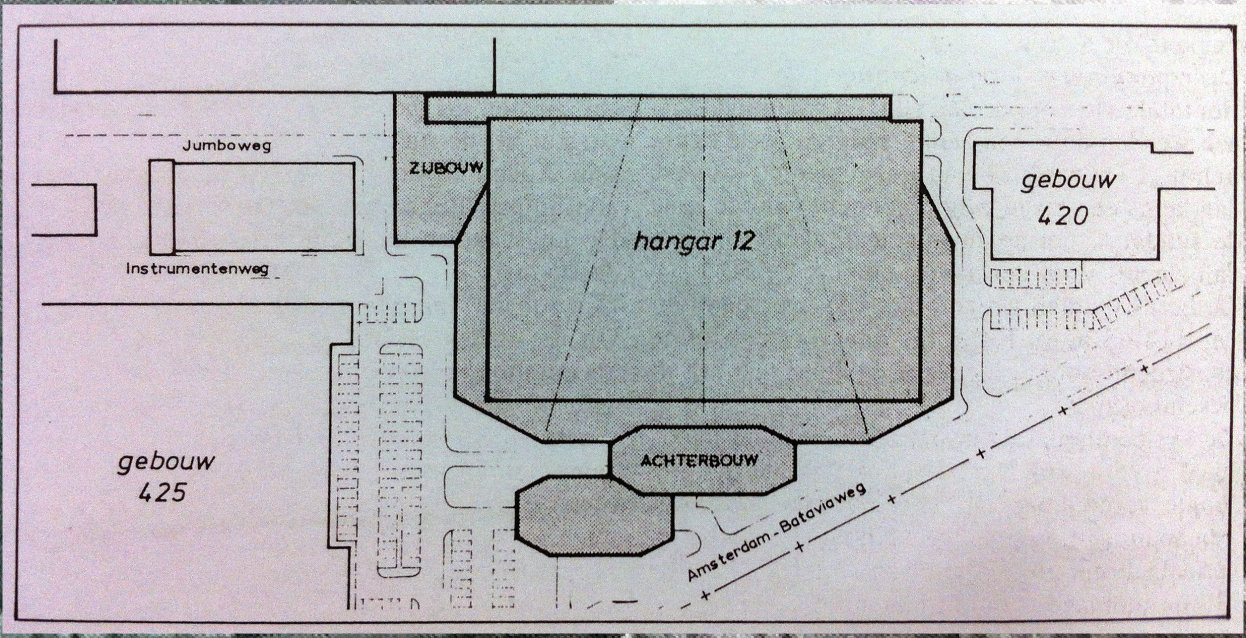


## 1. SPACE REQUIRED FOR TWO B747'S   2.DEFINITIVE SHAPE





## Context H12




## Construction of H12 hangaar doors

Source: 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20-29

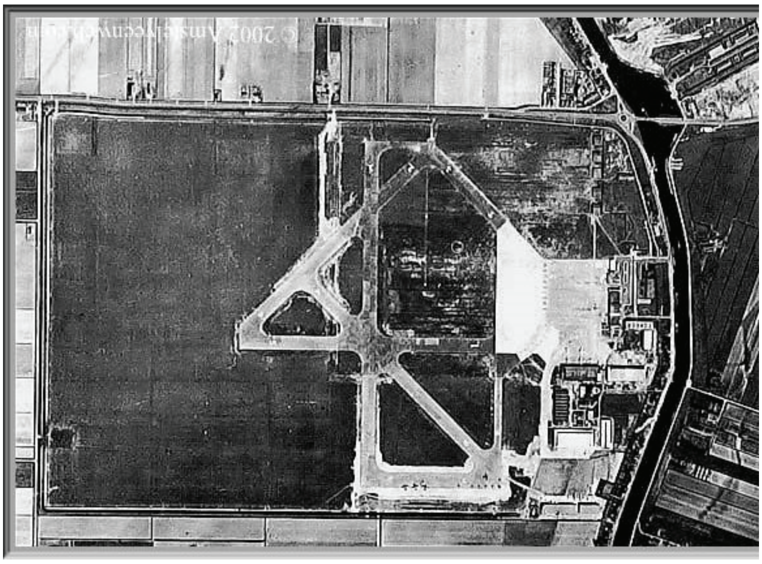
# 2.4 Conclusions History

**1916**
year that Schiphol started

## Flexibility

The traffic tower of Schiphol Oost was moved several meters when Schiphol moved to central in 1967 in order to preserve it. It is now in use as a cafe.

What we can learn form this is that when a design is created well, using materials that last a building can be used for a long time even when the function that the building was once designed for has changed. Perhaps in 100 years our hangar will be used to organize concerts in. Flexibility in the design is an important quality.



## Learn from the past

Originally Schiphol was built with a **tangential runway system**. The reason for this is that the wind in the Netherland changes a lot. While Schiphol only needs 3 runways at the same time, 7 are necessary to be able to cope with the wind. When Schiphol moved in **1967** the same system was chosen as it has proven to work well. The teminal system however was changed into a one terminal concept.

What we can learn form this for our hangar of the future is that we should look carefully at the aspects of H12 that already funtion well. These we should take with us in the design, but at the same time we should not be afraid to use un proven technology. This way it is impossible to design for the future.

**3** landings banen nodig

## Adaptability

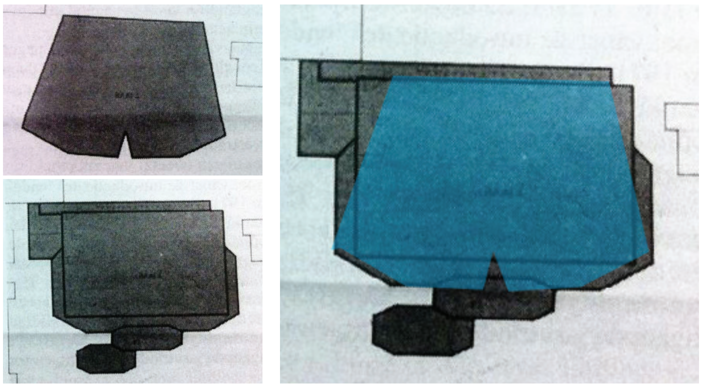
This picture shows the first time the Pan Am jumbo jet (747) arrived at Schiphol in 1970. Schiphol adjusted their architecture with a new connection at the end of the bridge to be able to welcome the 747.

When designing for the aviation industry one should keep in mind that aircraft are important features. The sizes of the different models differ and we know that in the future new models will be launched. Therefore we should, as Shiphol with the 747 did design in a way that allows the architecture to adapt to new models.

## Look around

In **1991** A new traffic tower was built because the old one cold not oversee everything anymore due to large grow of the airport. The new buildings were blocking the view

When making a design for a new building or extension, take into consideration what the impact on the surroundings is.



## Be prepared

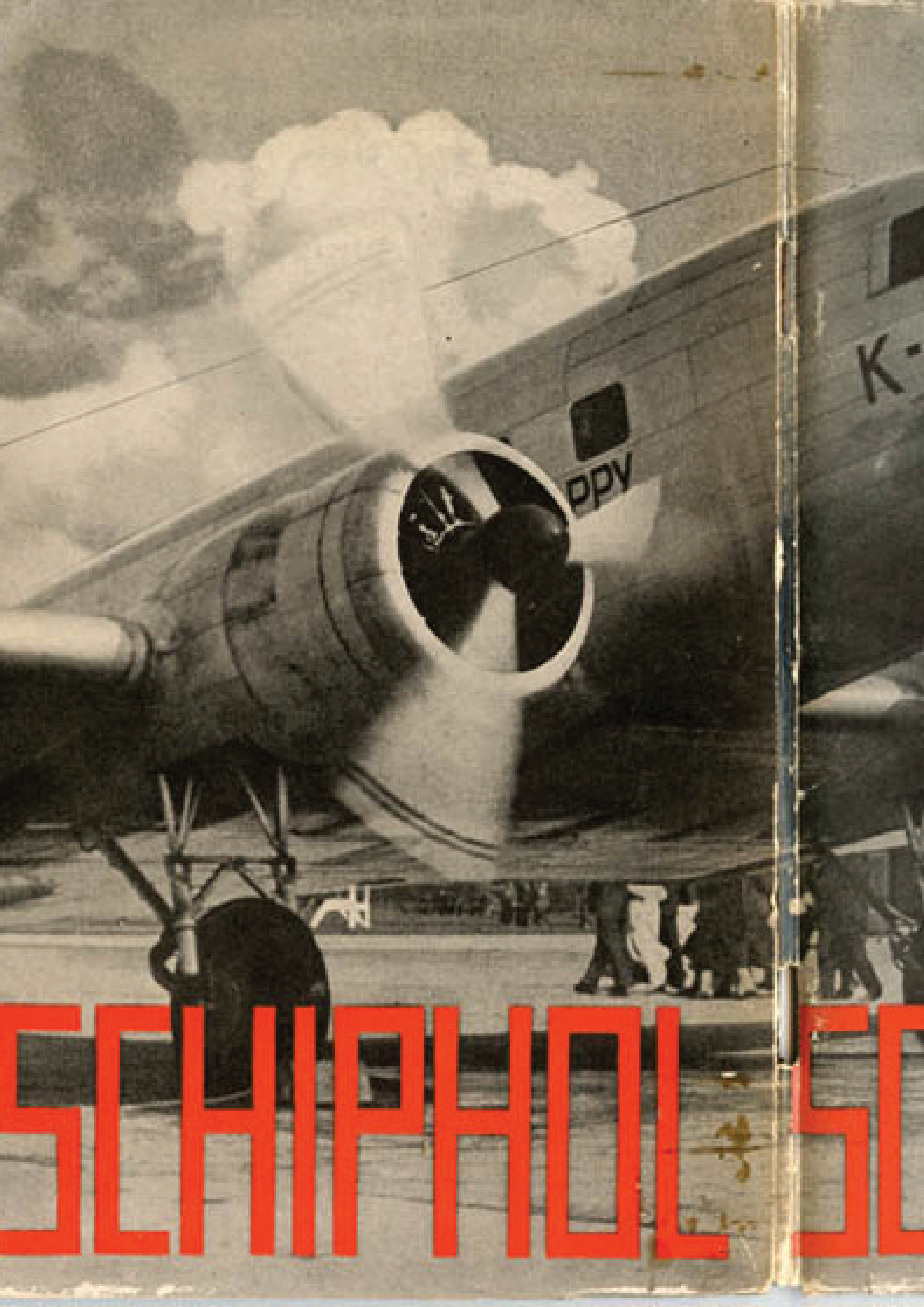
In **1979** a new hangar was built in Schiphol Oost. This hangar was designed for the Boeing 747's as they were too large to fit in other hangars.

Even today, the over 35 years ol hangar is still operational and will be renovated to last another 35. The sizes of the hanger allow the innovative B787 and A350 to also receive maintenance there. The hangar supports the functions of maintenance today and even in the future. This is a feature we also need to implement in our hangar of the Future, it should be prepared for the newer models and support other maintenance processes then we know of today.

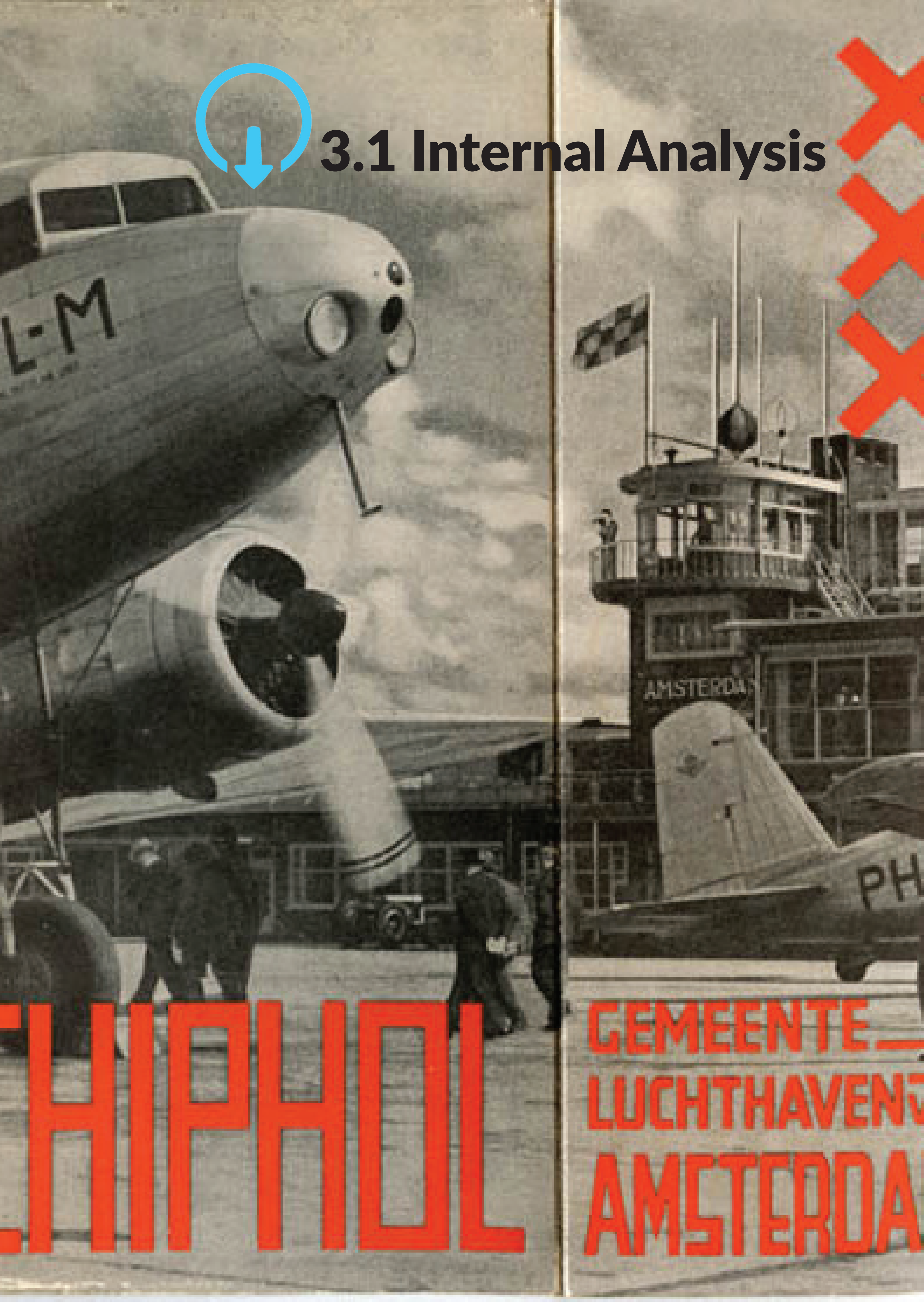
**1979**
**Hangar 12 was built**


KLM
KLM

# CHAPTER 3.
# KLM


SCHIPHOL

# 3.1 Internal Analysis



# 3.1 Company profile


## Mission

With Air France, KLM is at the forefront of the European airline industry. Offering **reliability** and a healthy dose of **Dutch pragmatism**, 32.000 KLM employees work to provide innovative products for our customers and a **safe, efficient, service oriented operation** with a proactive focus on **sustainability**. KLM strives to achieve profitable growth that contributes to both its own corporate aims and to economic and social development.

KLM works to create sustainable growth at Schiphol, to gain access to any market that will increase the quality its network and to maintain a level playing field for all industry players. It also works to ensure a balance between the company's interests and those of the people living and working close to the airport.


# Employees

In the KLM Group there are 32.000 people making a difference. **Availability** is central to their personnel policy. KLM wants its employees to be healthy and to enjoy working as long as possible for the group. Staff are encouraged to expand their skills and experience through training and changing jobs from time to time.
Rapid changes in technology and customer markets demand that KLM is able to adapt its organisation flexibly. This **flexibility** is also expected of individual employees.

# Responsibility

KLM has taken the initiative for **Corporate Social Responsibility** (CSR) in the airline sector. KLM and Air France together want to set the standard for an integrated approach in the airline sector. By signing the United Nation's Global Compact, KLM has contributed to the UN Millennium Development Goals.

KLM

# Network

With a small home base from which to work, KLM has maintained an international orientation from the beginning. KLM's strength lies in the tightlyknit, worldwide network it has built up with its partners. This network links just about every important economic region in the world with the Netherlands and with each other. Passengers are able to transfer quickly and easily at Schiphol, KLM's homebase, and practically every destination in the world can be easily accessed for cargo.

## TWO CONNECTED HUBS

Mainport Schiphol is the linchpin in the KLM network. For Air France this is the Paris airport Charles de
Gaulle. Through their joint venture, KLM and Air France are able to enjoy the benefits of two hubs. Network and hub are tightly interwoven. New destinations enhance the hub's position and increase the appeal of Schiphol for both passengers and freight companies. They also improve the Netherlands' competitive strength and benefit regional and national employment.

## AIR FRANCE KLM GROUP

KLM works closely with Air France within the AIR FRANCE KLM Group, which came into existence through the 2004 merger. The AIR FRANCE KLM Group is Europe's leading airline group and sets the standards for quality, innovation and sustainability.

## KLM SUSTAINABILITY

An important programme within KLM is "KLM takes care" KLM feels it is important to take responsibility, being one of the bigger players in the aviation industry. To contribute to a better world KLM is actively involved in many initiatives. As a result of continuous efforts, together with Air France, KLM has topped the Dow Jones Sustainability Index in the aviation sector for several years.

## KLM TAKES CARE

KLM has a special logo that shows their involvement: The Takes Care logo. It is apparent on for example their tea and coffee cups on board, which are 100% biodegradable.
KLM involvement projects
KLM is involved in many different projects that support sustainability and allows them to express their involvement.

Image± Air France-KLM network from the Hub of CDG © Corporate Air France
http://www.klm.com/corporate/en/aboutklm/airfranceklm/index.html

> KLM is making major progress in the development and use of sustainable biofuels. They have joined forces with the World Wide Fund for Nature (WWF), and others.
> They are working on sustainable solutions for reducing CO2 emissions.
> Serve sustainably produced foods on board where possible, such as products carrying the UTZ mark for sustainable coffee or the MSC organisation quality mark for sustainable fish.
> Support social projects such as Close the Gap and Wings of Support, and is KLM Health Services working with the VU University Medical Centre in a Doctor2Doctor programme, to contribute to medical care in Kenya.
> Continue talking to residents of the Schiphol area, for example about limiting noise pollution.

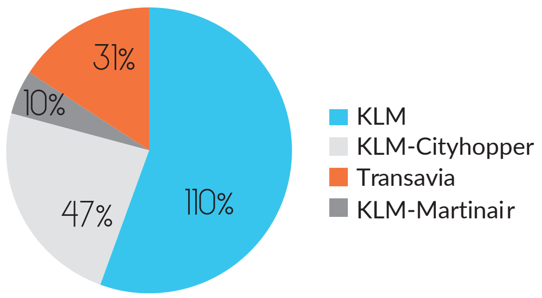
## CO2 NEUTRAL

KLM started a project which allows you to reduce your footprint in the sky.
They offer an online program to calculate the CO2 emissions of your flight when booking.The CO2 emission is transferred in an amount of money that you can contribute to the CO2 ZERO programme. The money earned through this programme is invested in various sustainable energy projects.

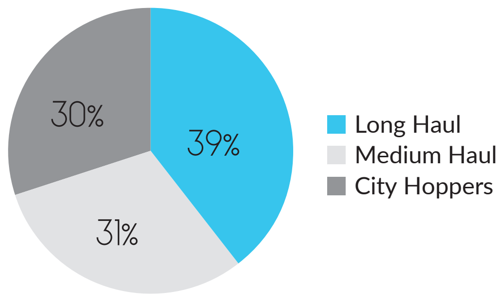
# 3.2 KLM fleet

## CURRENT FLEET

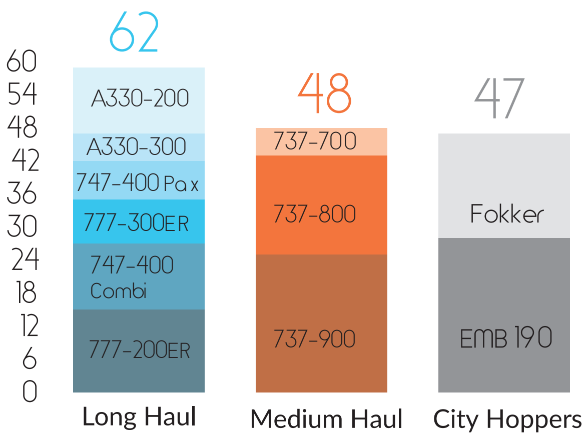
Aircraft in service KLM Group



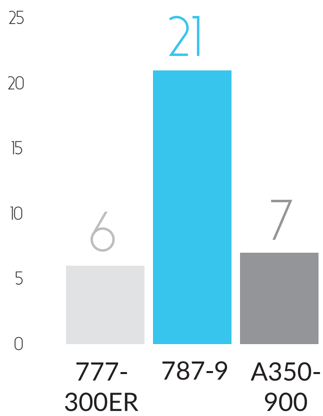

Distance types KLM




KLM Fleet jan 2015




KLM aircraft on order in jan 2015




## LONG TERM FLEET MANAGEMENT

Selection criteria of aircraft in order to maintain an efficient fleet

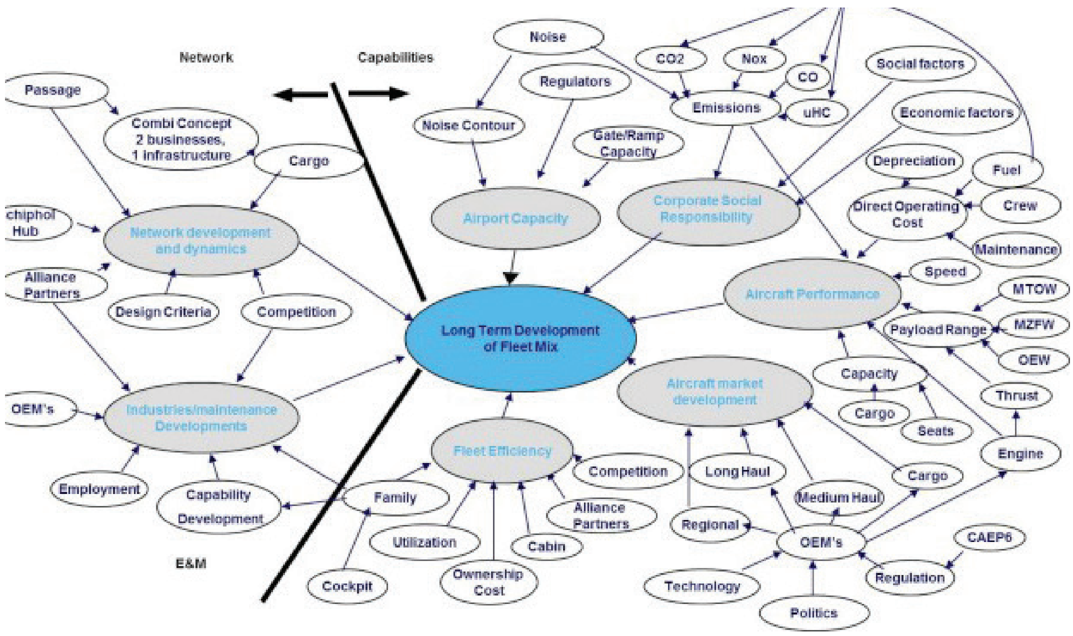
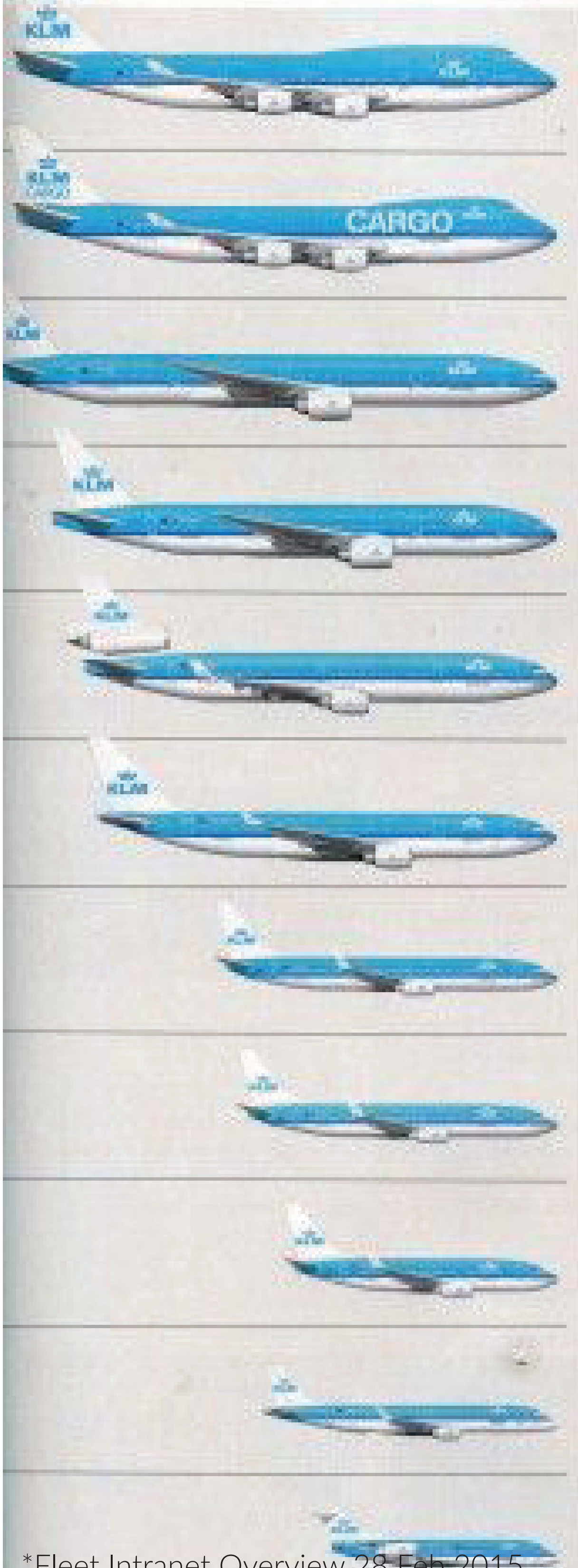



Image: Selection criteria new airplanes
myklm.org




## Boeing 747-400 Passenger/Combi

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 7/15 | MAXIMUM PASSENGERS | 408/273 |
| CRUISING SPEED (KM/H) | 920 | TOTAL LENGTH (M) | 70.67 |
| RANGE (KM) | 11,800 | WINGSPAN (M) | 64.44 |
| MAX. TAKE-OFF WEIGHT (KG) | 390,100/396,800 | PERSONAL INFLIGHT ENTERTAINMENT | |
| MAX. FREIGHT (KG) | 35,800 | | |

## Boeing 747-400ER Freighter

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 4 | MAX. FREIGHT (KG) | 112,800 |
| CRUISING SPEED (KM/H) | 920 | TOTAL LENGTH (M) | 70.67 |
| RANGE (KM) | 11,500 | WINGSPAN (M) | 64.44 |
| MAX. TAKE-OFF WEIGHT (KG) | 412,000 | | |

## Boeing 777-300ER

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 7 | MAXIMUM PASSENGERS | 425 |
| CRUISING SPEED (KM/H) | 920 | TOTAL LENGTH (M) | 73.86 |
| RANGE (KM) | 13,600 | WINGSPAN (M) | 64.80 |
| MAX. TAKE-OFF WEIGHT (KG) | 351,543 | PERSONAL INFLIGHT ENTERTAINMENT | |

## Boeing 777-200ER

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 15 | MAXIMUM PASSENGERS | 318 |
| CRUISING SPEED (KM/H) | 905 | TOTAL LENGTH (M) | 63.73 |
| RANGE (KM) | 13,800 | WINGSPAN (M) | 60.93 |
| MAX. TAKE-OFF WEIGHT (KG) | 297,560 | PERSONAL INFLIGHT ENTERTAINMENT | |

## McDonnell Douglas MD-11

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 7 | MAXIMUM PASSENGERS | 285 |
| CRUISING SPEED (KM/H) | 890 | TOTAL LENGTH (M) | 61.21 |
| RANGE (KM) | 11,000 | WINGSPAN (M) | 51.66 |
| MAX. TAKE-OFF WEIGHT (KG) | 280,320 | PERSONAL INFLIGHT ENTERTAINMENT | |

## Airbus A330-200/300

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 11/5 | MAXIMUM PASSENGERS | 243/292 |
| CRUISING SPEED (KM/H) | 880/880 | TOTAL LENGTH (M) | 58.37/63.69 |
| RANGE (KM) | 9,800/9,800 | WINGSPAN (M) | 60.30/60.30 |
| MAX. TAKE-OFF WEIGHT (KG) | 230,000/233,000 | PERSONAL INFLIGHT ENTERTAINMENT | |

## Boeing 737-900

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 5 | MAXIMUM PASSENGERS | 188 |
| CRUISING SPEED (KM/H) | 850 | TOTAL LENGTH (M) | 42.12 |
| RANGE (KM) | 4,300 | WINGSPAN (M) | 35.80 |
| MAX. TAKE-OFF WEIGHT (KG) | 78,000 | | |

## Boeing 737-800

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 23 | MAXIMUM PASSENGERS | 174 |
| CRUISING SPEED (KM/H) | 850 | TOTAL LENGTH (M) | 39.47 |
| RANGE (KM) | 4,200 | WINGSPAN (M) | 35.80 |
| MAX. TAKE-OFF WEIGHT (KG) | 73,750 | | |

## Boeing 737-700

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 18 | MAXIMUM PASSENGERS | 132 |
| CRUISING SPEED (KM/H) | 850 | TOTAL LENGTH (M) | 33.64 |
| RANGE (KM) | 3,500 | WINGSPAN (M) | 35.80 |
| MAX. TAKE-OFF WEIGHT (KG) | 64,000 | | |

## Embraer 190

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 22 | MAXIMUM PASSENGERS | 100 |
| CRUISING SPEED (KM/H) | 850 | TOTAL LENGTH (M) | 36.25 |
| RANGE (KM) | 3,300 | WINGSPAN (M) | 28.72 |
| MAX. TAKE-OFF WEIGHT (KG) | 45,000 | | |

## Fokker 70/100

| | | | |
|---|---|---|---|
| NUMBER OF AIRCRAFT | 26/1 | MAXIMUM PASSENGERS | 80/100 |
| CRUISING SPEED (KM/H) | 743/743 | TOTAL LENGTH (M) | 30.91/35.53 |
| RANGE (KM) | 2,400/2,400 | WINGSPAN (M) | 28.08/28.08 |
| MAX. TAKE-OFF WEIGHT (KG) | 38,000/44,400 | | |

*Fleet Intranet Overview 28 Feb 2015
KLM Group

# Future Fleet

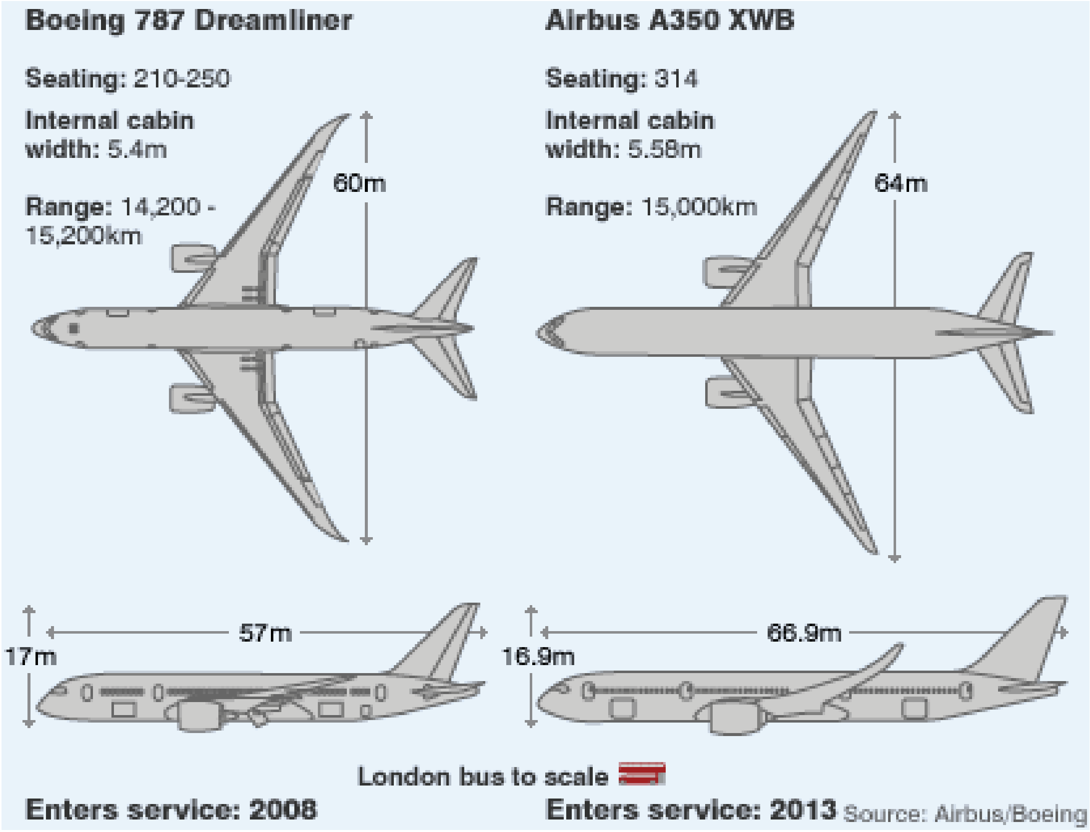
## Future fleet KLM

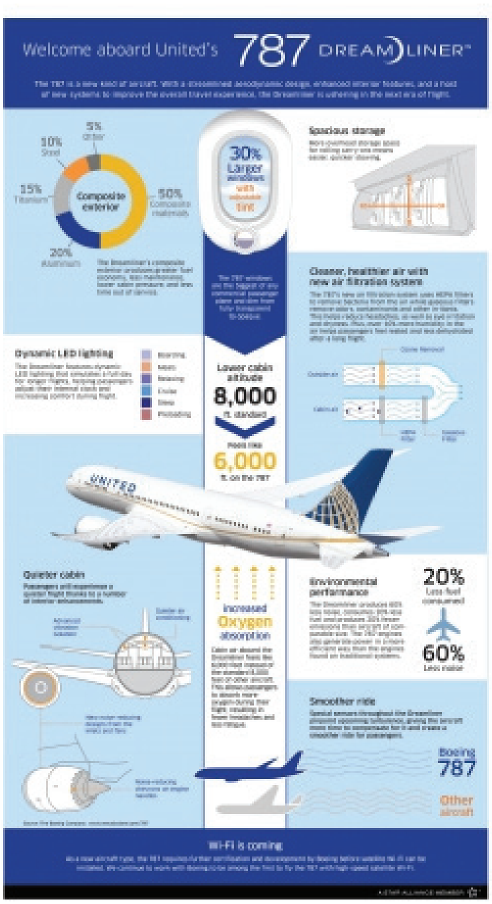
| KLM-vloot | | | | | | | |
|---|---|---|---|---|---|---|---|
| Toestel | Totaal | Orders | Passagiers | | | | Opmerkingen |
| | | | Business Class | Economy Comfort | Economy | Totaal | |
| Airbus A330-200 | 11 | 0 | 30 | 31 | 182 | 243 | Uit dienst: 2016 (4) |
| Airbus A330-300 | 5 | 0 | 30 | 40 | 222 | 292 | |
| Airbus A350-900 | 0 | 7 | (nog) niet bekend | | | | Verwachte ingebruikname: 2020 (3), 2021 (2), 2022 (2) |
| Boeing 737-700 | 18 | 0 | 20 | 12 | 90 | 122 | |
| Boeing 737-800 | 25 | 0 | 20 | 24 | 120 | 164 | |
| Boeing 737-900 | 5 | 0 | 28 | 18 | 132 | 178 | |
| Boeing 747-400 | 7 | 0 | 35 | 36 | 337 | 408 | Uit dienst: 2016 (1), 2017 (1) |
| Boeing 747-400M | 14 | 0 | 35 | 36 | 197 | 268 | Uit dienst: 2016 (4), 2017 (4) |
| Boeing 777-200ER | 15 | 0 | 35<br>34 | 34<br>40 | 249<br>242 | 318<br>316 | "Oude" indeling<br>"Nieuwe" indeling[8] |
| Boeing 777-300ER | 10 | 4 | 35<br>34 | 40<br>40 | 350<br>334 | 425<br>408 | "Oude" indeling<br>"Nieuwe" indeling. Verwachte ingebruikname: 2016 (2), 2017 (2) |
| Boeing 787-9 | 2 | 13 [9] | 30 | 48 | 216 | 294 | Verwachte ingebruikname: 2016 (6), 2017 (2), 2018 (1), 2019 (1), 2022 (1), 2023 (1), 2024 (1)[bron?] |
| Boeing 787-10 | 0 | 6 [9] | 38 | 36 | 264 | 338 | Verwachte ingebruikname: 2020 (3), 2021 (3) |
| KLM Cargo-vloot | | | | | | | |
| Boeing 747-400ERF | 3 | 0 | 112.760 kg | | | | Geleased aan Martinair Cargo |
| Totaal | 115 | 30 | | | | | |

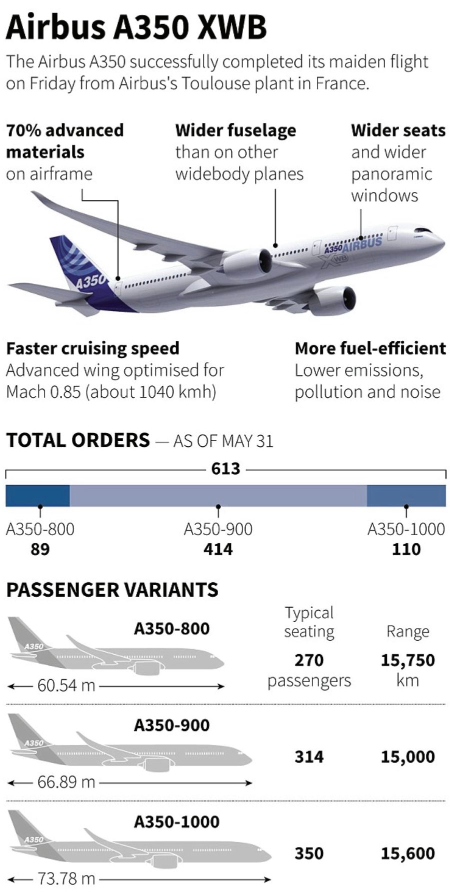
## Specifications A350 en 787 (new in fleet in future)

| | A350 XWB | | | | | Ter vergelijking | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | -800 [1] | -900 [2] | -1000 | -900R[3] | -900F | 787-9 | 787-10 | 777-300ER[4] | 777-200LR | 777-200F |
| Lengte | 60,54 m | 66,89 m | 73,78 m | 66,89 m | | 63,0 m | 68,9 m | 73,9 m | 63,7 m | |
| Hoogte | 17,05 m | | | | | 16,5 m | 17,0 m | 18,7 m | 18,8 m | 18,6 m |
| Spanwijdte | 64,75 m | | | | | 60,1 m | | 64,8 m | | |
| Vleugelhoek | 31,9° | | | | | 32,2° | | 31,64° | | |
| Rompbreedte | 5,96 m | | | | | 5,74 m | | 6,19 m | | |
| Romphoogte | 6,09 m | | | | | 5,97 m | | 6,19 m | | |
| Passagiers (3 klassen) | 276 | 315 | 350 | 315 | 90t vracht | 263 | 323 | 365 | 301 | 103t vracht |
| LD3-containers | 26 | 36 | 44 | 36 | | 36 | 44 | | 32 | |
| Startgewicht (t) | 259,0 | 268,0 | 308,0 | | | 250,836 | 251 | 351,534 | 347,452 | 347,450 |
| Landingsgewicht (t) | 182,5 | 202,5 | 225,5 | | | 183,7 | 197,3 | | | |
| Leeggewicht (t) | | | | | | 115,3 | 125 | 167,8 | 145,2 | |
| Max. brandstof (l) | 138.000 | | 156.000 | | | 138.700 | 145.000 | 181.280 | 202.287 | 181.280 |
| Kruissnelheid (M) | 0,85 | | | | | 0,85 | | 0,84 | | |
| Max. snelheid (M) | 0,89 | | | | | 0,89 | | | | |
| Stuwkracht (lb) (x 2) | 75.000 | 87.000 | 97.000 | 95.000 | | 71.000 | 76.000 | 115.300 | | |
| Motoren | RR Trent XWB of GE GEnx[5] | | RR Trent XWB | | | RR Trent 1000 of GE GEnx-1B | | GE90-115B | | |
| Bereik (km) | 15.730 | 15.540 | 15.360 | 17.600 | 9.250 | 15.700 | 13.000 | 14.630 | 17.445 | 9.065 |
| Prijs (mln US$) | 254,3 | 287,7 | 332,1 | n.n.b. | n.n.b. | 249,5[6] | 288,7 | 320,2 | 296,0 | 300,5 |

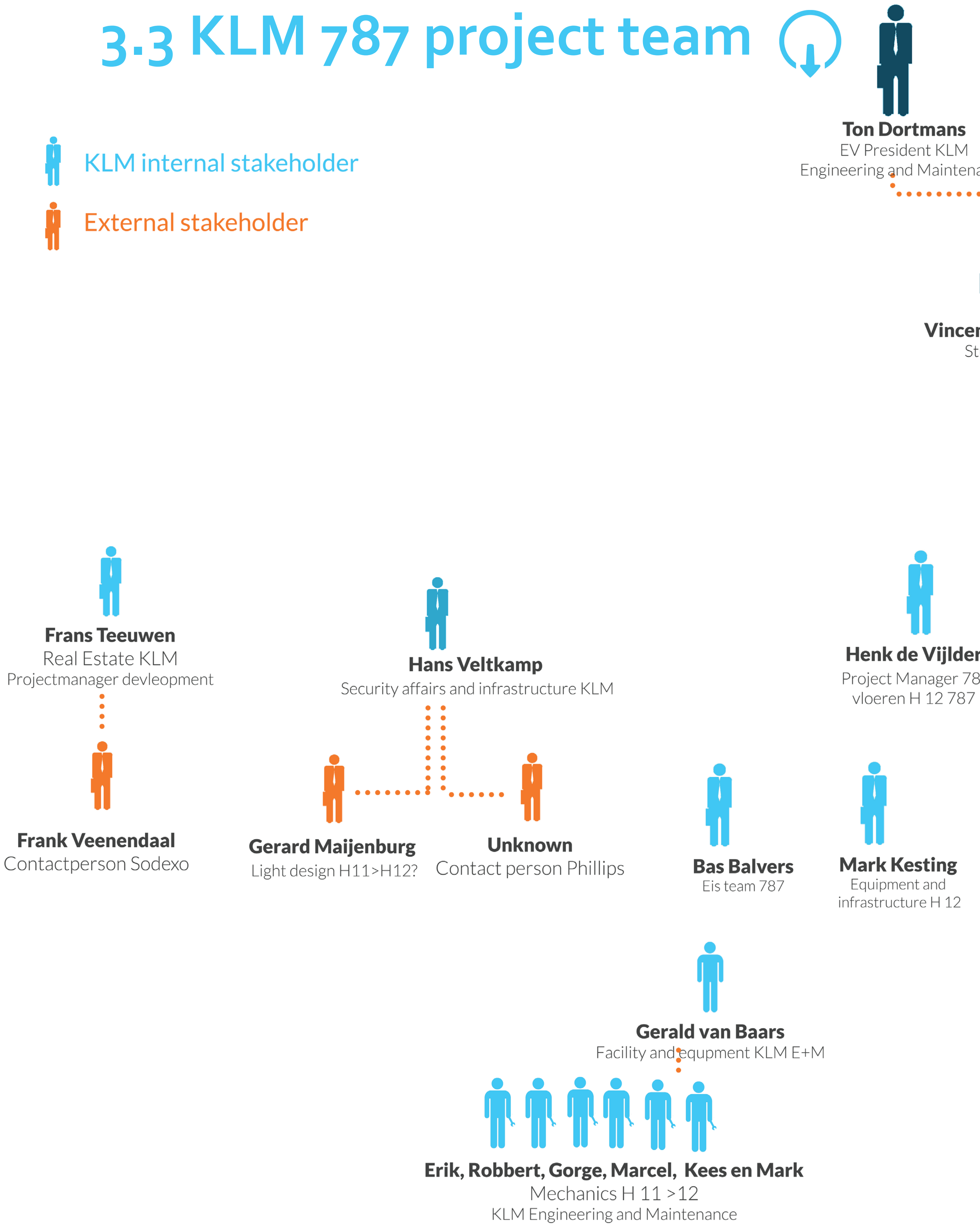
## Measurements aircraft of the future fleet



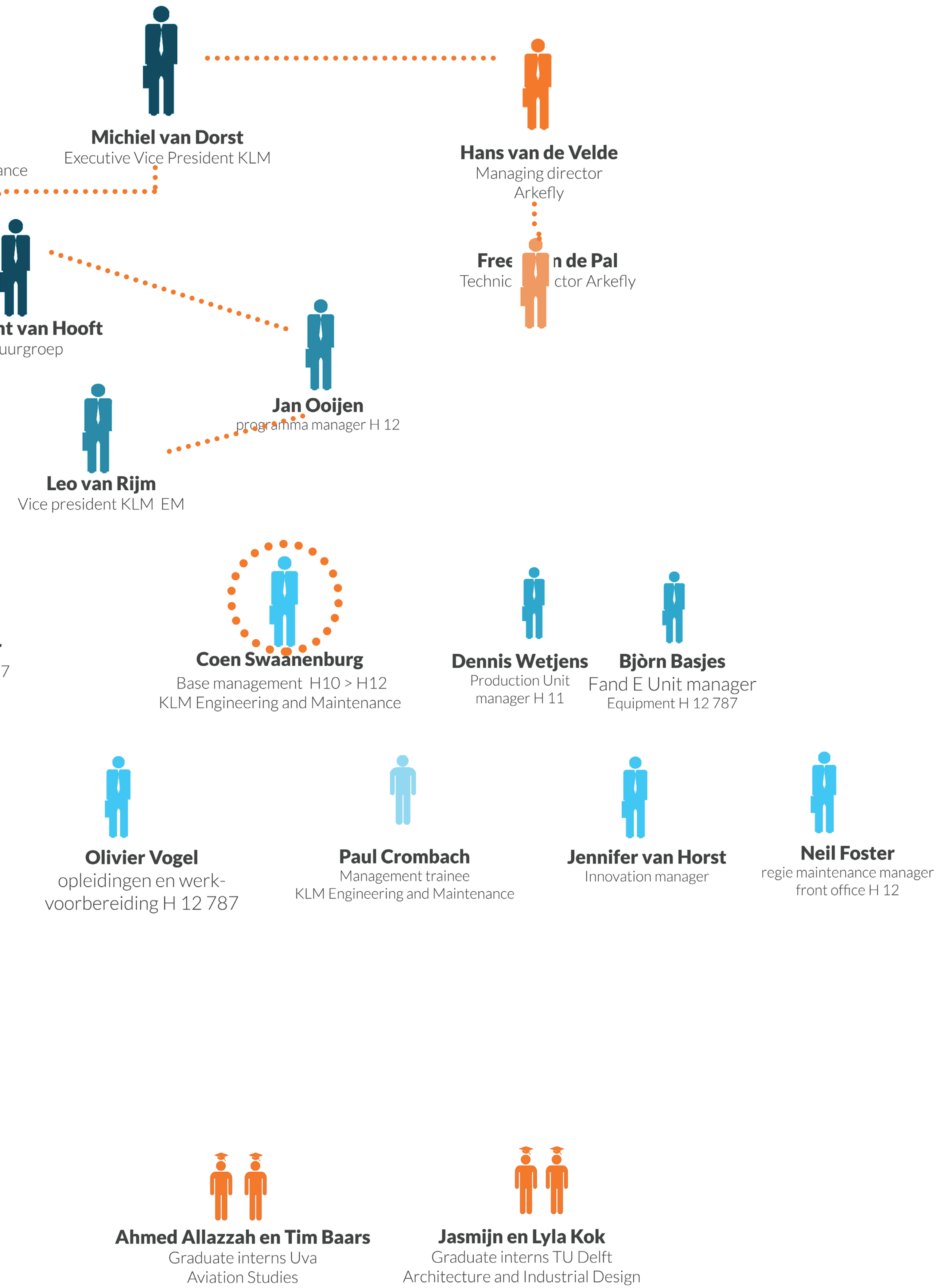



# 3.3 KLM 787 project team




Image± Air France-KLM network from the Hub of CDG © Corporate Air France
http://www.klm.com/corporate/en/aboutklm/airfranceklm/index.html


Michiel van Dorst
Executive Vice President KLM
ance
Hans van de Velde
Managing director
Arkefly
Free n de Pal
Technic ctor Arkefly
nt van Hooft
uurgroep
Jan Ooijen
programma manager H 12
Leo van Rijm
Vice president KLM EM
7
Coen Swaanenburg
Base management H10 > H12
KLM Engineering and Maintenance
Dennis Wetjens
Production Unit
manager H 11
Bjòrn Basjes
Fand E Unit manager
Equipment H 12 787
Olivier Vogel
opleidingen en werk-
voorbereiding H 12 787
Paul Crombach
Management trainee
KLM Engineering and Maintenance
Jennifer van Horst
Innovation manager
Neil Foster
regie maintenance manager
front office H 12
Ahmed Allazzah en Tim Baars
Graduate interns Uva
Aviation Studies
Jasmijn en Lyla Kok
Graduate interns TU Delft
Architecture and Industrial Design

# 3.4 Brainstorm sessions

Part of the research is to join in on lean sessions and brainstorm sessions that are held at KLM. The reason they are organized is that KLM is now working on the renovation plans for Hangaar 12. In order to realise this renovation in the best way, the imput from the employees is required.

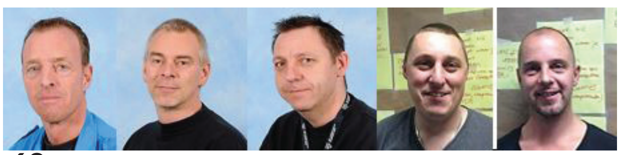
THE TEAM

The brainstormsessions are lead and organized by Jeniffer van der Horst. Together with a group of mechanics but also employees from the engineering and communication departments we think about the opportunities that this renovation offers. Management is also involved and the ideas that come out of these sessions will be presented tot the top management of Engineering and Maintenance in order to get money to implement them.

SESSIONS

The sessions were organised every friday during 5 weeks. Then an "innovation week" followed where the different KLM innovation teams gave an update of what they were doing in order to inspire the team. From now on every friday will be used again to develop the ideas further and actually implement them.

We started from dreams without limitations, do we even need a hangar was the question that was posed. Then the ideas were rated on feasebility and imact. The ideas with high impact and easy to implement were placed on the planning that you see on the right.



Discussed topics in Brainstorm sessions

Opportunities

● Paperless taskcard system

Ton Dortmans and Coen Swaanenburg want to get rid of the paper system that is perceived as " old fashion" by both management and hangar workers.
However what sort of product could replace it is not clear yet

● Equipment at hand

To keep the production line efficient, the men need to be close to the ai rplane, and simply work. Ton Dortman: " they need to have their hands on the plane, no where else". This is something everybody agrees on: the men want to work on the plane, they do not l ike walking long distances to get the tool they need, or searching the enti re hangar for the right equipment. Equipment available also when working on stairs or on docks.

● Floors and light

Light colored floors reflect light. Mechanics can work faster and with less mistakes when they have a wel l lit environment.
The height of the hangar is a problem. Light is needed near the floor of the hangar, and under the wings. Light from the cei l ing as usual is probably not the best solution, but what is remains a question. KLM is cooperating wi th Phillips on the lighting aspect.

● The Front Office is an important faci l i ty for all divisions working on a plane. It's location makes a large di fference in efficiency and the state of mind of the workers.

## Dreams of session 1.

## Session 3 06-03-2015

## Dreams>plans>ranked on feasebility

## High impact easy to implemnt Idea were placed on the project planningline


Brainstorm sessions KLM H12 March - June 2015

# Conclusions Brainstorms

Not all wishes of the mechanics can be solved by architecture or design. Some are organisation related and can be solved by different planning or communication.

However, all the problems that arise now, communication planning etc. Should not exist in the Hangar of the Future. This information is also very useful to know before starting the design of a Hangar.

**Main outcomes brainstorm sessions**

- Daylight + better light in hangar
- 400 Hz cables are really heavy to lift
- Nitrogen car hard to move
- They would like a space to relax outside
- They walk a lot to get materials ( 12K/shift)
- Noise in planningarea> dived areas needed
- They want a good coffee spot
- They want to work on the plane as much as possible
- Efficiencly right now is low> Cleaners + planning
- Waiting times for ordered tools and materials" 3-4 hours because of distances.
- Less tan 9% on time delivery, they do not like picking up other tasks, they just hang around.
- Paperless will arive in 2 years hopefully > improvement

No waitingtime for equipment and material

DAYLIGHT

LESS NOISE!

Sit in the sun

LOGICAL VLEKKENPAN

REALLY WARM IN THE AIRCRAFT

NO WATER ON FLOOR

2016
sept planned completion renovation

WE HAVE TO WALK FAR!

52 years
Average Age KLM Employees

Notification for Buizenpost

QUIET PLANNINGSRUIMTE

Quick Access to tools

LUNCH OUTSIDE

ENOUGH GRIJPVOORRAAD

WE WANT GREENERY

Better artficial lighting during nights

UGLY BUILDING
NOW

DRINK NICE COFFEE

enough parking space
(motors cars bikes)

CABLES FROM THE
FLOOR ARE HEAVY

CLEAN WORKSPACE

Get a better planning
scheme

Less waiting behind the computers

LONG WAITINGTIMES
> MATERIAL AND PLANE

Better communication with Engineerig and IT

# HIglights interviews

"We moeten vooruit kijken ondanks de financiele tijden" Ton Dortmans

Shifts Gerald
- The men work in shi( s of 8,5 hours, 2x 12 min break + 30 min lunch break.
- Many workers bring their own lunch.
- Smoke + coff ee policy  too much not effi ciently used working me.
- Diff erent crew: Avianical men and mechanical men, GWK's senior mechanic on the fl oor checking the work of mechan-ics.

"Boeing 787 will create changes in maintenance and will have large impact on the aviation industry. KLM is preparing for years." Michiel van Dorstit's maintenance hours and maintenance methods.

**"We work on a project that strives for innova-tive outcomes, but at**
**the same  me is bound to strict dead-lines and a practical function" Coen**

"20% of orders are done at the desk, not in the computer" Remco Greefhorst

"The Hangar of the Future en de komst van de 787 worden gebruikt als leverage om te veran-deren" Ton Dortmans

**"We aim for a 5% sick percentage cur-rently 14%"  Wisse van der Gugten**

"Let the mechanics return the buizen from the buizenpost themselves"  Remco Greefhorst

"you can ask AreFly (B787-9) for help

" Hans van de velde Arkefly

"Genx is 6x the length of a regular motor" Arjan otten

"We moeten outside the box kijken en denken" Henk de Vijlder

**"We hebben teveel beton"  Gerald**

"We should match taskcards and tooling, this is already possible" Arjan otten

**"Norm jden vroeger werden bepaald door bij de 747 standaard 24% vd  jd die voor een taak stond "erover heen te gooien" Martin Vink**

**"If you do not want to digitalize you should not work for KLM"  Dortmans**

"Runner has no fixed schedule to make his round and thus creates an unpredictable process"  Remco Greef-horst

**"about 4 on 300 people in the hangar is female"  Gerald**

**"Nog maar zien of die 787 niet ge-woon in H10 wordt gezet ipv 12"  Gerald**

**"Green Horizonlampen, low budget much result"  Hans veldkamp**

Engineering says it will be a great deal the same tools, they will just be used less frequent.  From this I conclude that the maintenance can not diff er that dras cally between a 73 and a

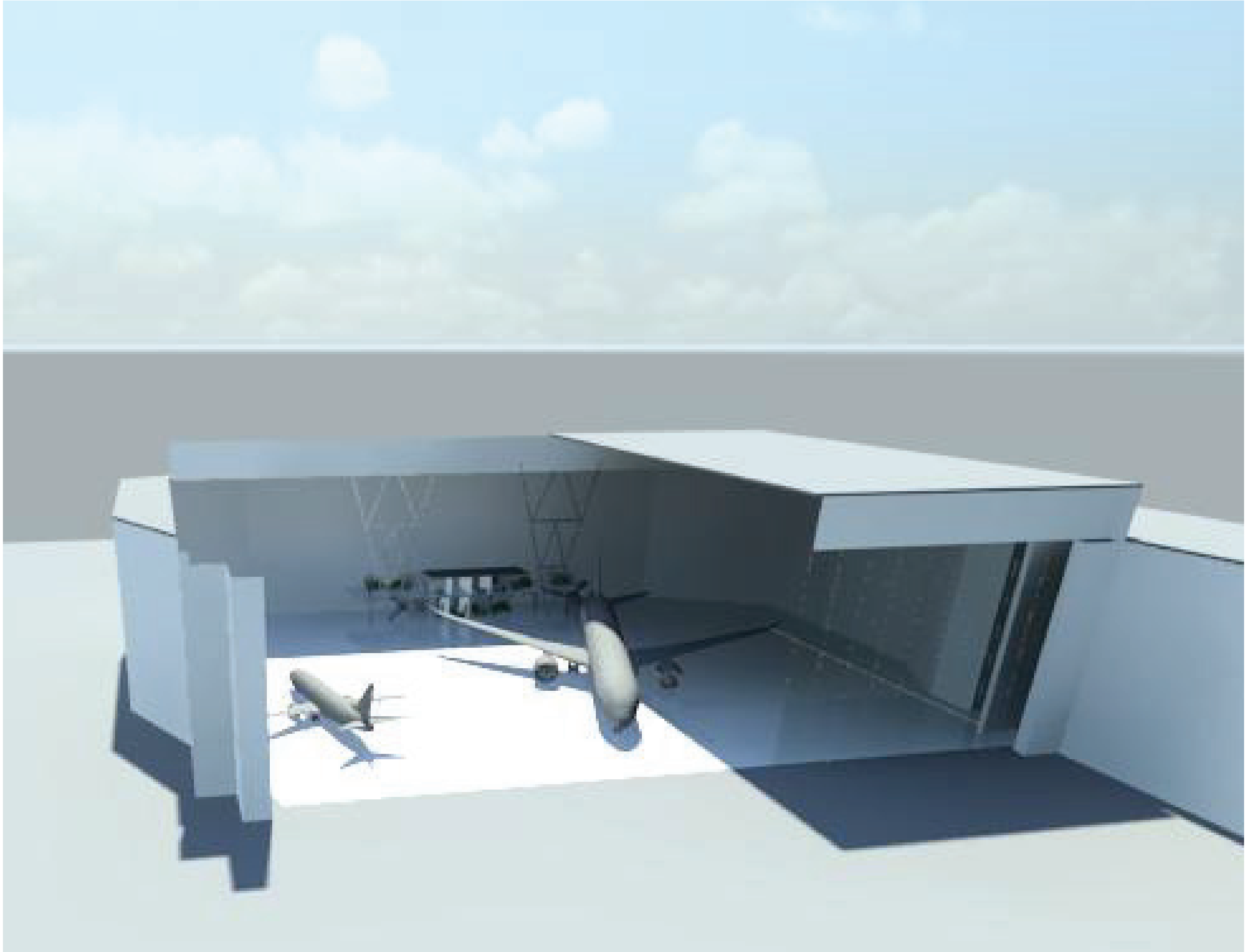
Checks Gerald
- A checks are opera onal 24/7.
- A check takes about 10 hours.
- C checks are mostly only during the day unless the work is behind schedule.
- C checks take about a week to 3 weeks
- All maintenance now on task cards.
- 787 diff erent maintenance, now training group of people.

# Internship Design Hangar 12

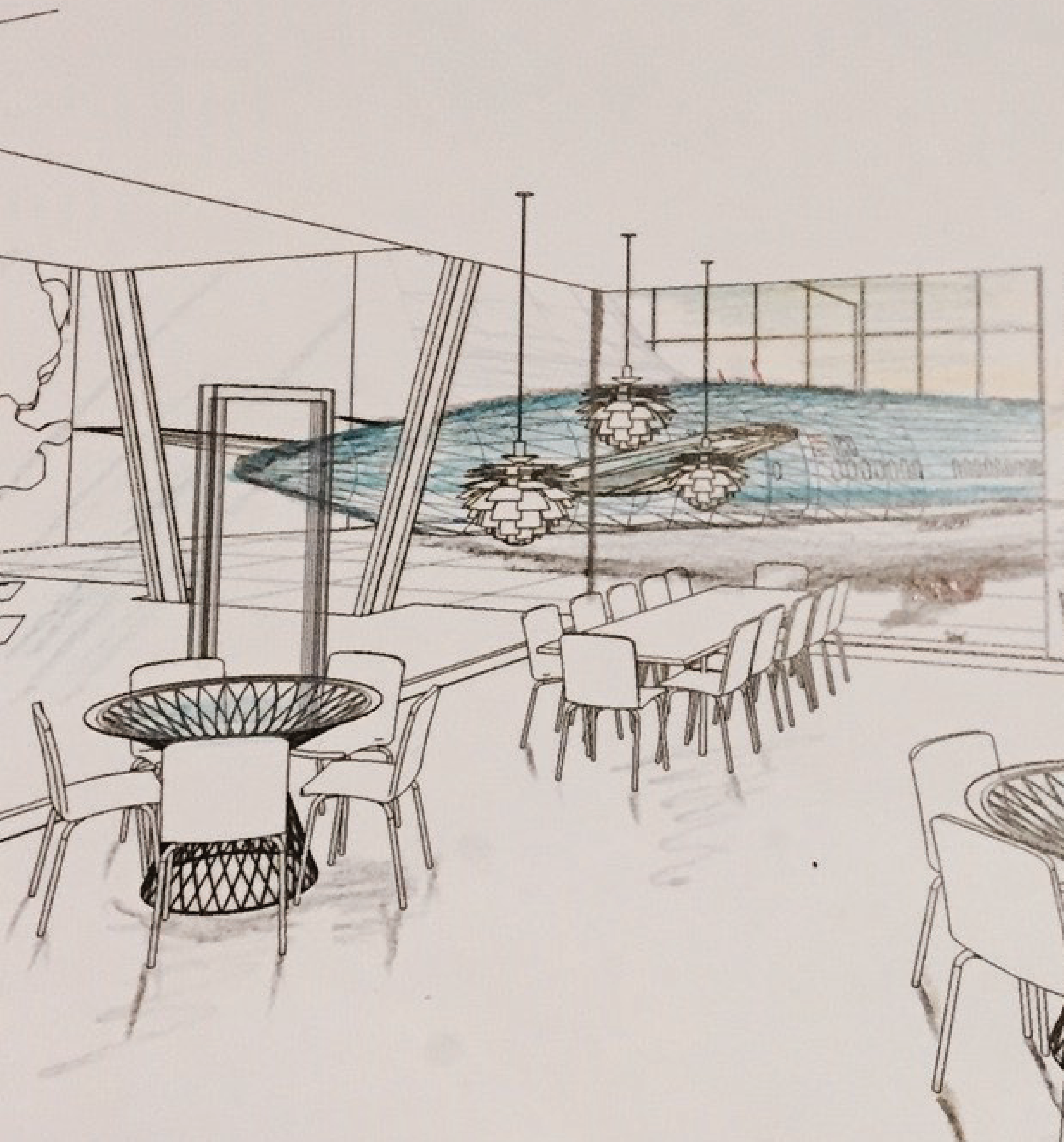

ROKEN


VERBODEN TE ROKEN


PH-BFK
The Flying Dutchman
2 3




VERBODEN
KLM
KLM
KLM
3 4
4 5



# Internship design Outdoor area


Maintenance


DAY

# NIGHT

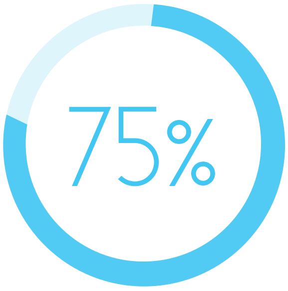
# 4.1 Maintenance

# 4.1 Maintenance

# THE NUMBERS


# Productivity per Hangar

## H10

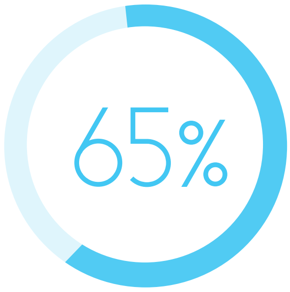



Work planners devide the work in the most efficient way in between the times the aicraft have to be brought to the back. Productivity can be seen as how fast the workers complete the taskcards set for 1 A-check.

## H11


They therfore calculate the time that is needed per task. This is done by using "norm times" from Boeing. Engineers multiply these times with a factor 1.4. The 1.4 factor is neccessary because

## H12

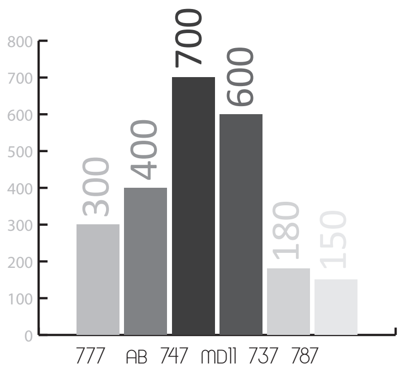


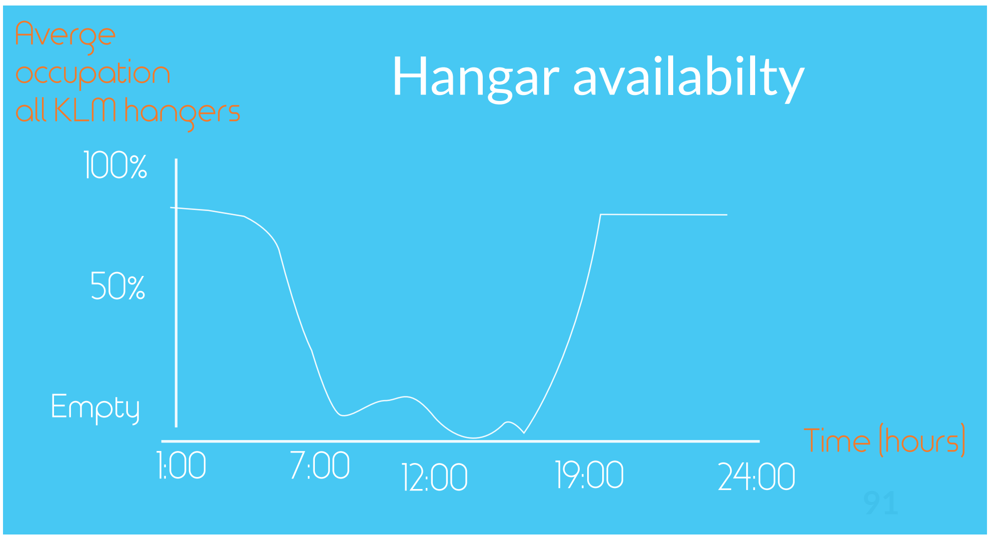

need time for personal hygiene walking to get material and breaks. There is a difference between **task times** and **acces times.** Boing times are clean "task times".

6 out of 8

hours of shift are "productive".

Man hours per type for standard A-check



# Maintenance in general

KLM Engineering & Maintenance is KLM's technical division. It is one of the world's largest workshops for aircraft and has about 5,000 people working around the world. KLM E&M provides technical support to KLM and more than twenty other airlines at more than fifty airports. We will be looking at the different aspects regarding maintenance of aircraft in order to fully understand the needs and demands of a hangar and the work done by the mechanics.
There are three types of maintenance: On Platform, Extensive and Major Overhaul.


## The Hangar

Most aircraft maintenance takes place in hangars. The largest hangar at Schiphol Airport is more than three hundred meters wide, more than a hundred meters from front to back, and about thirty-five meters high. It takes six jumbo jets to fill it up.

Out Hangar, H12 ( Han Luymes , is connected to H11. It has a ground surface of 131x92 m and is 31 m high. You can read more about "our hanger in **"Name Heading, on page..."**

## Maintenance on platform

Aircraft that fly every day get a little bit of maintenance before every flight. This type of maintenance takes place right where the aircraft are standing, out on the platform, so they can get back into the air as quickly as possible. Ground engineers - specialized technicians - give each aircraft a thorough check in a short period of time. They check the components (an aircraft can have over 30,000 components) accoriding to a checklist and to reports from the aircraft crew. An aircraft can not take off without this check and official approval.

http://www.klm.com/corporate/en/aboutklm/profile/index.html

### Extensive Maintenance

Every four or five weeks, every aircraft has to spend a full day in the hangar for extensive maintenance. This includes thorough cleaning of the aircraft cabin. If necessary, mechanics will repair or replace things inside or outside

### Major Overhaul

Evry eighteen months, an aircraft goes into the hangar for a thorough inspection. Then there is the major overhaul, in which technicians take five or six weeks to more or less turn each aircraft inside out. They look


KLM

Robert: " I love troubleshooting, It's my favourite part of the job:  like a puzzle that you have to solve."

## Stock equipment

Stock equipment is larger equipment that is specifically ment for one task. sometimes it consists out of several parts and is kept on moveable trolleys. It is often calibrated and therefor needs to be stored with care. When a tasks demands such a tool, the worker can collect the tool at the stockroom. When showing his id card, the tool is registred at his name in SAP.H When returning it, the tool is deregistred in SAPH.

## Standard equipment

Hammers, screwdrivers, tongs and other small and simply tools are kept in red or blue tool trolleys. The men take their trolley to the aircraft at the beginning of their shift. The idea is that all equipment is near the aircraft when working, which limits walking distances to the stockroom. The trolleys are discharged by (chip) card on name of the specific worker that collects that cart. When a tool is missing, tooling can be quickly refound when checking the that specific worker.

## Hangar equipment

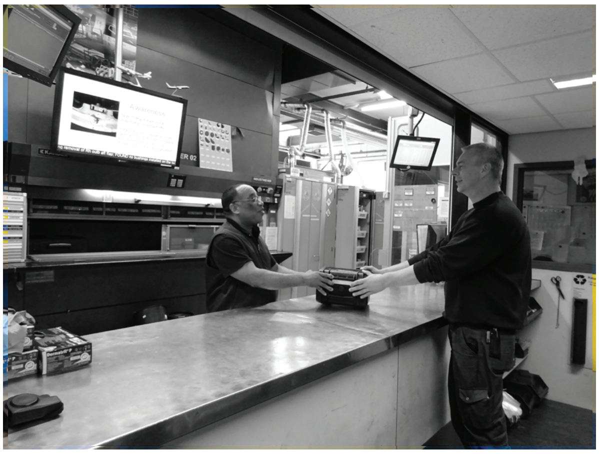
This is all larger equipment that is stored in the hangar itself. Squares marked by yellow lines indicate where the equipment can be placed. Think of stairs, jacks or airco units. These lines are called " vlekkenplan"

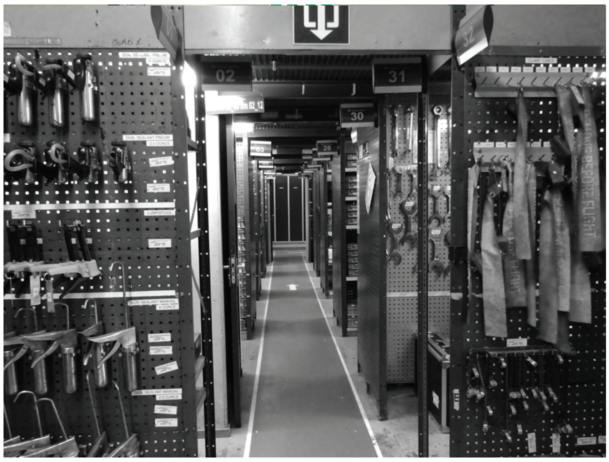
## 100% list

All equipment and materials that are mentioned on the taskcards of that day are assembled in one list: The 100%list. This list contains all equipment that are on the taskcards. In the current situation. This list is checked manually to see wheter all equipment is actually in stock and can be used. This is an immense job ( 45 lists a week). Simply showing what is missing would be more efficient.

# Stock Management

Stockmanagement consist out of three parts: Maintenance of equipment, Calibration of equipment and users/registration of the equipment. Mechanics walk to the equipment stock about 4 times each shift.






**Maintenance of equipment**
Just like all products, equipment wears out after a certain amount of time or use. Equipment needs to be cleaned and lubricated. This is done in the stockroom, by the Hangar Support Group (HSG). When a mechanic misses a tool or finds one damaged, he fills in  damage report form and drops in a specified mailbox. The forms inlcude serial number of the tool and it is than taken care of,

**Defective equipment**
When a tool is defect the men fill in the form mentioned before. By rights, the lead needs to be notefied, so he will take care of fixing antother tool, but often men go to the stockroom themselves because it is less of a hussle. Replacement can be ordered from another hangar. Defective equipment does not happen too often, about once

Ronald: “Equipment management is essential for eficient maintenance, If the tools aren’t there, those boys can’t do their jobs”

**Registration and Ownership**

All equipment is “owened” by somebody. When grabbing a toolcar, the user scans his employeecard and than grabs a key to the tooltrolley from the TRAKA. each new user checks wheter the trolley is complete. Same when getting equipment from the stockroom: stockemployee scans the card and scans the serialcode of the tool. This way all tools are always trackable to a mechanic when lost.

**Transport**

When a tool is not present, it needs to be ordered from another hangar stockroom. This is done by the stock room employee. A runner brings the specific tool to the right hangar. This runner does rounds around the hangards and comes by every 15 minutes. During night shifts there are no runners or too little. In that case, mechanics grab van to get the missing tool themselves.

# Materials

Stockmanagement consist out of three parts: Maintenance of equipment, Calibration of equipment and users/ registration of the equipment.

**Pre ordered materials**
Since many checks always need the same basic materials to complete te planned maintenance, materials are ordered centrally. However 50% of the time, materials are missing or the wrong material is delivered. Matarials are than ordered afterwards which causes waiting time and waste.

**Consumables**
“Verbruiksartikelen” These are materials that you can grab from the “ Bonloze Kast”, think of bolts and screws. They are not integrated in tooltrolleys, but centralized in one board. The board is refilled by runners, but often refill is too slow leaving the boards empty. Mechanics often take too much materials with them because they want to avoid walking up and down when taking too little. They often mis place the remaining items when returning them.

**Serviceables**
“ Gebruiksartikelen” These materials are pre ordered, but when encountering a non-routine, or when something went wrong, the men have to order these materials ( spare parts, tires etc) They are brought by a runner, but often the delivery stands are far from the plane.

**Transport of materials**
Small materials ( bolts, screws etc) are deliverd from the stock room via “buizenpost”. This is the fastest and the cheapest way of moving goods. Disadadvantages of this method are that the GWK’s do not know when their ordered material is delivered, so they have to walk several times up and down to check, and when the system is old or not well maintained, materials get stuck often. Larger materials are brought down by a runner.

**Materials system analysis**
Consumables are ordered in RUMBA,Servicables are in SAPH.

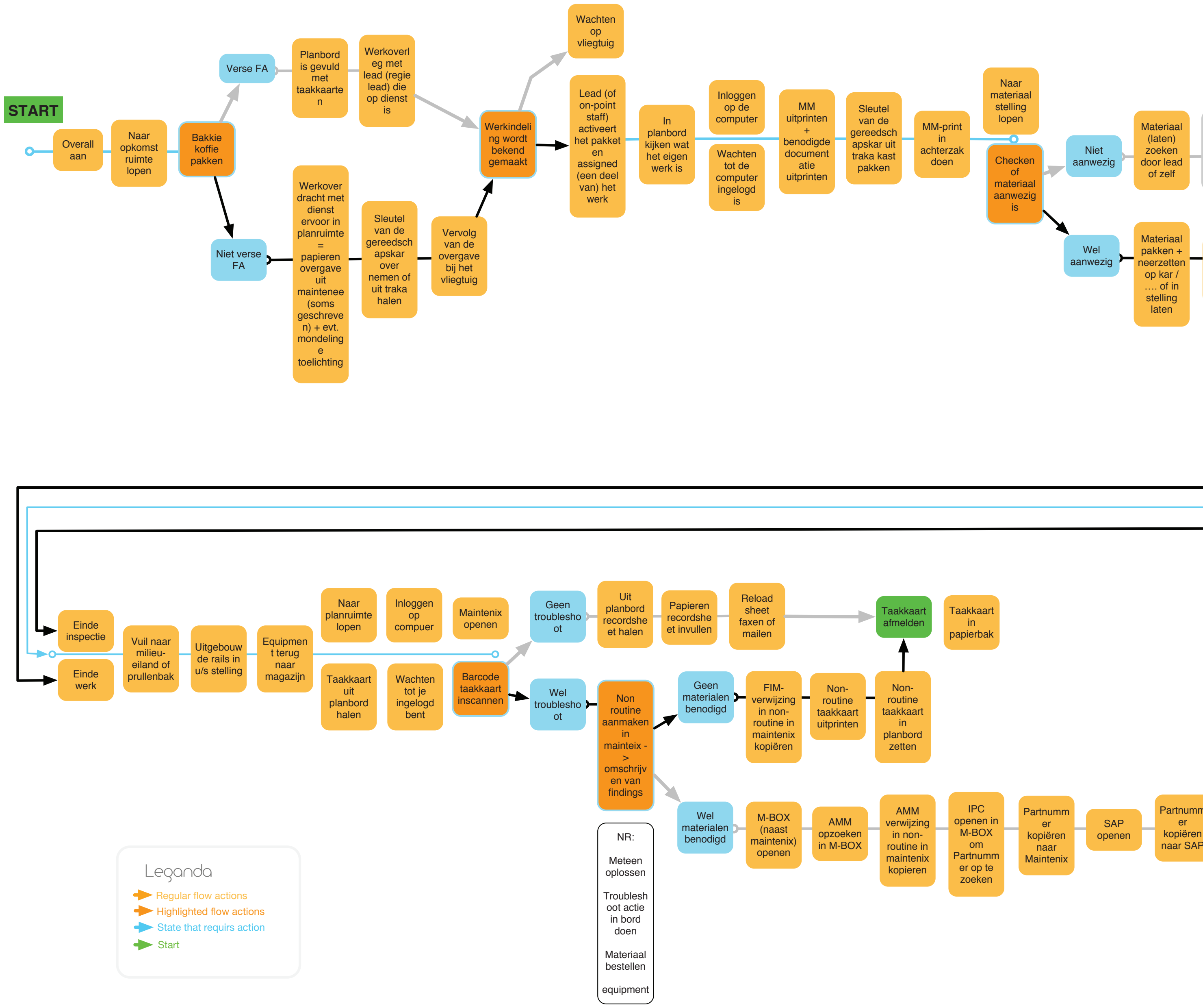
"During night shifts, there are no runners.. So I just go and get my stuff myself. I guess it is less efficient, but I still need that material"

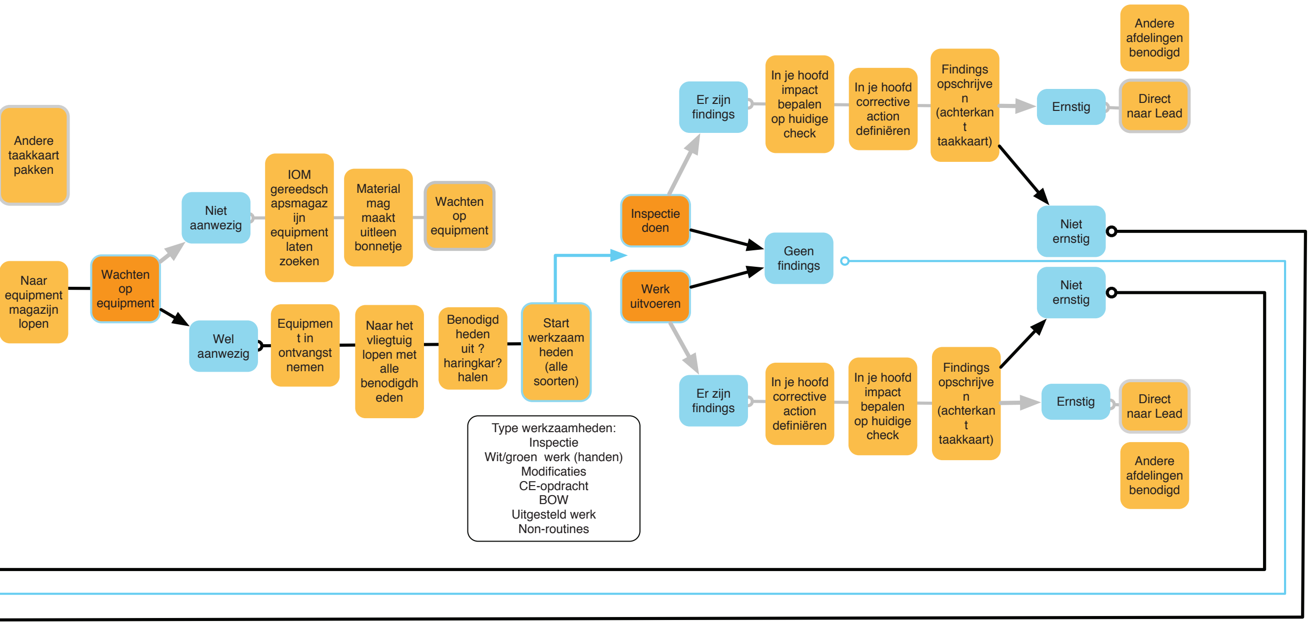

# Flowchart tasks

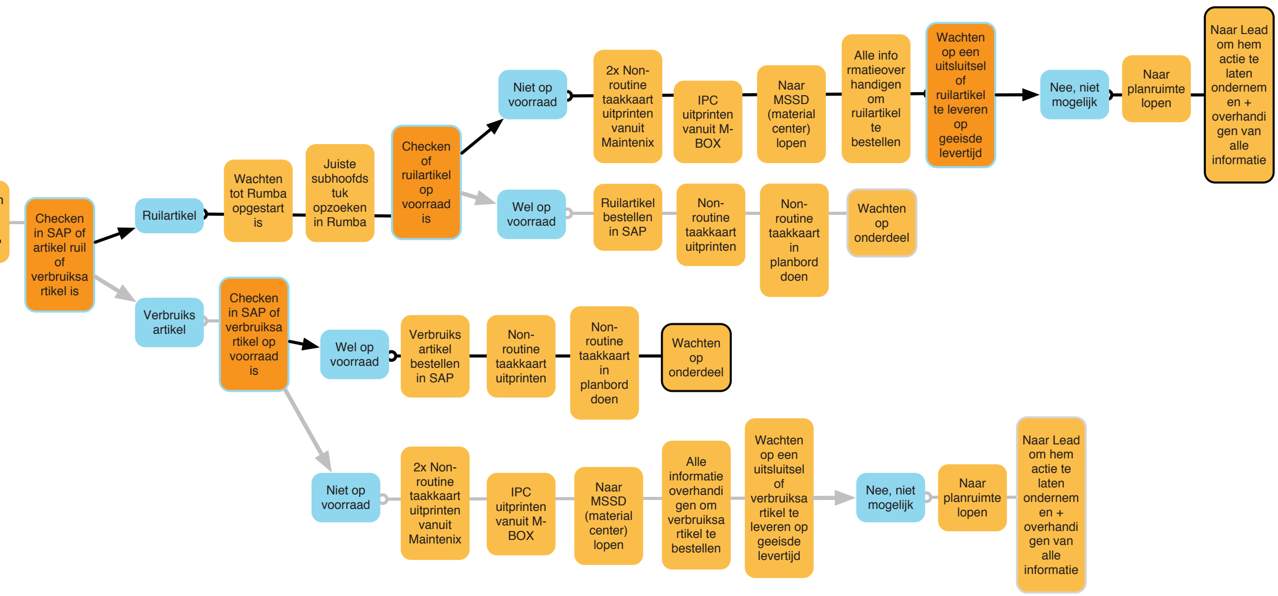
## GWK actions during a general A-check

The flowchart below gives a general overview of the actions executed by a mechanic (GWK) when working on an A-check. The chart starts when putting on an overall to start the eight hour shift, and ends when the shift ends.

The orange blocks represent the actions executed. Dark orange is an action that includes a decision. Blue blocks represent the two possibilties the GWK can encouter, each option has its own color arrow, grey or black. For larger version see appendix.

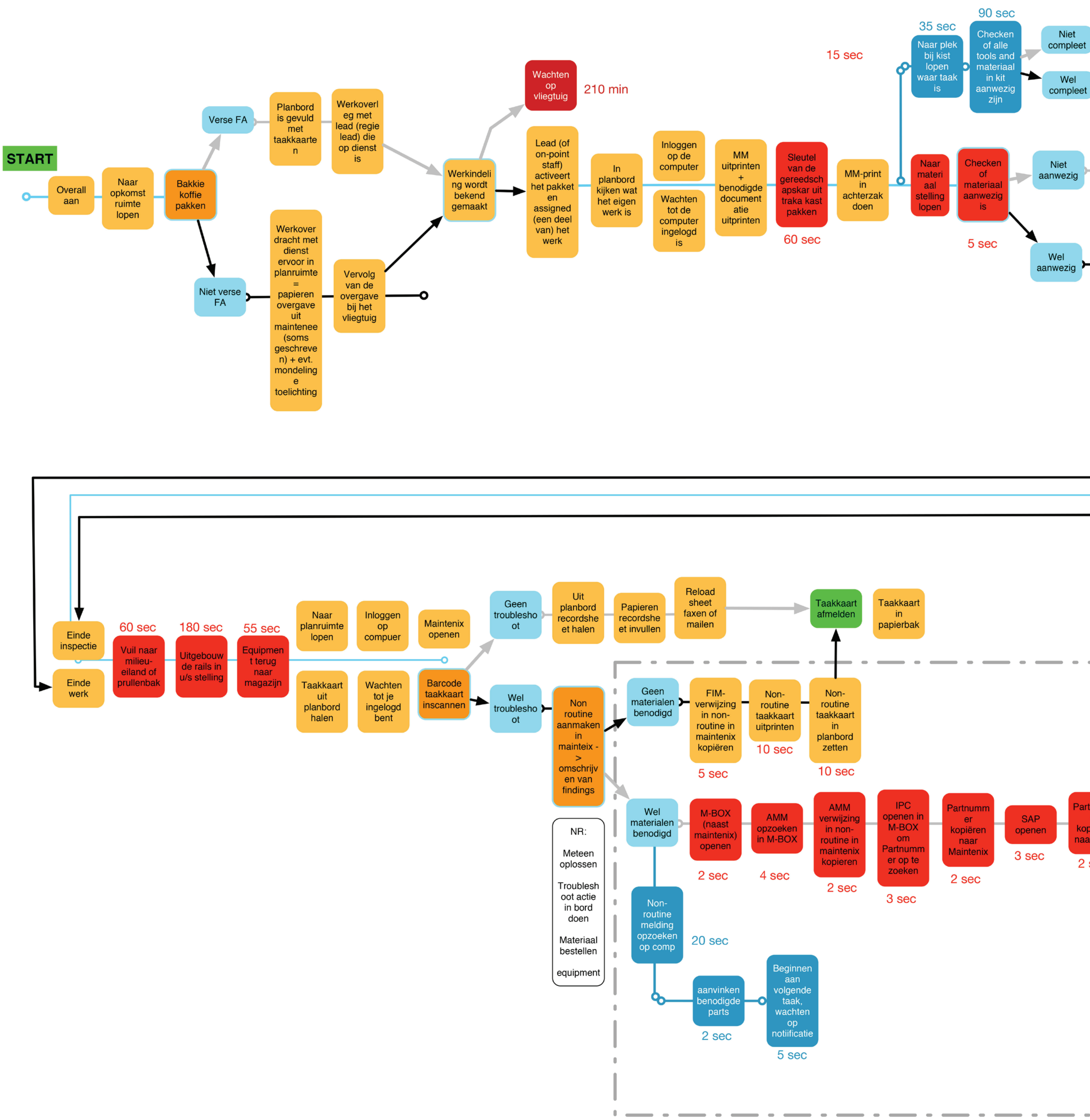


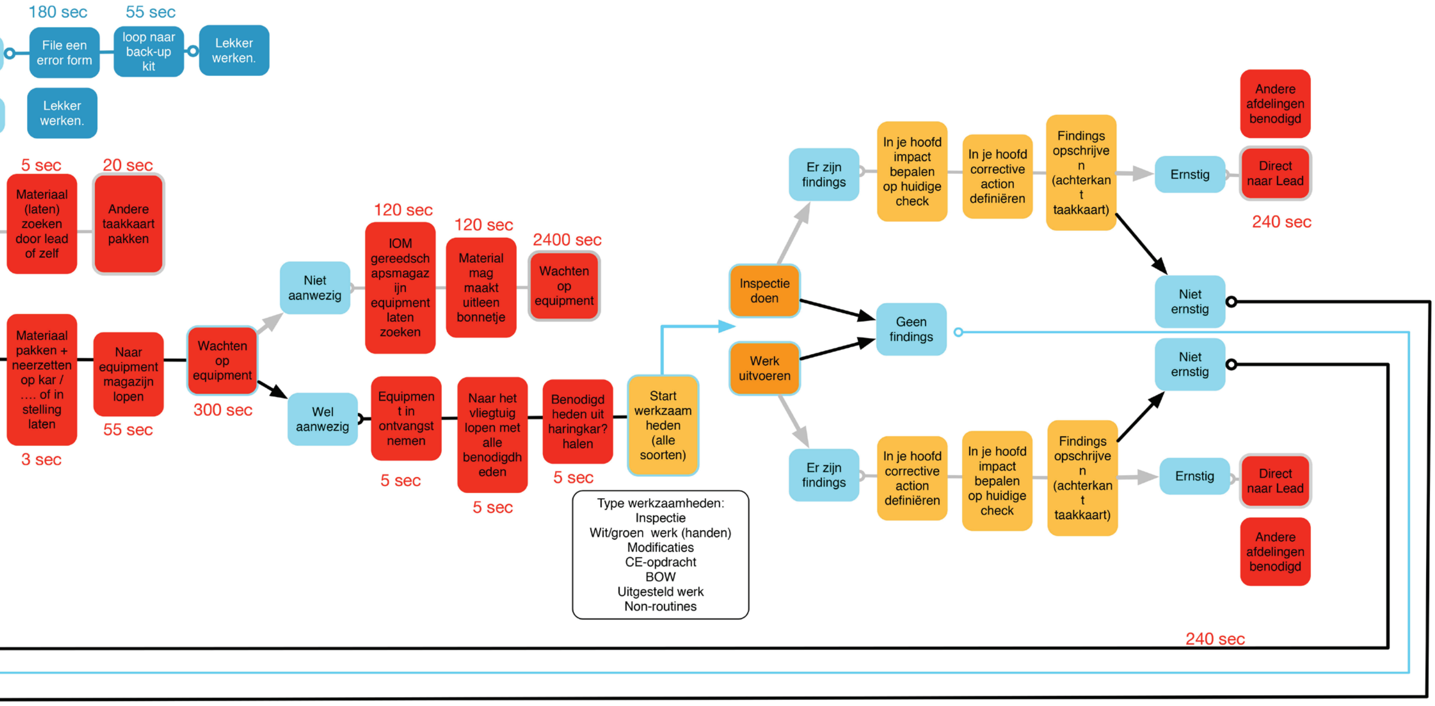

Andere taakkaart pakken
Naar equipment magazijn lopen
Wachten op equipment
Niet aanwezig
IOM gereedschapsmagazijn equipment laten zoeken
Material mag maakt uitleen bonnetje
Wachten op equipment
Wel aanwezig
Equipment in ontvangst nemen
Naar het vliegtuig lopen met alle benodigdheden
Benodigdheden uit ? haringkar? halen
Start werkzaamheden (alle soorten)
Type werkzaamheden:
Inspectie
Wit/groen werk (handen)
Modificaties
CE-opdracht
BOW
Uitgesteld werk
Non-routines
Inspectie doen
Werk uitvoeren
Er zijn findings
In je hoofd impact bepalen op huidige check
In je hoofd corrective action definiëren
Findings opschrijven (achterkant taakkaart)
Ernstig
Andere afdelingen benodigd
Direct naar Lead
Niet ernstig
Geen findings
Er zijn findings
In je hoofd corrective action definiëren
In je hoofd impact bepalen op huidige check
Findings opschrijven (achterkant taakkaart)
Niet ernstig
Ernstig
Direct naar Lead
Andere afdelingen benodigd

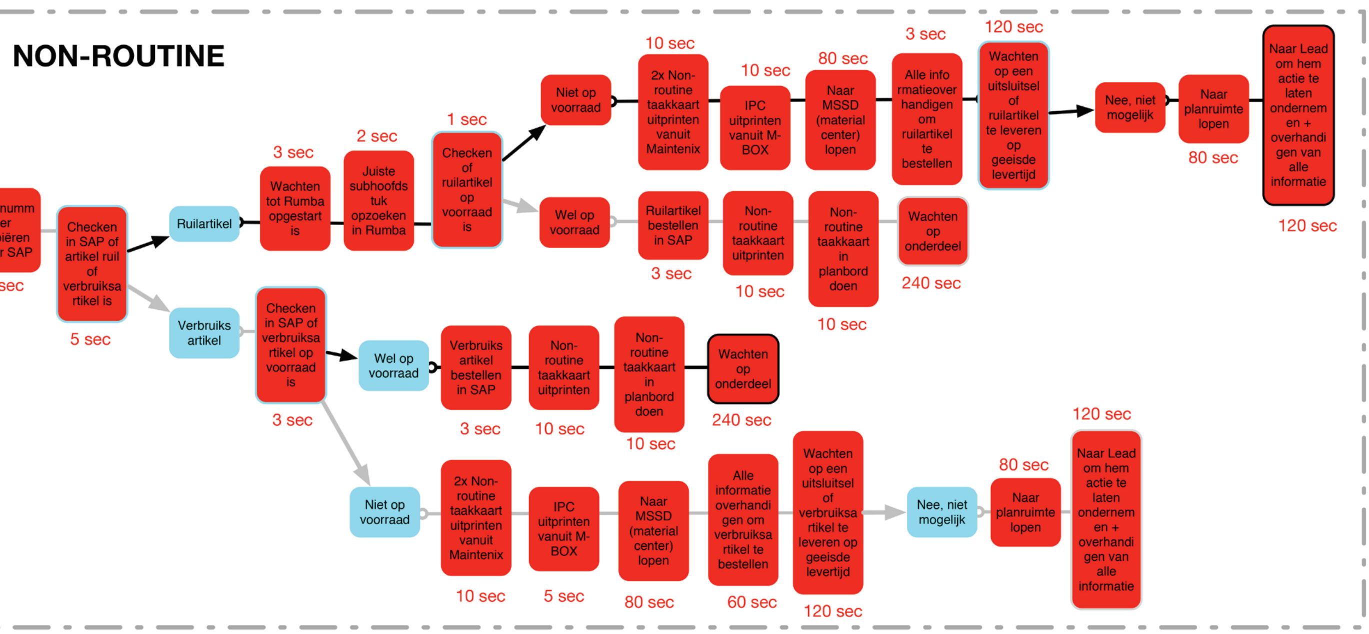

Checken in SAP of artikel ruil of verbruiksartikel is
Ruilartikel
Wachten tot Rumba opgestart is
Juiste subhoofdstuk opzoeken in Rumba
Checken of ruilartikel op voorraad is
Niet op voorraad
2x Non-routine taakkaart uitprinten vanuit Maintenix
IPC uitprinten vanuit M-BOX
Naar MSSD (material center) lopen
Alle informatieoverhandiging om ruilartikel te bestellen
Wachten op een uitsluitsel of ruilartikel te leveren op geeisde levertijd
Nee, niet mogelijk
Naar planruimte lopen
Naar Lead om hem actie te laten ondernemen + overhandigen van alle informatie
Wel op voorraad
Ruilartikel bestellen in SAP
Non-routine taakkaart uitprinten
Non-routine taakkaart in planbord doen
Wachten op onderdeel
Verbruiksartikel
Checken in SAP of verbruiksartikel op voorraad is
Wel op voorraad
Verbruiksartikel bestellen in SAP
Non-routine taakkaart uitprinten
Non-routine taakkaart in planbord doen
Wachten op onderdeel
Niet op voorraad
2x Non-routine taakkaart uitprinten vanuit Maintenix
IPC uitprinten vanuit M-BOX
Naar MSSD (material center) lopen
Alle informatieoverhandigen om verbruiksartikel te bestellen
Wachten op een uitsluitsel of verbruiksartikel te leveren op geeisde levertijd
Nee, niet mogelijk
Naar planruimte lopen
Naar Lead om hem actie te laten ondernemen + overhandigen van alle informatie

# Flowchart tasks

## Waste indicated

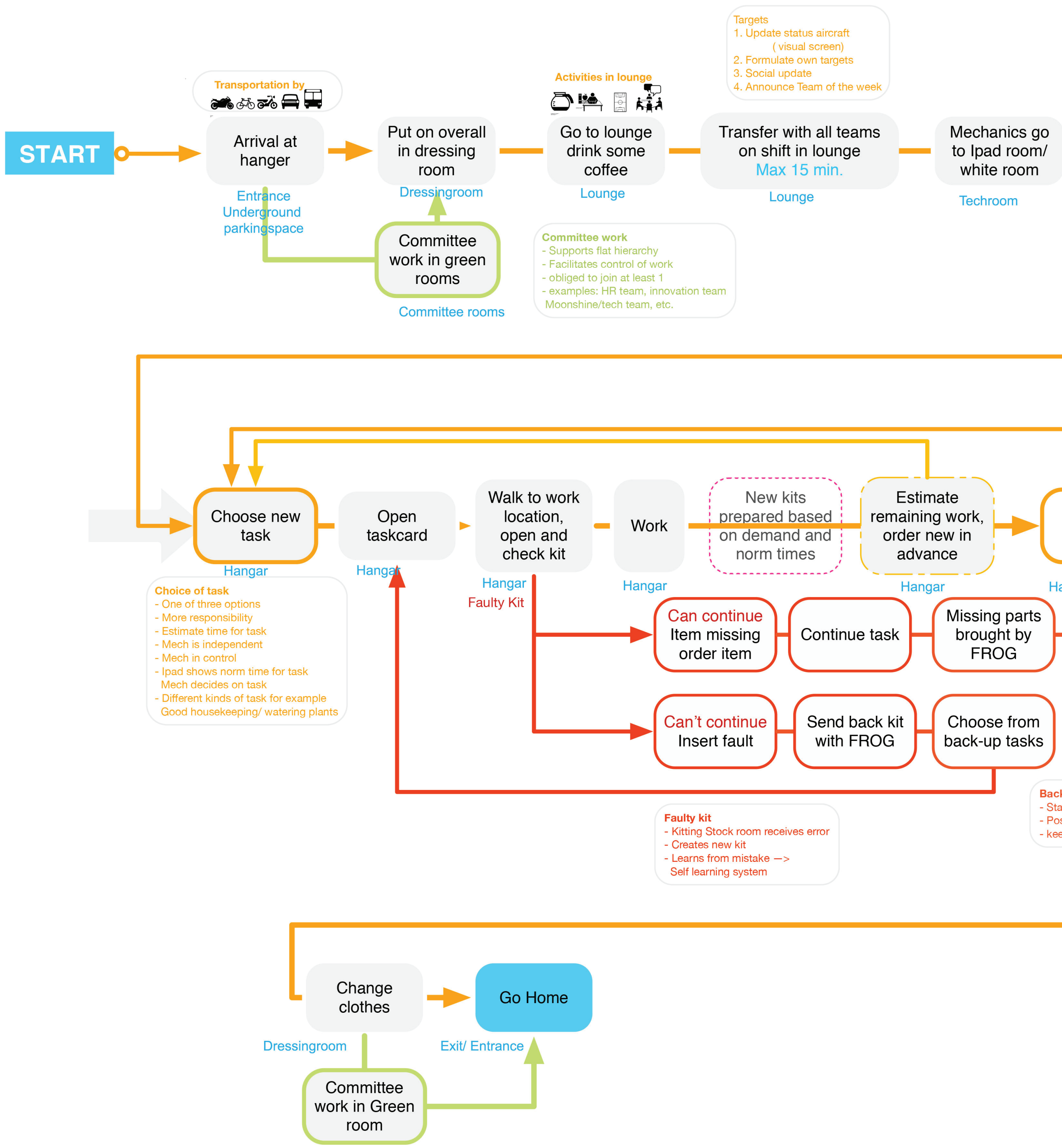


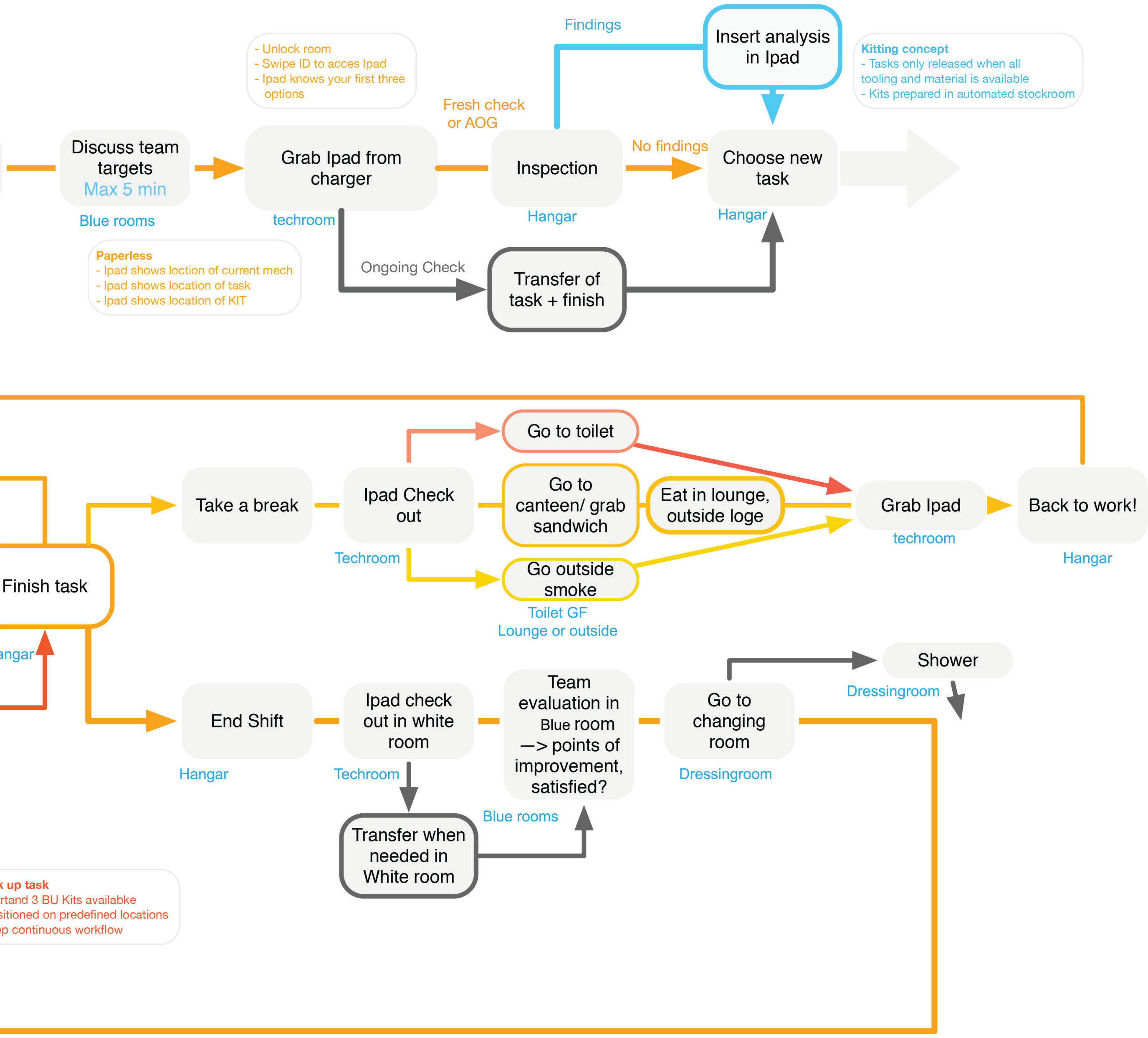

180 sec
55 sec
File een error form
loop naar back-up kit
Lekker werken.
Lekker werken.
5 sec
20 sec
Materiaal (laten) zoeken door lead of zelf
Andere taakkaart pakken
Materiaal pakken + neerzetten op kar / .... of in stelling laten
3 sec
Naar equipment magazijn lopen
55 sec
Wachten op equipment
300 sec
Niet aanwezig
Wel aanwezig
120 sec
IOM gereedschapsmagazijn equipment laten zoeken
120 sec
Material mag maakt uitleen bonnetje
2400 sec
Wachten op equipment
Equipment in ontvangst nemen
5 sec
Naar het vliegtuig lopen met alle benodigdheden
5 sec
Benodigdheden uit haringkar? halen
5 sec
Start werkzaamheden (alle soorten)
Type werkzaamheden:
Inspectie
Wit/groen werk (handen)
Modificaties
CE-opdracht
BOW
Uitgesteld werk
Non-routines
Inspectie doen
Werk uitvoeren
Geen findings
Er zijn findings
In je hoofd impact bepalen op huidige check
In je hoofd corrective action definiëren
Findings opschrijven (achterkant taakkaart)
Ernstig
Andere afdelingen benodigd
Direct naar Lead
240 sec
Niet ernstig
Er zijn findings
In je hoofd corrective action definiëren
In je hoofd impact bepalen op huidige check
Findings opschrijven (achterkant taakkaart)
Niet ernstig
Ernstig
Direct naar Lead
Andere afdelingen benodigd
240 sec


NON-ROUTINE
Checken in SAP of artikel ruil of verbruiksartikel is
5 sec
Ruilartikel
Verbruiksartikel
3 sec
Wachten tot Rumba opgestart is
2 sec
Juiste subhoofdstuk opzoeken in Rumba
1 sec
Checken of ruilartikel op voorraad is
Niet op voorraad
Wel op voorraad
10 sec
2x Non-routine taakkaart uitprinten vanuit Maintenix
10 sec
IPC uitprinten vanuit M-BOX
80 sec
Naar MSSD (material center) lopen
3 sec
Alle informatie overhandigen om ruilartikel te bestellen
120 sec
Wachten op een uitsluitsel of ruilartikel te leveren op geeisde levertijd
Nee, niet mogelijk
Naar planruimte lopen
80 sec
Naar Lead om hem actie te laten ondernemen + overhandigen van alle informatie
120 sec
Ruilartikel bestellen in SAP
3 sec
Non-routine taakkaart uitprinten
10 sec
Non-routine taakkaart in planbord doen
10 sec
Wachten op onderdeel
240 sec
Checken in SAP of verbruiksartikel op voorraad is
3 sec
Wel op voorraad
Verbruiksartikel bestellen in SAP
3 sec
Non-routine taakkaart uitprinten
10 sec
Non-routine taakkaart in planbord doen
10 sec
Wachten op onderdeel
240 sec
Niet op voorraad
2x Non-routine taakkaart uitprinten vanuit Maintenix
10 sec
IPC uitprinten vanuit M-BOX
5 sec
Naar MSSD (material center) lopen
80 sec
Alle informatie overhandigen om verbruiksartikel te bestellen
60 sec
Wachten op een uitsluitsel of verbruiksartikel te leveren op geeisde levertijd
120 sec
Nee, niet mogelijk
Naar planruimte lopen
80 sec
Naar Lead om hem actie te laten ondernemen + overhandigen van alle informatie
120 sec

# Flowchart  of the Future

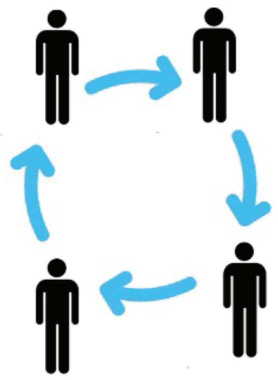
## Rooms specified




Findings
Insert analysis in Ipad
- Unlock room
- Swipe ID to acces Ipad
- Ipad knows your first three options
Kitting concept
- Tasks only released when all tooling and material is available
- Kits prepared in automated stockroom
Fresh check or AOG
Discuss team targets
Max 5 min
Blue rooms
Grab Ipad from charger
techroom
Inspection
Hangar
No findings
Choose new task
Hangar
Paperless
- Ipad shows loction of current mech
- Ipad shows location of task
- Ipad shows location of KIT
Ongoing Check
Transfer of task + finish
Go to toilet
Take a break
Ipad Check out
Techroom
Go to canteen/ grab sandwich
Eat in lounge, outside loge
Grab Ipad
techroom
Back to work!
Hangar
Go outside smoke
Toilet GF
Lounge or outside
Finish task
angar
Shower
Dressingroom
End Shift
Hangar
Ipad check out in white room
Techroom
Team evaluation in Blue room —> points of improvement, satisfied?
Blue rooms
Go to changing room
Dressingroom
Transfer when needed in White room
k up task
rtand 3 BU Kits availabke
sitioned on predefined locations
p continuous workflow

# New Organisation

## Four elements specified

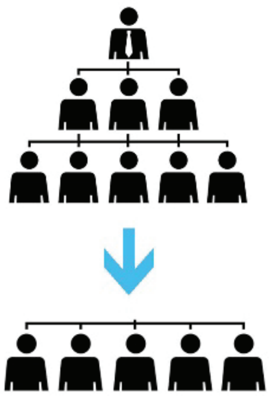


### Transfer of Knowledge : Rotation
Presentation at start of shift " opkomst"

**Circulation of the overall opkomst lead**
Every month a new lead who presents to the complete group of 20 employees what the updates are on the aircraft.
**>> Personal development of the mechanics, flat organisation, respect for the lead and social cohesion.**

**Circulation of the teams**
Every 6 months the teams of about 5-6 people will be mingled again >> strong co-hesion between the large group of employees, nice workenvironment when you know your collgues. This is comparable to the university world where you meet fellow students during projects
**>> Get to know collegues and feel bound and at home at KLM because of the social connections you have. This will make KLM a personal and pleasant wotk environment while operating in a large environment, people and building wise.**

**Circualtion of the team lead during evaluation and start sessions**
The start of shifts and the evaluation should be led by somebody. Otherwise chaos will arrise. THis lead will change every month. This way all team members furfill the lead position once before the teams are circulated again. During the team evalua-tion the focus is on the person and on the day and work progress. Everybody tells how their day was and how their personal situation at home is. Birthdays are cele-brated here and during the " opkomst" in the lounge.
**>> Personal approach and attention in a large environment.**
**>> Personal development, presenting and leading skills**
**>> Respect for the lead and each other within the team**
**>> Commitment to the team, community building**
**>> development and research into most effective work strategy**

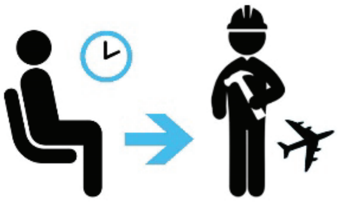


### Flat Hierarchy
The hangar of the future will not have managers and leads. Committees of mechanics will take care of the tasks that are not purely maintenance based. Examples of such activities are selecting and hiring new employees, organising social events and work-ing on intrapreneurship and innovation. Employees will join apart from their regular tasks. Participation in at least one committee is obligated but employees are free and stimulated to join more committees.

**Comittees**
>Social activities committee
> Cook committee (lunch or dinner once or twice a week)
> Innovation committee
> Intrapreneurial committee ( blue box with support for start up ideas)
> Sustainability committee
> HR committee
> Sports and Health committee
> Research and Analysis committee
> New committees can be established after subscription of at least 3 members

**Flat hierarchy and committee system**
> Feeling of freedom trust and responsibility for the employees
> stronger focus on the team that is responsible as a group to deliver on time but is set fre in the way how they want to
> Supports community building> pleasant work environment
> There is also a board that existst out of a representative from every commitee that is larger then 5 employees
> When employees do not obey the rules that are set up in a democratic way they will be called before the board of their own collegues.

## Waiting is bad



Shifts start at defined times and employees spent much time waiting and drinking coffee

**Nobody likes to wait**
>> Not the company not the employees and right now there is lot's of waiting

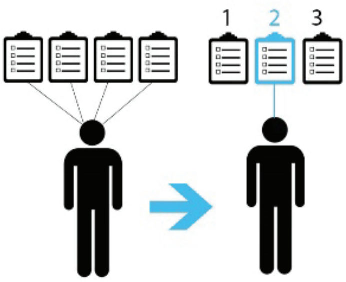
**Sign up for shifts by yourself as employee**
3 weeks on forehand arrivaltimes of aircraft are already available
>> Control, freedom, responsibility, motivation

**Minimum amount of shifts is low**
Employees are free to work more then the minimum they just sunscribe for more shifts. if you do not subscribe the system will do this for the min. hours. Better balance between employees with different wishes. people with cchildren for example can work less. (Theres should be a night/dayshift regulation)
>> Feeling of control and motivation

**Work based hours**
Shifts should be based on the work that has to be done and not based on amount of hours that have to be made.
>> Optimisation of productivity no waste.

## Smart Kitting

Taskcards are linked to kits with matching tools and materials.




**There is no lead who plans in the taskcards**
Taskcards are not predefined and scheduled by the lead on forehand
>> Flexibility and choice
>> Flat hierarchy and less waste, strong feeling of responsibility and control

**Choise in which taskcard to activate**
Mechanics get to choose between 3 different taskcards each time they finish a task
>> Feeling Independent, under control

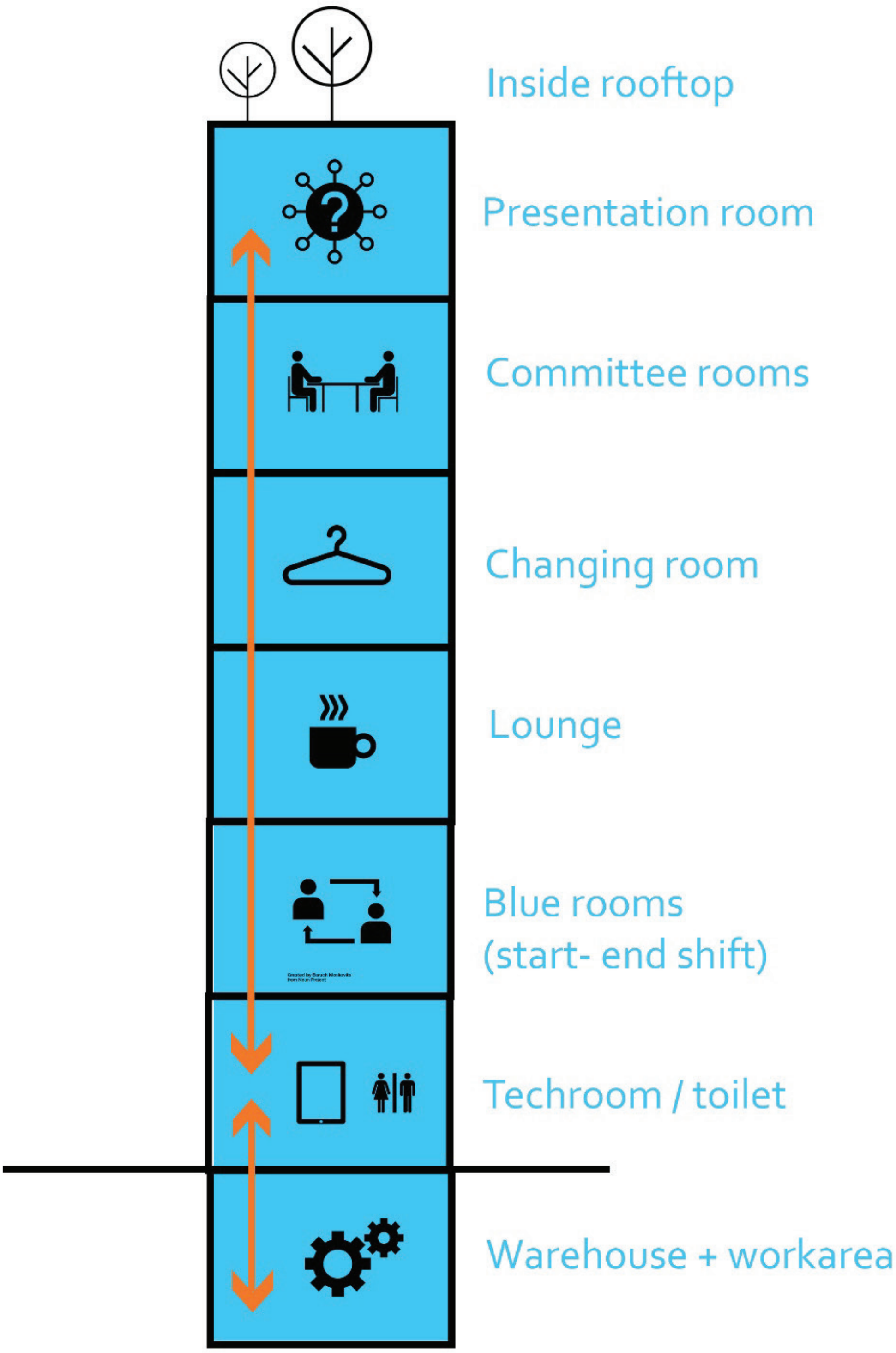
**Small stock**
The kits linked to different taskcards are prepared one by one in stead of preparing all of the kits at once before the start of the shift. This leads to a relatively small and up to date warehouse since material and equipment can be shared
>>Dynamic fast flows, up to date process and positive effect on the cashflow of KLM
>> Mechanics can fill in which tasks they prefer to optimize work pleasure and control
>> Small warehouse with optimised use of tooling equipment and material.

**Timing of taks is possible:**
The computer in the warehouse takes normtimes into account as well as the moments employees need a break and when the end of the shift is. This way breaks can be schedu-aled after completing a taskcard and tascards can be completed before the end of a shift. Finish task before breaks and end of shift
>> Less mistakes when tasks are not abandoned abruptly and feeling of control and completion for the mechanics.

**Housekeeping tasks as relaxation**
The regular taskcards exist purely out of maintenance tasks. As relaxation, also house-keeping tasks such as watering the plants and taking out the trash will be added.
>> These tasks will pop up between the 3 choices once or twice a day dependent of the amount of "regular tasks" .
>> This implementation will leed to a change and surprise effect during the shift which will activate and motivate the employee.
>> The tasks nobody likes to do today are turned into relaxation activities

# Conclusion

**Having performed the research, I understood how the hangar of to-day functions. It was then possible to think what the flowchart of the hangar of the future should look like. In this future the KLM organ-isation would ideally be organised in a different way. This new pro-cess with new organisation and implementation of new technolo-gy such as tablets requires differ-ent spaces and a new flow. This will be taken into account when de-signing the output specifications**


Inside rooftop
Presentation room
Committee rooms
Changing room
Lounge
Blue rooms
(start- end shift)
Techroom / toilet
Warehouse + workarea

# 4.2 CONTEXT IN AVIATION INDUSTRY

Introduction of the new Boeing 747  in 1970 with stewardesses from the different airlines that bought the new model. Source,  klm website.

# 5.1 Context Boeing 787

KLM Royal Dutch Airlines was founded on 7 October, 1919 to serve the Netherlands and its colonies. KLM is today the oldest airline still operating under its original name. KLM has been part of the AIR FRANCE KLM group since the merger in 2004. KLM is the core of the KLM Group, which further includes the wholly-owned subsidiaries KLM Cityhopper, transavia.com and Martinair.

The Boeing 787 Dreamliner was introduced to the public on the 8th of July in 2007 in a roll out ceremony (7/8/7 in American date notation). The plain performed it's first three hour test flight on 15 december 2009 in Everett and was completed in 2011.

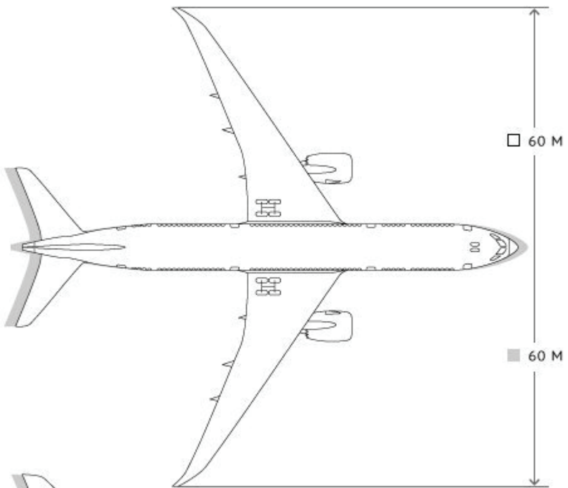
Originally the airplane was planned to be completed in 2008, but several difficulties caused a delay that would take three years. Also, In 2013 problems occurred with the lithium batteries of several 787's and the airplane was not allowed to make any more flights until this problem was investigated and solved. After Boeing completed tests on a revised battery design, the FAA* approved the revised design, and lifted the grounding on April 26, 2013. The 787 returned to passenger service on April 27, 2013 with Ethiopian Airlines.

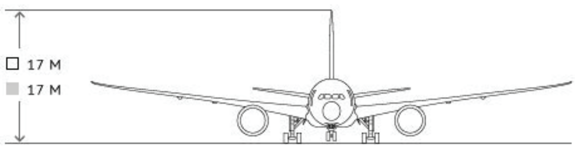
The assembly of the 787 was also innovative, Boeing used subcontractors much more in the process then in previous airplanes. The different parties produce different parts that are joined and integrated in Everett. The location of the factory in Everett was chosen by organising a competition between the different states. Washington has the best entry, and won the competition. **

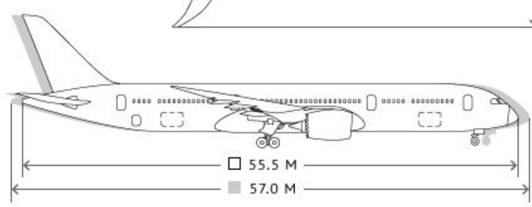
The 787-9 variant was completed in july 2014, this is the type that KLM purchased. The dash nine variant is 6m longer and can fly further than the first series. The first Dutch airline to buy a 787-8 is Arke fly, now KLM follows with the 787-9. The 787-9 offers place for 263 to 282 passengers and the first of 25 airplanes will arrive at Schiphol in september 2015.***

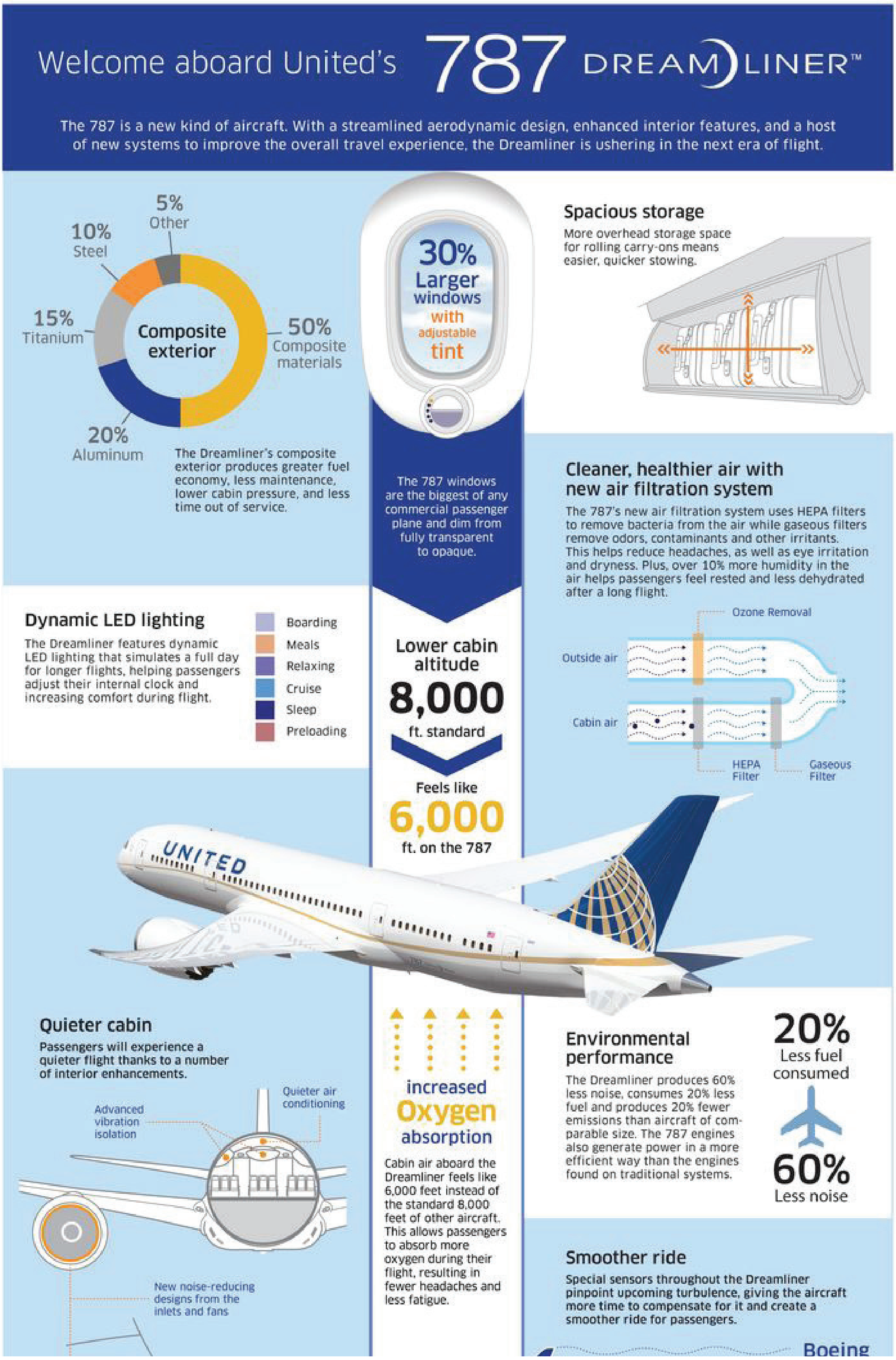
**Modifications**

| BOEING 787-8 | | BOEING 787-9 |
|---|---|---|
| 5.77 | FUSELAGE DIAMETER (M) | 5.77 |
| 154.2 | EMPTY WEIGHT (TONS) | 174.2 |
| 227.9 | MAXIMUM TAKEOFF WEIGHT (TONS) | 250.8 |
| 210–250 | PASSENGER CAPACITY | 250–290 |
| 903 | CRUISE SPEED (KM/H) | 903 |
| 14,200 – 15,200 | RANGE (KM) | 14,800 – 15,750 |
| 13,000 | SERVICE CEILING (M) | 13,000 |
| 2011 | FIRST DELIVERY | 2014 |






Product chart Boeing 787 source The Boeing company newairplane.com-787

* Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA)

** Wagner, M., & Norris, G. (2009). Boeing 787 dreamliner. Zenith Press

***Boeing 787: Orders and Deliveries The Boeing Company. January 2015. Retrieved April 4, 2015.

# 5.2 Boeing 787, 747 and 737

## BOEING 787

The 787 is a wide body airplane, meaning that it has more than one corridor. To be precise, the interior has a capacity of transporting 242 to 335 passengers in a 3 class seating configuration. The Boeing was developed by Boeing Commercial airplanes as a long/range, twin engine midsize jet airliner and it is the most fuel efficient airplane Boeing has built.

One of the reasons it is so efficient is that is it the first airplane to exist out of composite materials, the 787 is 20% more efficient than the 767 it is replacing. Next to that the airplane has mostly electrical flight systems, a four panel windshield and a more aerodynamic design. The assemblage takes place in fabrics in Boeing factories in Everett (washington) and Charleston (South Carolina)

## THE BOEING 747

When Boeing created the 747 in 1970, a new type of airplane was born. This airplane was the first wide-body airplane and from the first commercial flight in 1970 until the introduction of the Airbus A380 in 2007 it was the biggest airplane in the world. At the time Airbus expected that in the near future it would become possible to build supersonic airplanes. Therefore they designed the possibility to transform the 747 into a cargo airplane by increasing it's height and adding a door in the nose of the airplane.

Airbus responded to this 747 by creating the A380 to increase their market share in in the segment of the larger airplanes, in which Boeing previously had a monopoly.

The Airbus A380 with a capacity of between 555 and 853 passenger indeed changed this monopoly position of Boeing . **

## BOEING 737

The Boeing 737 was originally developed as a low cost, short twin engined airliner. It is a short to medium range airplane developed from earlier models such as the 707 and 727. A line of nine airplanes was produces that could carry between 85 to 215 passengers. At the moment the 737 is Boeings only narrow-body airliner in production, the -700, -800, and -900 ER variants are still currently built. Boeing has even redesigned the model, the 737 MAX will be presented in 2017.

The Boeing 737-100 made its first flight in April 1967 and started it's airline service at Lufthansa in 1986 17 After that the longer 737-200 entered airline service in 1968. The -300, -400 and -500 series were presented in the 1980's which lead to the name "Boeing 737 Classic series" These Classics The 737 Classics added capacity and with the CFM56 Turbofan engine and wind improvements these airplanes were considered innovative. The 737 Next Generation existed out of the -600, -700, -800 and -900 versions and the lengths differ from 31 to 42 meters.

As Kinglsey Jones describes: "The 737 series is the best selling jet airliner in the history of aviation" The assembly lines of the 737 are located at the Boeing Renton Factory in Renton, Washington. The aircraft currently competes with the A320 family. ***

# 5.3 The future context

The Boeing 787 is again a response from Boeing to the Airbus A380. But the goal of the 787 was no longer to just build a bigger airplane, things in the aviation industry had changed. Boeing expects that in the future airlines will be more interested in smaller, fuel-efficient airplanes that fly non-stop. They expect more fligths to be without transfers, also called point-to-point flights instead of hub-and-spoke ****

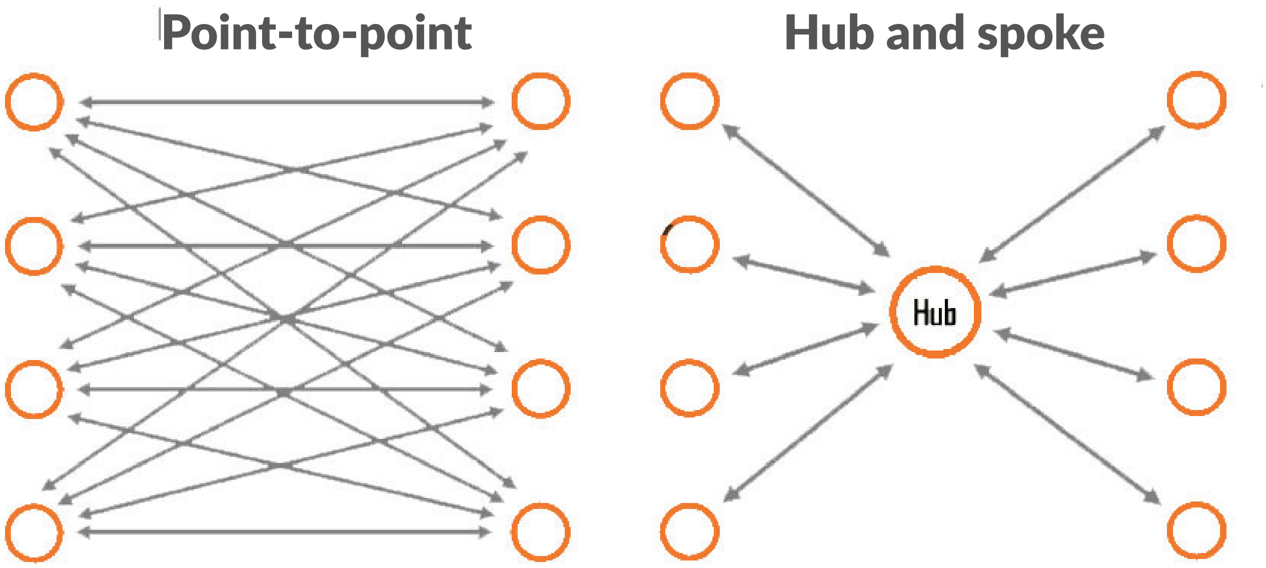
As a reaction to the Boeing 787 Airbus has now started developing the Airbus A350, which will be smaller than A380.

The developments in the aviotion industry are relatively predictible since aircraft are ordered years in advance. This makes it possible to design for the near future.

The changes in the aviation industry, such as type and size of aircraft have an impact on the activities that have to be performed in the hangar and are therefore interesting for analysis : See chapter about the fleet and the external analysis.

Hangar 12 will be the first 787-equipped hangar in the Netherlands in an industry that will contain an increasing amount of this type of aircraft. This creates opportunities that should be considered while designing for the future.

The expectations for the future will be visible in the list of requirements since the hangar has to match the functionalities of the future as well as the functionalities of




Visualisation of difference betweem Point-to-Point en Hub-and-Spoke, https://people.hofstra.edu/geotrans/eng/ch1en/conc1en/hubnetwork.html


* Vetter, J. A., & Board, C. F. S. (2011). US Department of Transportation Federal Aviation Administration.
** A380 superjumbo lands in Sydney. BBC (25 oktober 2007)
***The Boeing 737100/200." Airliners.net, Demand Media, Inc. Retrieved: April 22, 2009.
*** KingsleyJones, M. (2009). 6,000 and counting for Boeing's popular little twinjet. Flight International.
**** Cannegieter, R. (2010). Long Range vs. Ultra High Capacity. Aerlines. nl. Retrieved April, 8.

# 4.3External Analysis B787

## Maintenance

**Airlines currently flying B787's with capacity of a 100% own maintenance ( hangar and equipment capacity )**

- British Airways (part of Boeing Goldcare)
- Lufthanse Technics
- Sabena Technics
- Monarch Aircraft Engineering (part of Boeing Goldcare)
- ANA
- JAL
- United Technical Operations
- KLM

# 5.2 KLM E&M clients

KLM E&M ' s vision is to execute high qualtiy maintenance on blue aircraft.
About 10% of aicraft maintained in a KLM hangars however is of one of their daughters or competitors

When an aircraft is stranded on Centrum, and they are in need of thorough repair, they are welcome in one of KLM's hangers when there is a free spot in the scedule. Over the years, almost every airline has visited KLM's E & M.

# 4.5 Design for emotion

The faculty of Industrial Design Engineering of the TU Delft hosts a chair that is called design for emotion. This chair focusses on how design can influence the way people act and feel. This chair uses emotions as a designtool.

When you design for the emotion “pride” the product or building will become very different from designing for the emotion “feeling safe”. To be able to design a toolkit and hangar that the people feel happy in research in the feeld of designing with emotions will be used. and that by doing so increases the productivity research in this field will be used while designing.

Literature about designing for emotions will be used to design a space not only based on technical specifications but also taking the actual user into account.



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# Granularity of emotions

Firstly we have to understand emotions in order to design for this. When you ask “how are you” and somebody says “ good!” This does not say anything yet. Emotional granularity is the level of detail that is present in the data of all emotions. This understading of details in emotions can help us design better for the different positive emotions.

In the images the different emotions are categorized. In the black and white picture several emotions are visualized. The emotion “happy” actually is much more then just one emotion as the classification immage shows.

When we can identify emotions we can start looking at emotional dilemma’s. Human behaviare often is a reaction on a certain dilemma. A svery simple example of a dilemma: “shall I eat a coockie or an apple”

Anger Contempt Disgust Surprise Sadness **Happyness** Fear

## Classification of positive emotions

**empathy**

**sympathy**
To experience an urge to identify with someone's feelings of misfortune or distress
*compassion / empathy / pity*

**kindness**
To experience a tendency to protect or contribute to the well-being of someone
*caring / friendly / tenderness / warm*

**respect**
To experience a tendency to regard someone as worthy, good or valuable
*appreciation / approval*

**affection**

**love**
To experience an urge to be affectionate and care for someone
*affection / intimacy / romance / infatuation*

**admiration**
To experience an urge to prize and estimate someone for their worth or achievement
*impressed / esteem*

**dreaminess**
To enjoy a calm state of introspection and thoughtfulness
*pensive / contemplative*

**aspiration**

**lust**
To experience a sexual appeal or appetite
*passion / sensual / horny / sexy*

**desire**
To experience a strong attraction to enjoy or own something
*attraction / yearn / crave*

**worship**
To experience an urge to idolize, honour, and be devoted to someone
*adore / devotion / reverence*

**enjoyment**

**euphoria**
To be carried away by an overwhelming experience of intense joy
*ecstasy / elation / exhilaration / jubilation*

**joy**
To be pleased about (or taking pleasure in) something or some desirable event
*happy / pleasure / delight / cheerful*

**amusement**
To enjoy a playful state of humour or entertainment
*entertained / gaiety / humorous / glee*

**optimism**

**hope**
To experience the belief that something good or wished for can possibly happen
*optimistic / encouraged / wishful*

**anticipation**
To eagerly await an anticipated desirable event that is expected to happen
*eager / expectant*

**animation**

**surprise**
To be pleased by something that happened suddenly, and was unexpected or unusual
*amazement / astonished / startled / dazzled*

**energized**
To enjoy a high-spirited state of being energized or vitalized
*exuberant / zest / excitement / stimulation*

**assurance**

**courage**
To experience mental or moral strength to persevere and withstand danger or difficulties
*brave / heartened*

**pride**
To experience an enjoyable sense of self-worth or achievement
*triumphant / self-satisfaction / smug*

**confidence**
To experience faith in oneself or one’s abilities to achieve or to act right
*assurance / secure / trust*

**interest**

**inspiration**
To experience a sudden and overwhelming feeling of creative impulse
*enthusiasm / determination / challenged / zeal*

**enchantment**
To be captivated by something that is experienced as delightful or extraordinary
*awe / charmed / moved / touched*

**fascination**
To experience an urge to explore, investigate, or to understand something
*curious / attentive / interest / engrossed*

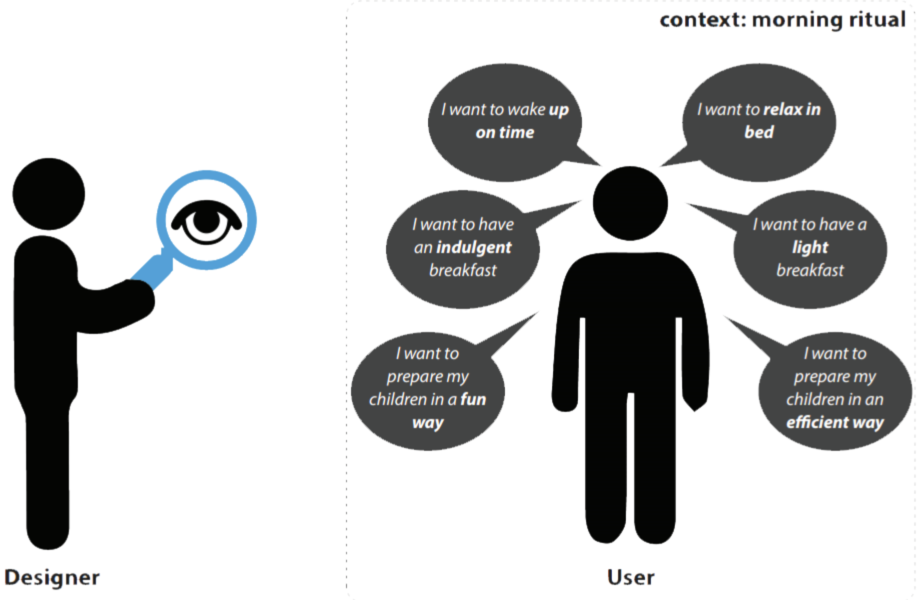
**gratification**

**relief**
To enjoy the recent removal of stress or discomfort
*reassured / soothed / gratitude*

**relaxation**
To enjoy a calm state of being free from mental or physical tension or concern
*comfortable / carefree / serene / tranquillity*

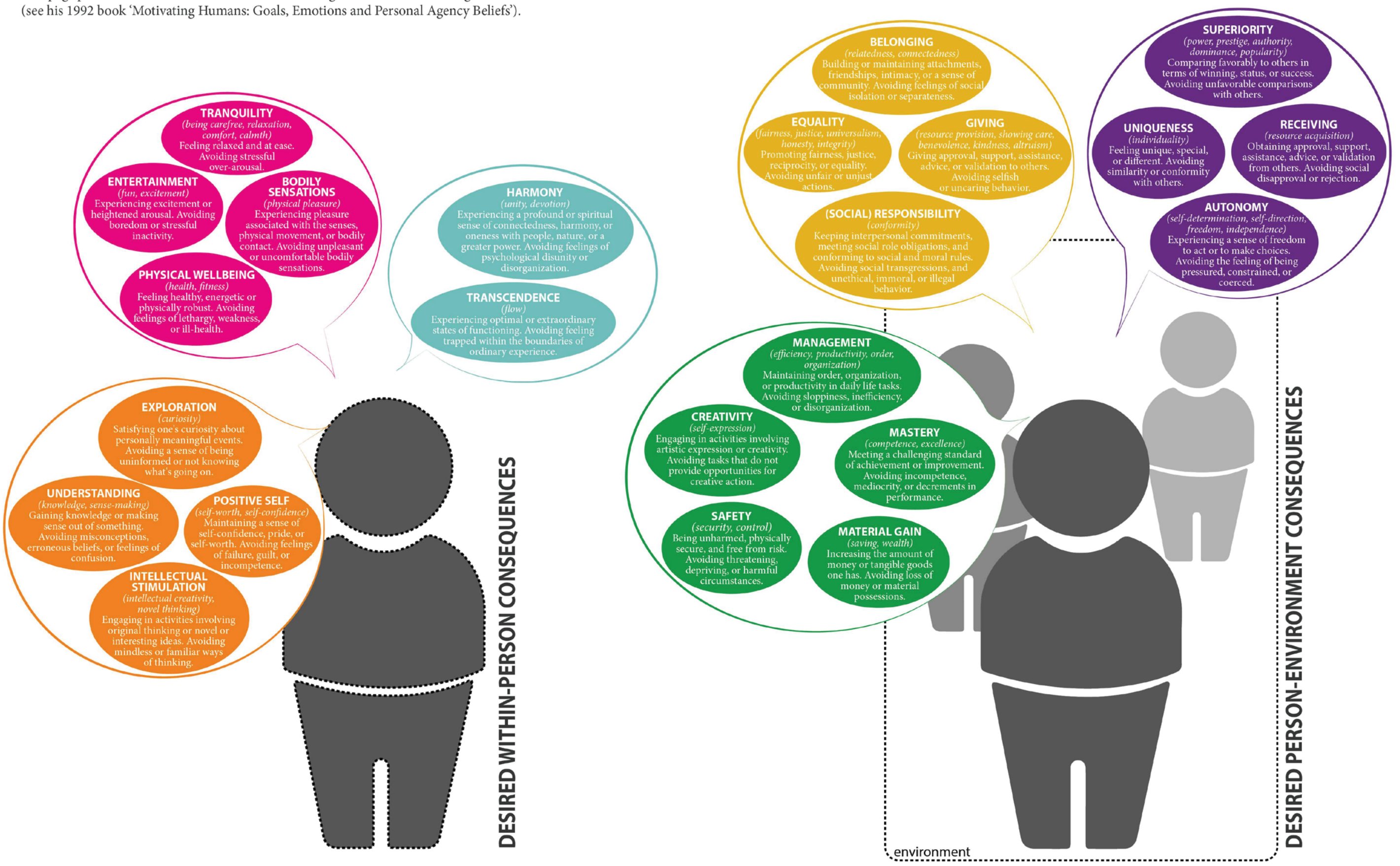
**satisfaction**
To enjoy the recent fulfilment of a need or desire
*gratified / pleased / contentment / fulfillment*

## Designing for Dilemma's




## Universal Human Goals

This page provides an overview of 23 universal human goals clustered according to the work of Martin Ford (see his 1992 book 'Motivating Humans: Goals, Emotions and Personal Agency Beliefs').




Source images: Ozkaramanli, D., Desmet, P. M., & Hekkert, P. P. M. (2012, September). Proud to be in control: Understanding concern conflicts and initial principles for conflict-inspired design approaches. In Out of Control: Proceedings of the 8th International Conference on Design and Emotion, London, UK, 11-14 September 2012.

# Implementation
## "Design for emotion" as designtool Outdoor area H12

The theorie about design for emotion can be implemented for the design of the outdoor area of Hangar 12 to show how this design tool can work. Step one is to pick different emotions that you want people to experience or that you want to influence. In the outdoor area of the hangar I chose the following three emotions that are also part of the key words for the design of the entire hangar.

**1. Connected/socially involved**
**2. Inspired**
**3. Relaxed**

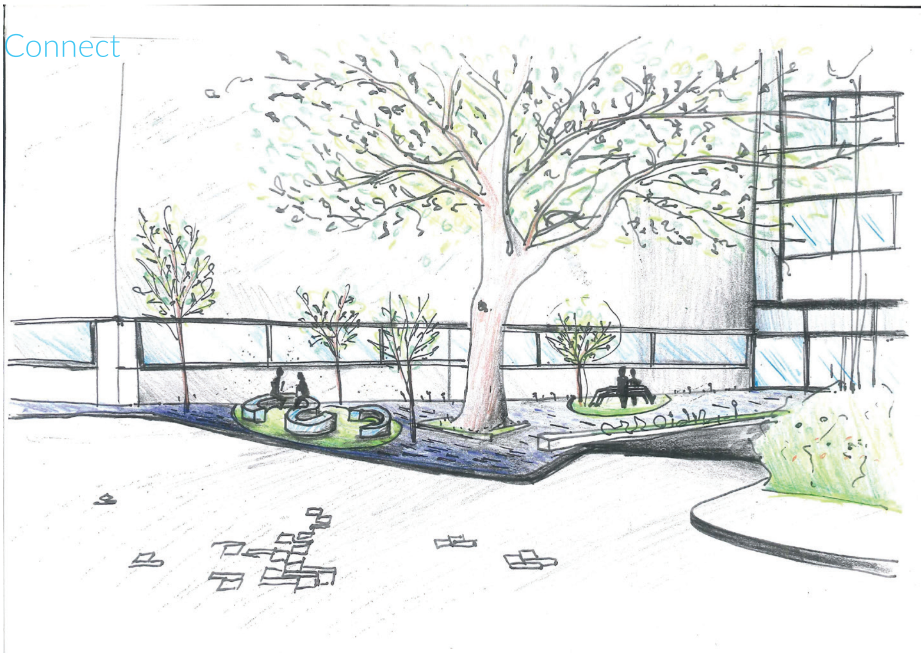
1. Relaxed
The option below shows comfortable furniture, benches with back support, a table to sit on a a chair to lay in. The choises for this design were made by thinking of how to support people when they want to relax in the garden.

2. Connected
This option invites people to feel connected to each other. The circles on the ground and the round shapes of the furniture contributes to this.

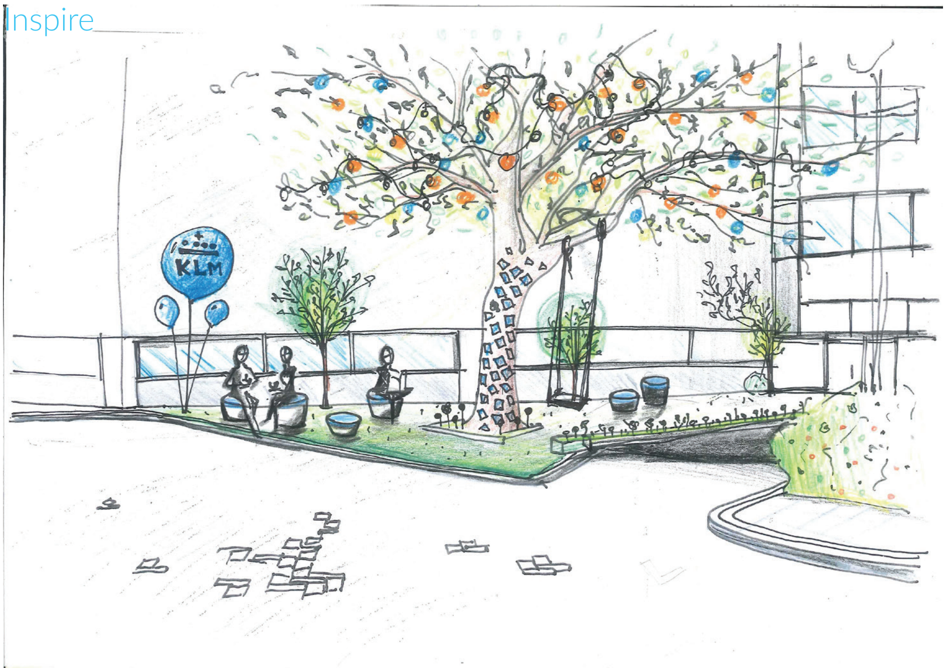
3. Inspired
This design gives freedom to people to sit in different directions with different people. Besides surprising elements are added to the design such as wish and idea notes on the tree (waterproof) and coloured lights in the tree to inspire in the nightshifts.

Buitenruimte H12

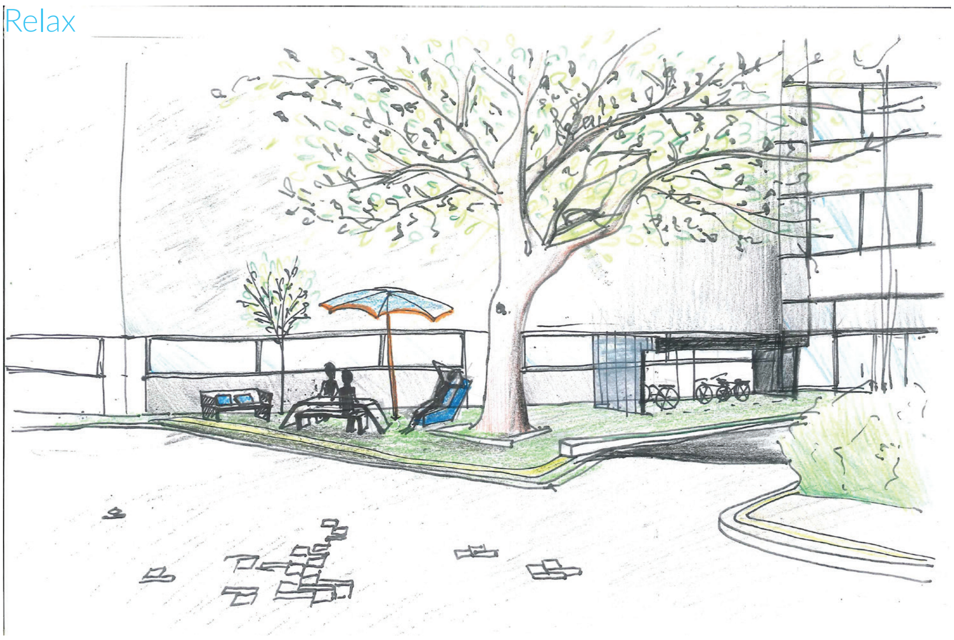
Connect



Inspire




Relax



## 4.6 Conclusion research into offices

- Open offices have several downsides: noise from colleagues, no privacy and distraction.
- Open offices have several advantages: better communication, more social activity among em ployees, pleasant work environment.
- The use of plants and decoration has a positive influence on the appreciation of the work area.
- New way of working is not about a fancy office but about a change of idea. Businesses should not try to control productivity by a strict corset of office hours, workplaces, hierarchy and work groups. The focus should be more result driven, more responsibility and freedom for the em ployee will lead to high productivity, work satisfaction and health.
- Overall: New way of working has positive effect on productivity and work satisfaction
- Flex working / working from home can save costs, increase work satisfaction and productivity. However the work culture should first be prepared before this is implemented. Otherwise no change in behavior of the employees will occur and there will not be enough workplaces.
- It is not a trend to work from home, this way of working will continue in the future. "The work place " as it was once known does no longer exist, people work from home, in the train, in bars and café's and the style of working (casual long tables for example) has changed as well. Here we should define what is just a fashion and will change and which aspects are usefull for the design of the future.

- The concept of The New Way of Working is already old and offers room for improvement and requests more research since much research was performed before the developments of new technology such as for video calling, new computers and mobile phones.
- Personalization of the workplace is important for employee wellbeing.
    1. Emphasize Personal Identity : The use of decoration pictures etc. or the very lack of decoration says something about the person that you are.
    2. Emphasize Shared interest: for example at KLM a picture of B 787 will stimulate a feeing of community and supports the group feeling
    3. Building relations: When you place pictures of your family colleagues can more easily ask how they are doing and tell about their own family.
    4. Motivation: research shows that 33% of the personal objects are not visible for others and serve a motivational, inspirational purpose. For example a family vaction picture calmes you down is stressful situations.


VERBODEN TE ROK

## Implementation advice for the design of offices after research:

- Create small open office groups of around 6-8 people.
- Design the main work area with flex places and a pleasant informal ambiance.
- Arrange  small area's for calls to decrease noise.
- Arrange private work spaces for tasks that need to be performed in upper concentration besides the main office.
- Create area's and meetingrooms where video calling is possible, when people work from h home it should still be possible to connect with colleagues.
- Design a relaxing area at a location where the noise does not disturb the employees and that is located near a coffee machine and in good view of the walking routes.
- Pay attention to liminal spaces, the corridors, stairs, toilets, coffee corners and other non defined area's in the hangar because they are part of the experience as well.
- Offer space for personal expression even when the offices are flex
- Create the possibility to personalize the workspaces or planningarea's

## Literature: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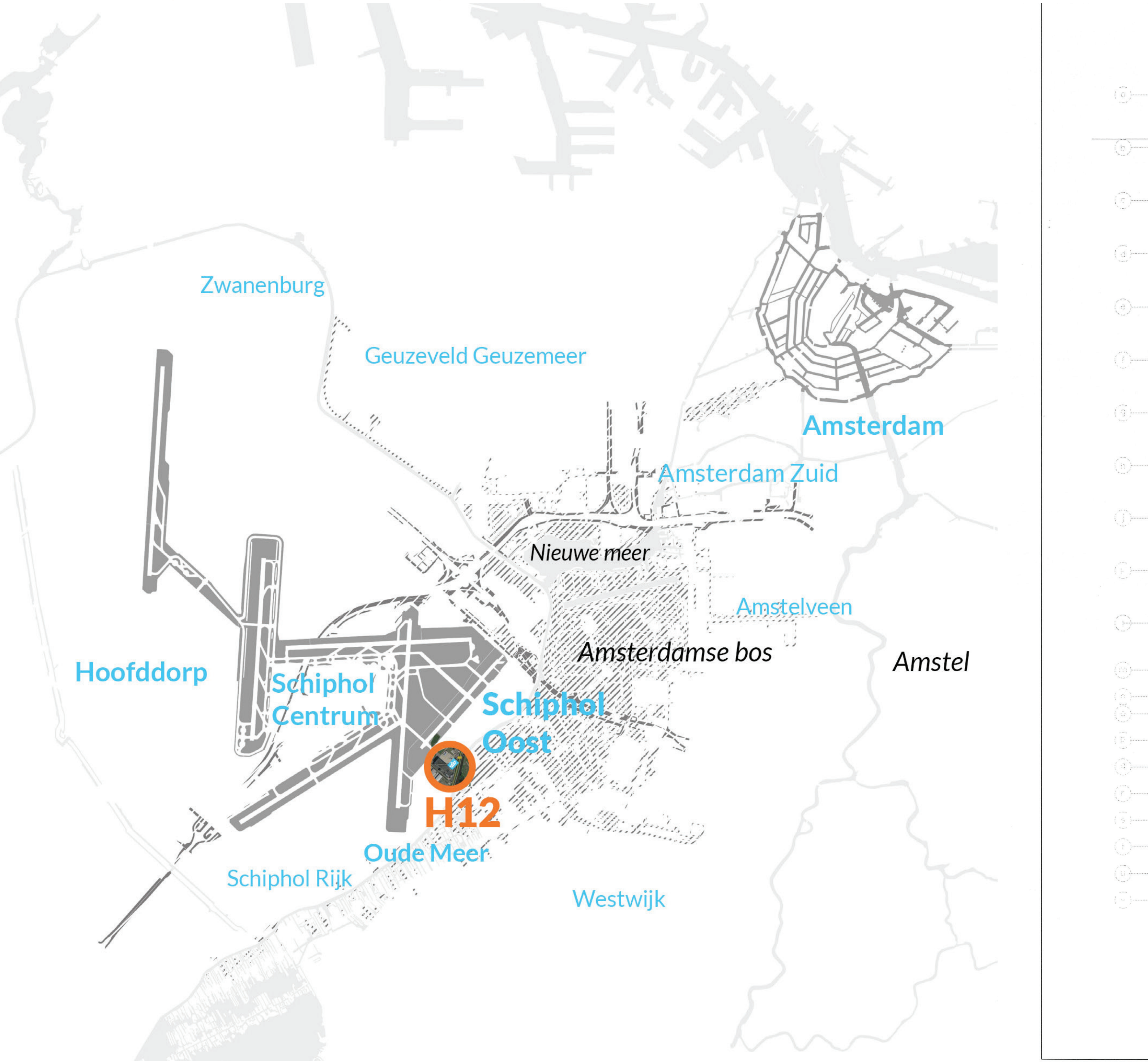
Betrouwbaar KLM

# Chapter 5
# Analysis H12

## 5..1 Context

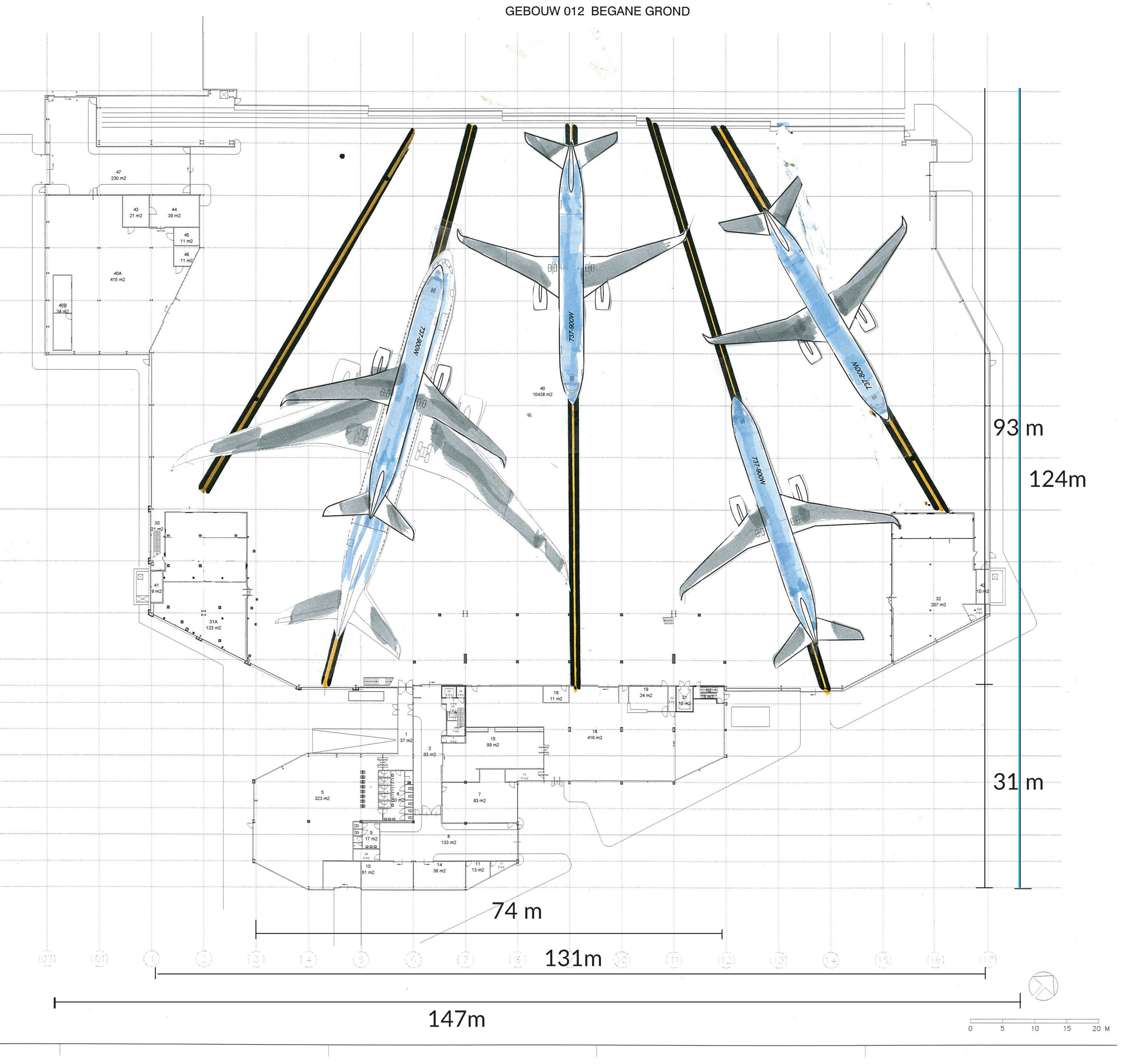
### Map Schiphol

Hangar 12 in the orange ring




source: own illustration

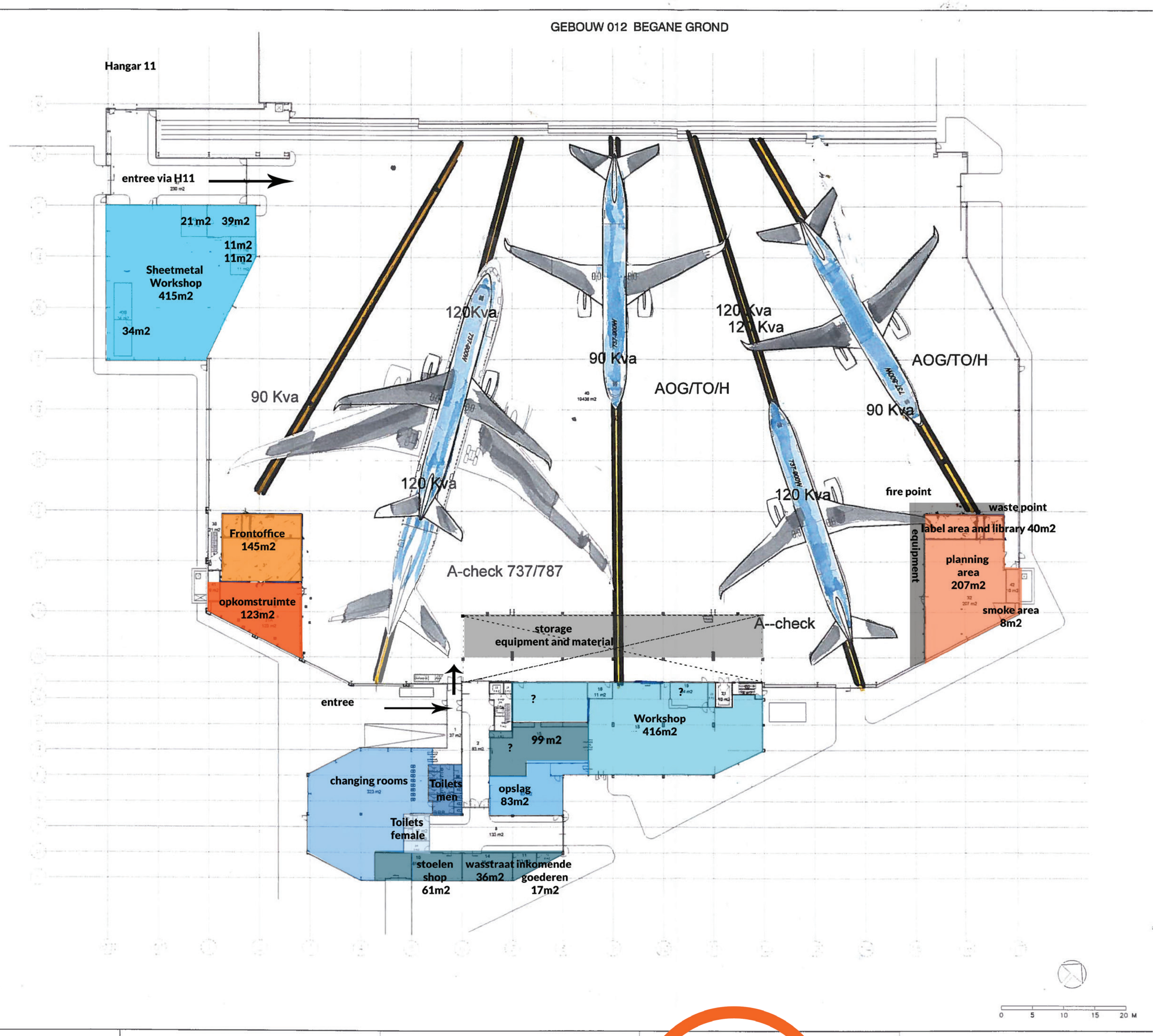
## Floorplan Hangar 12
### Ground Floor




source: KLM tekenkamer

# 5.3 Functions Hangar 12

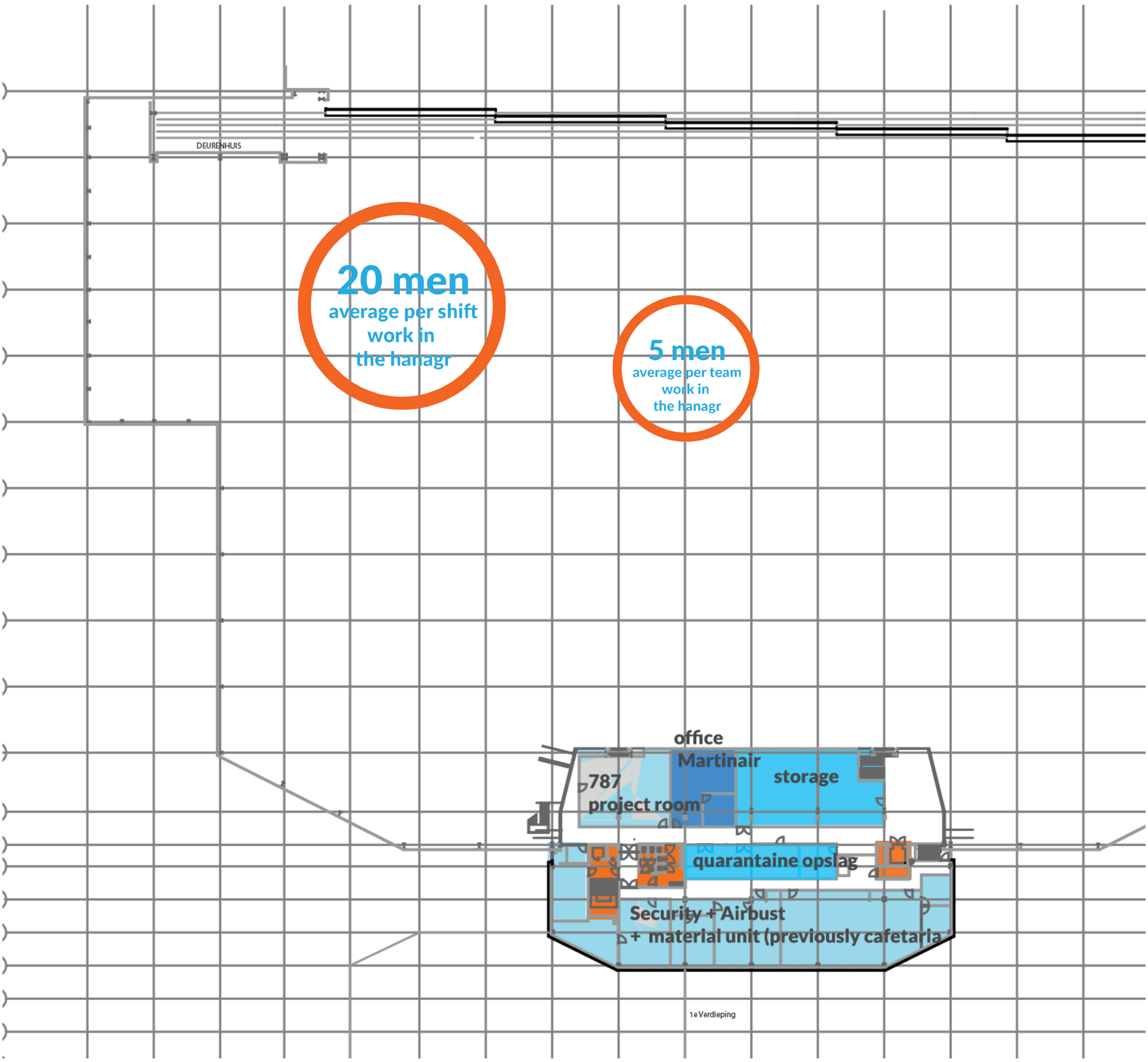
## Ground Floor



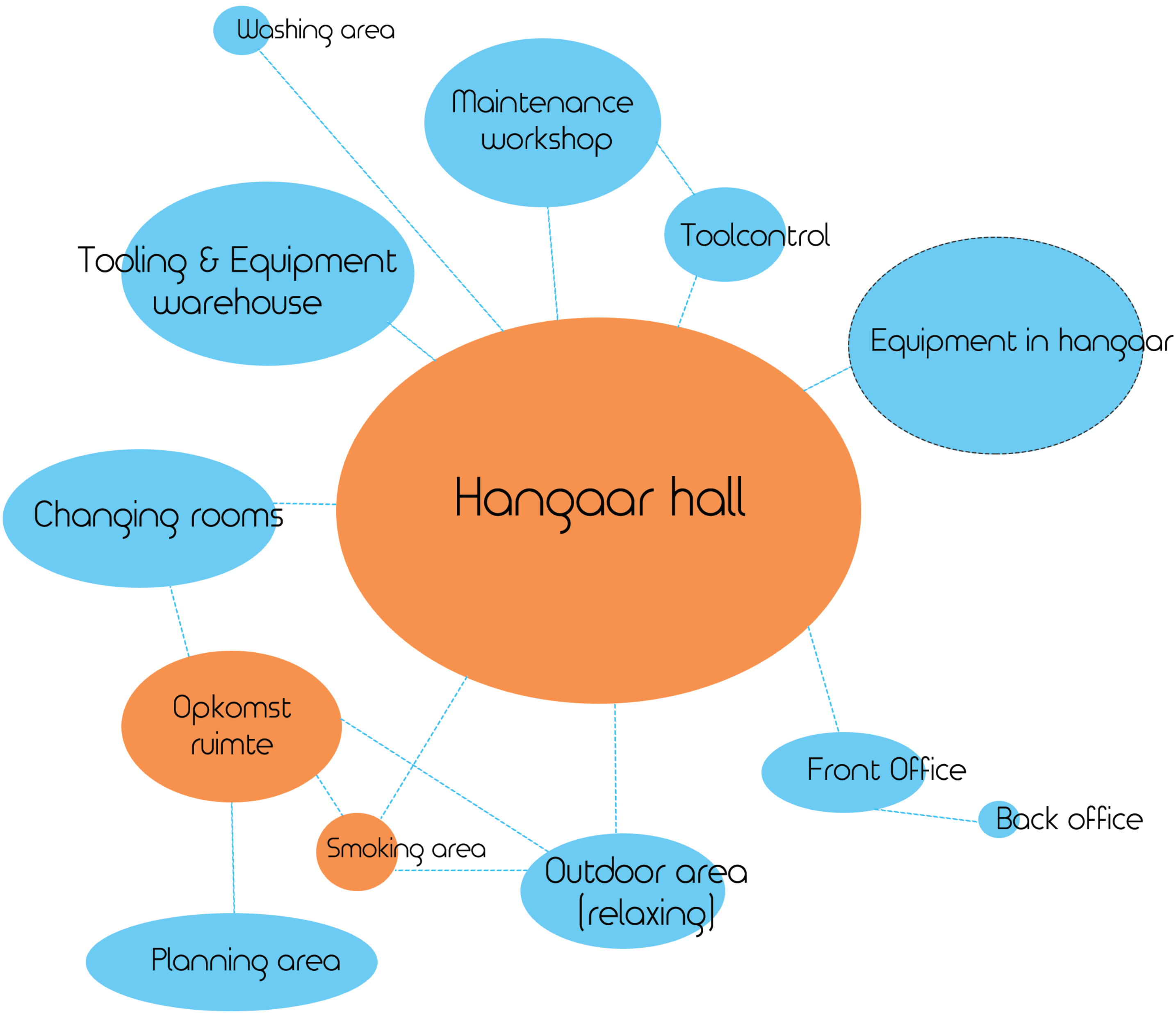

2 years
before full
digitalisation >>
change functions

# Functions Hangar 12

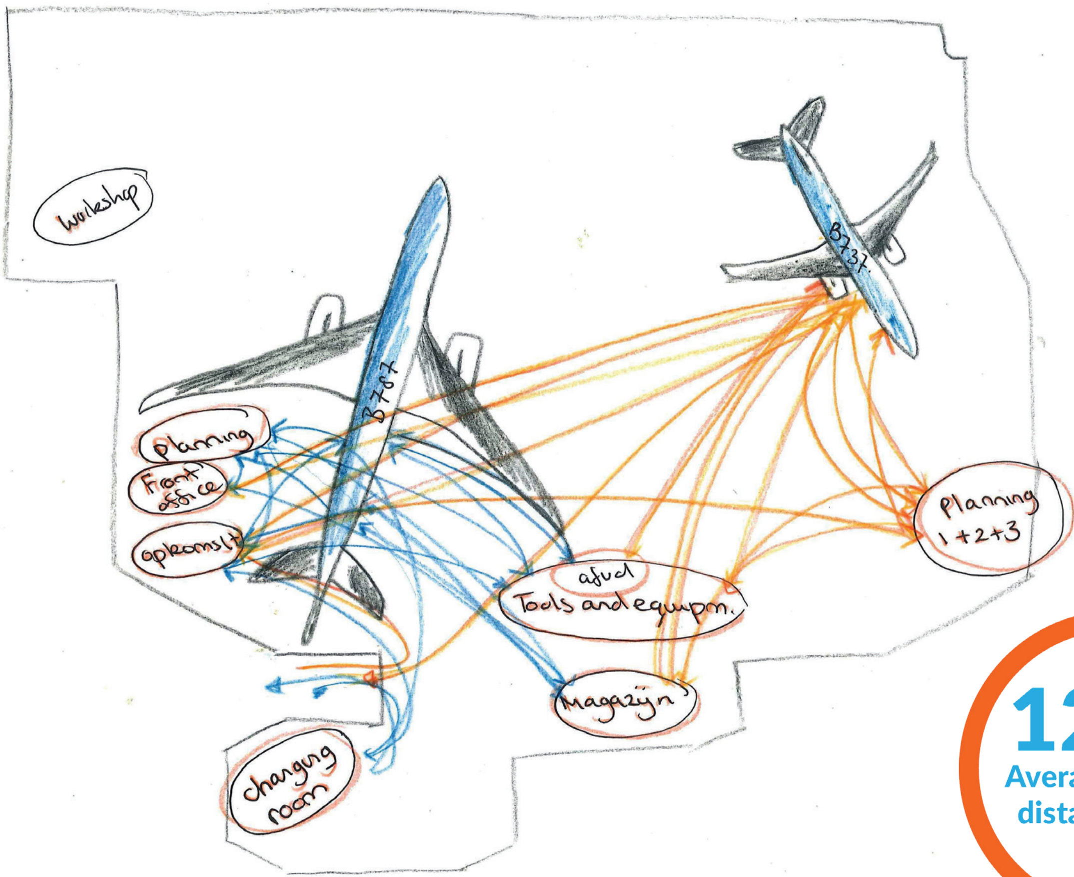
## 1st Floor



# Relation functions H12 KLM

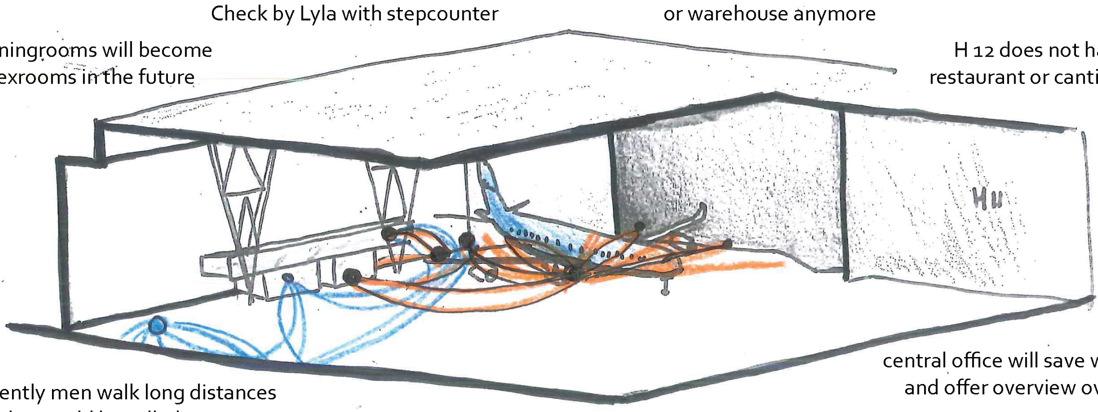


# Walking roots H12

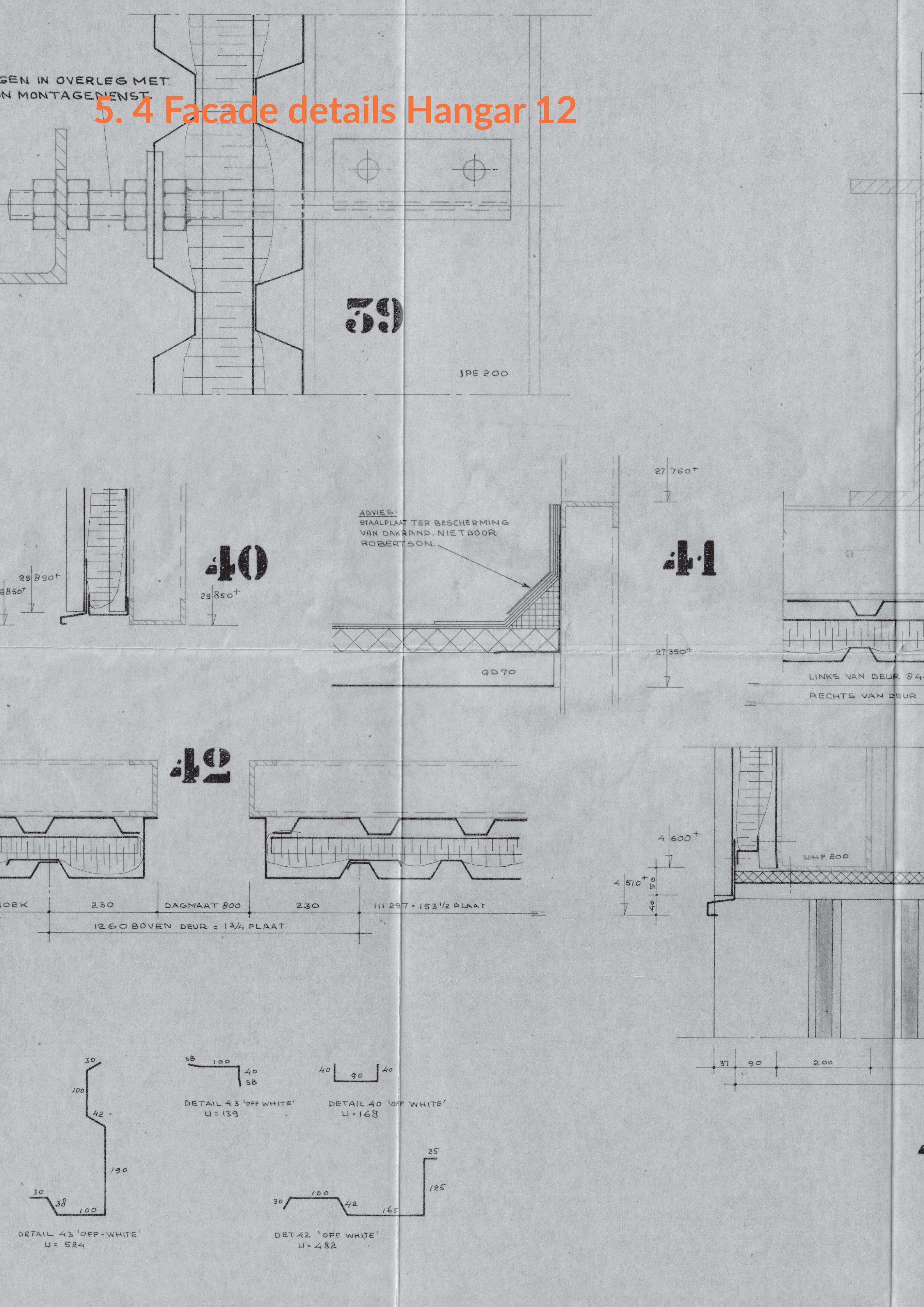


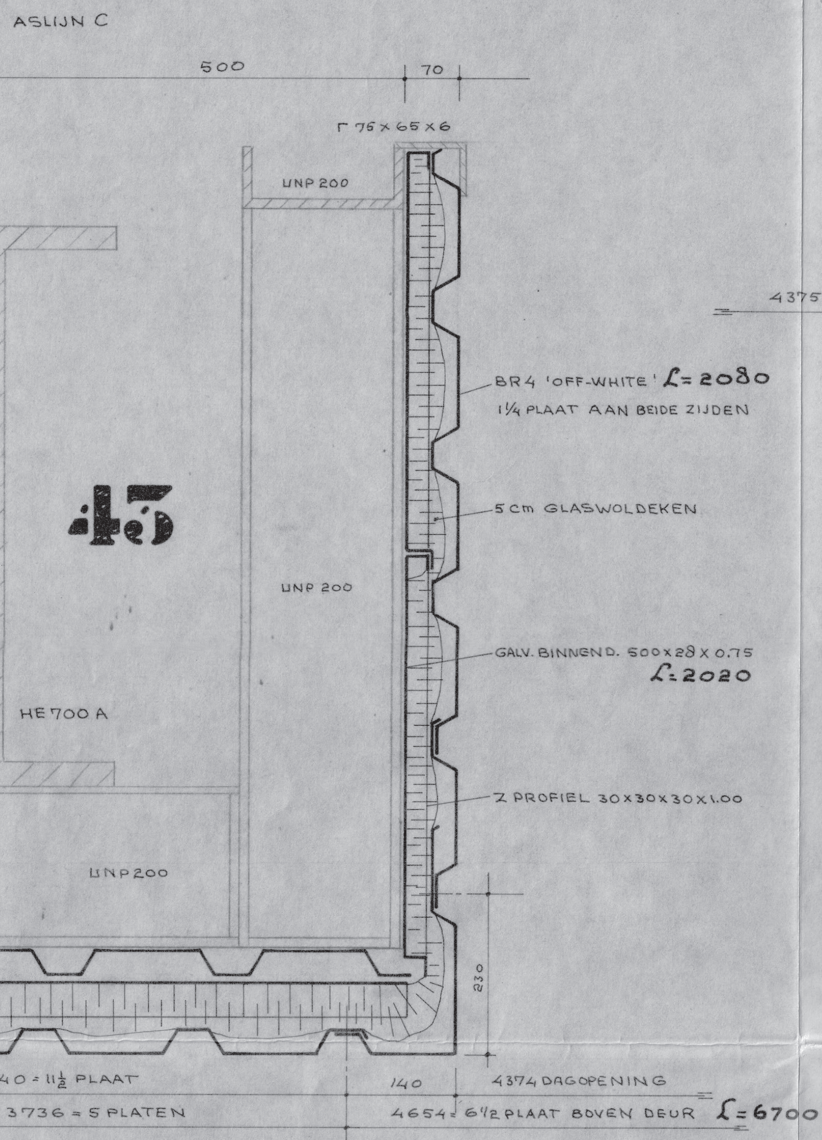

**12km**
**Average walking distance 1 shift**

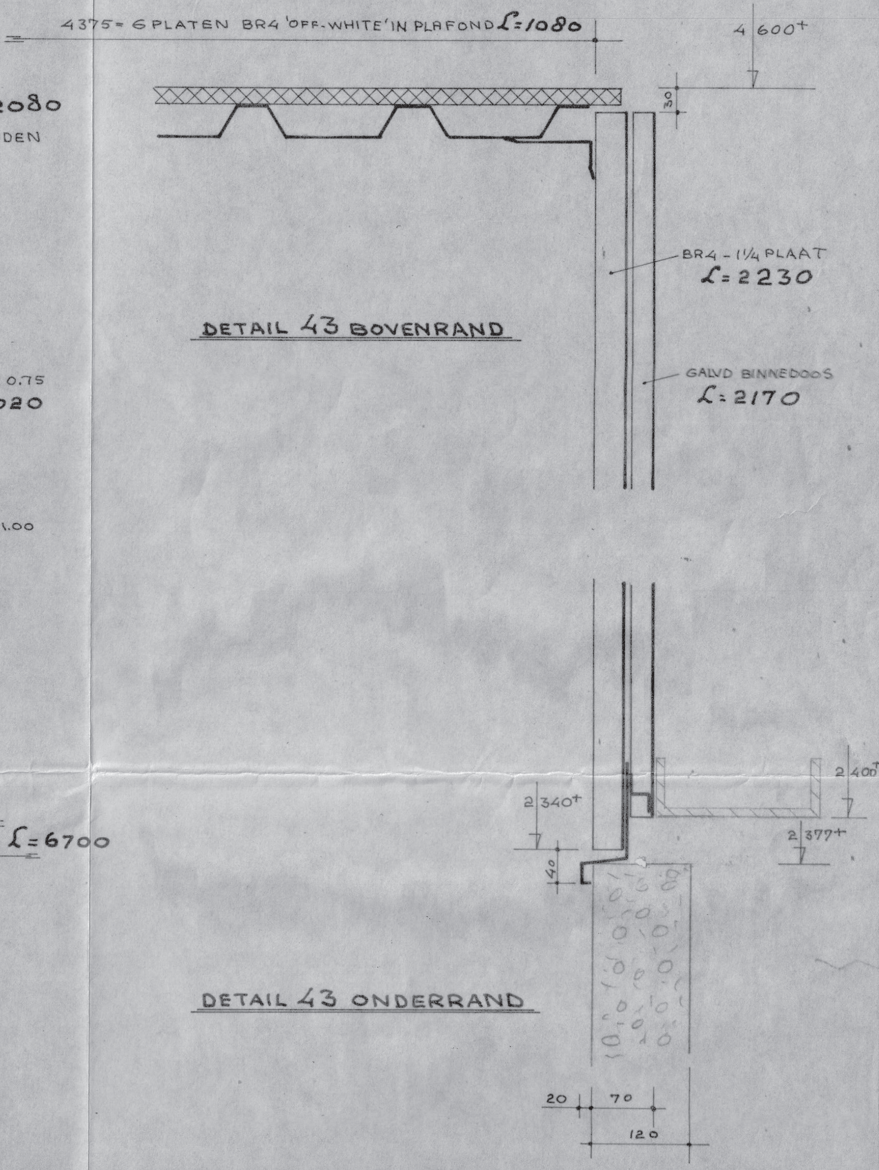
# Conclusion drawing movement + function



# 5. 4 Facade details Hangar 12

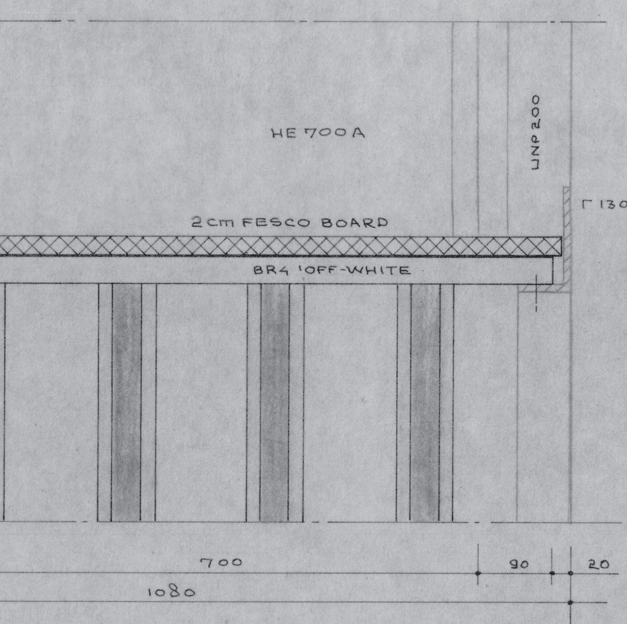





DETAIL 43 BOVENRAND

DETAIL 43 ONDERRAND

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| 20-11-78 | | A |

opdrachtgever: directie:
KON. LUCHTVAART MIJ N.V. - SCHIPHOL

HANGAR 12

onderwerp:
DETAILS 39 - 44

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blad: 19 / 20

P 2800/8

N 4503/8

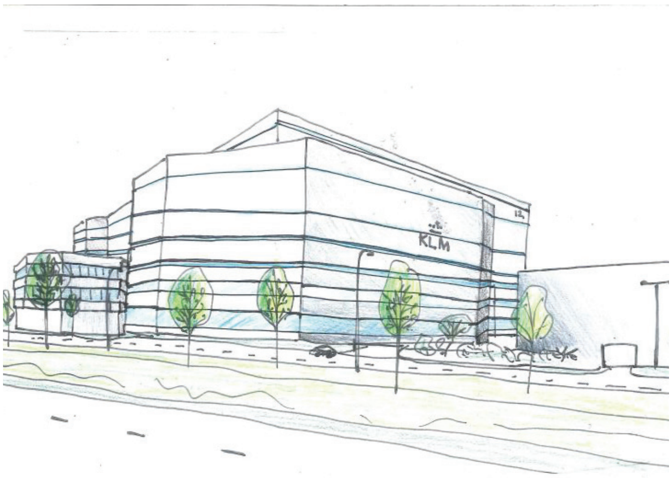
afm.:

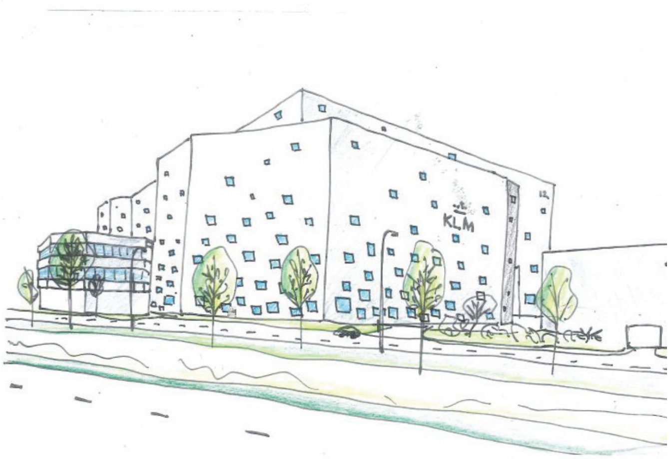
Robertson

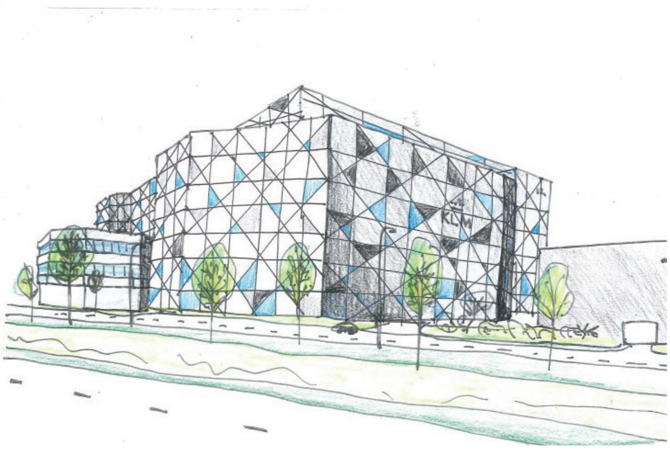
Robertson Nederland b.v.
Parklaan 43, Bussum, Postbus 93
Tel. 02159 - 44544, Telex 13290

# Facade impressions H12

## 3 options

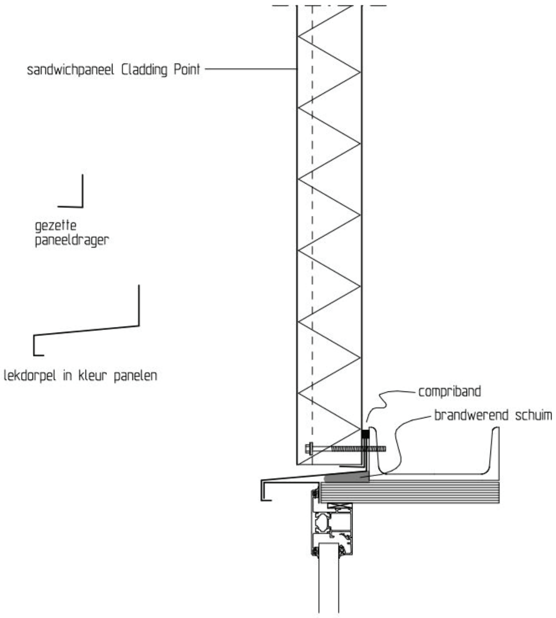


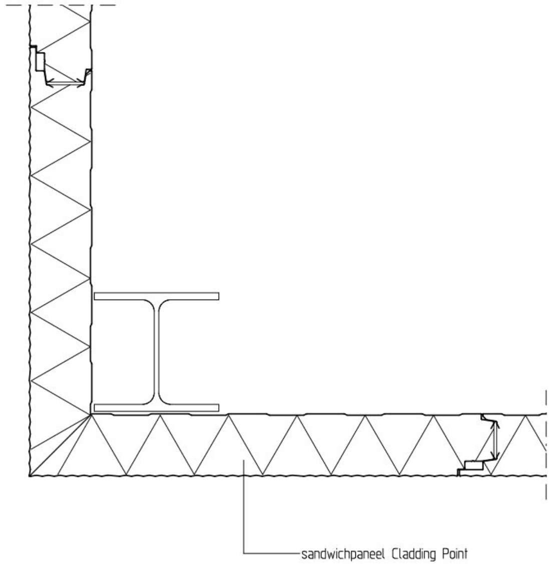



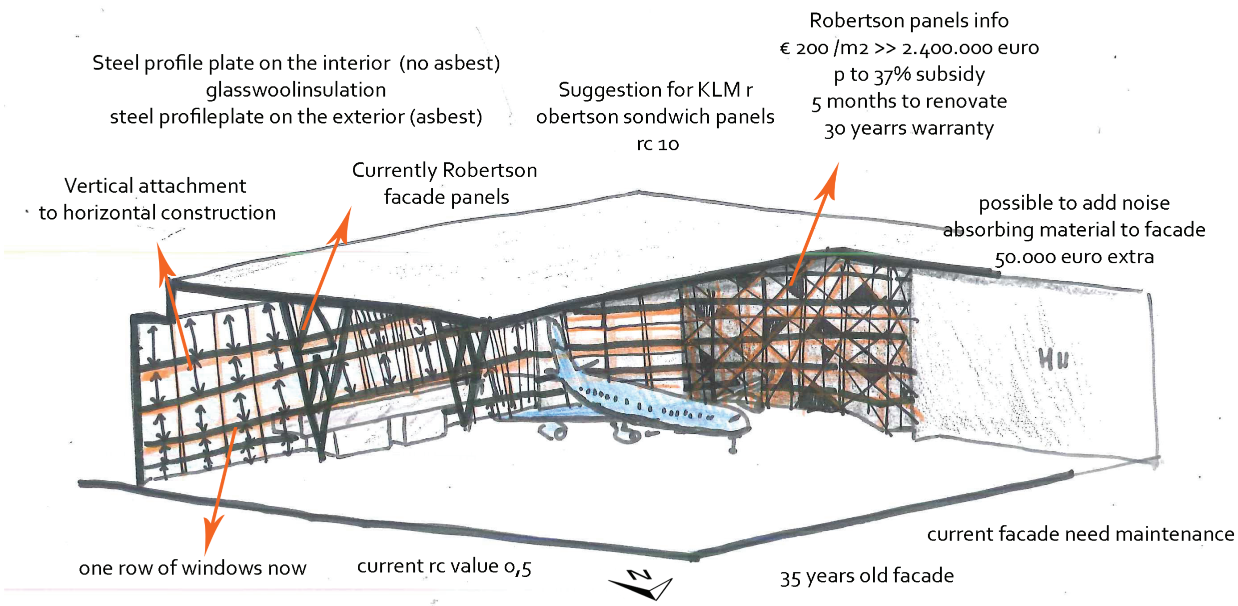
# Facade impressions H12

## 3 options



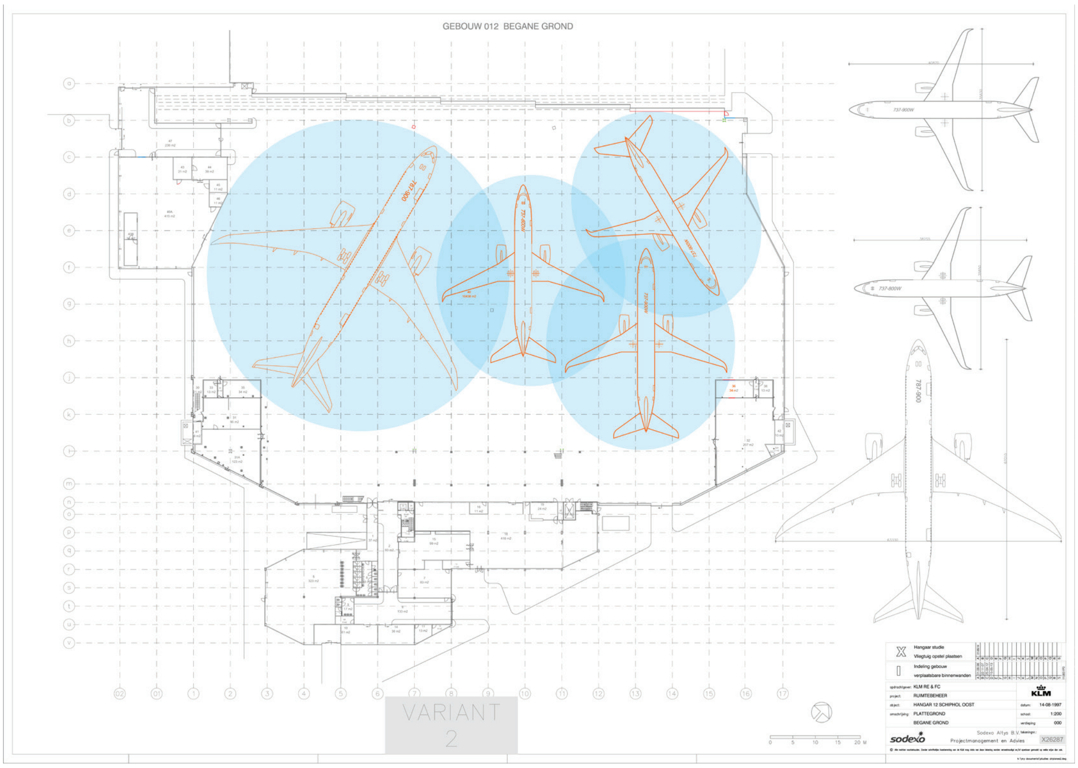




# Conclusion drawing facade

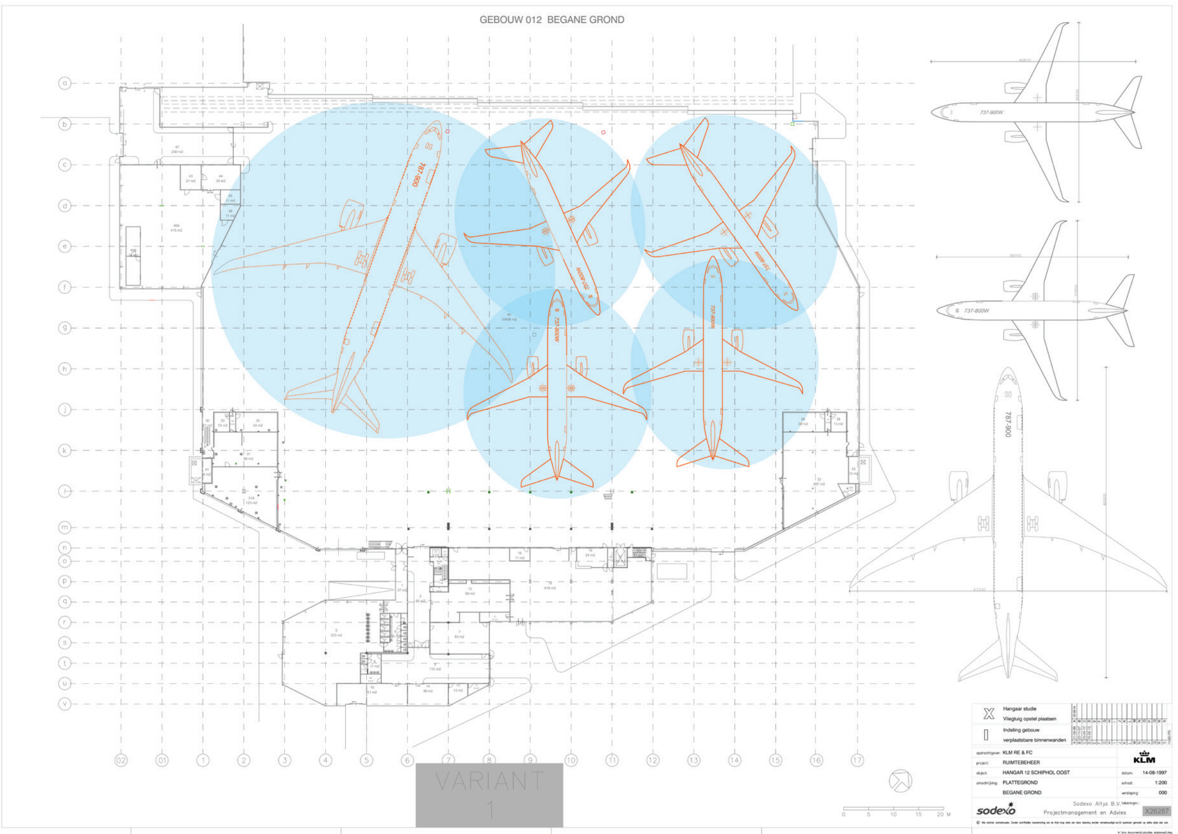


# 5.5 Positions aircraft

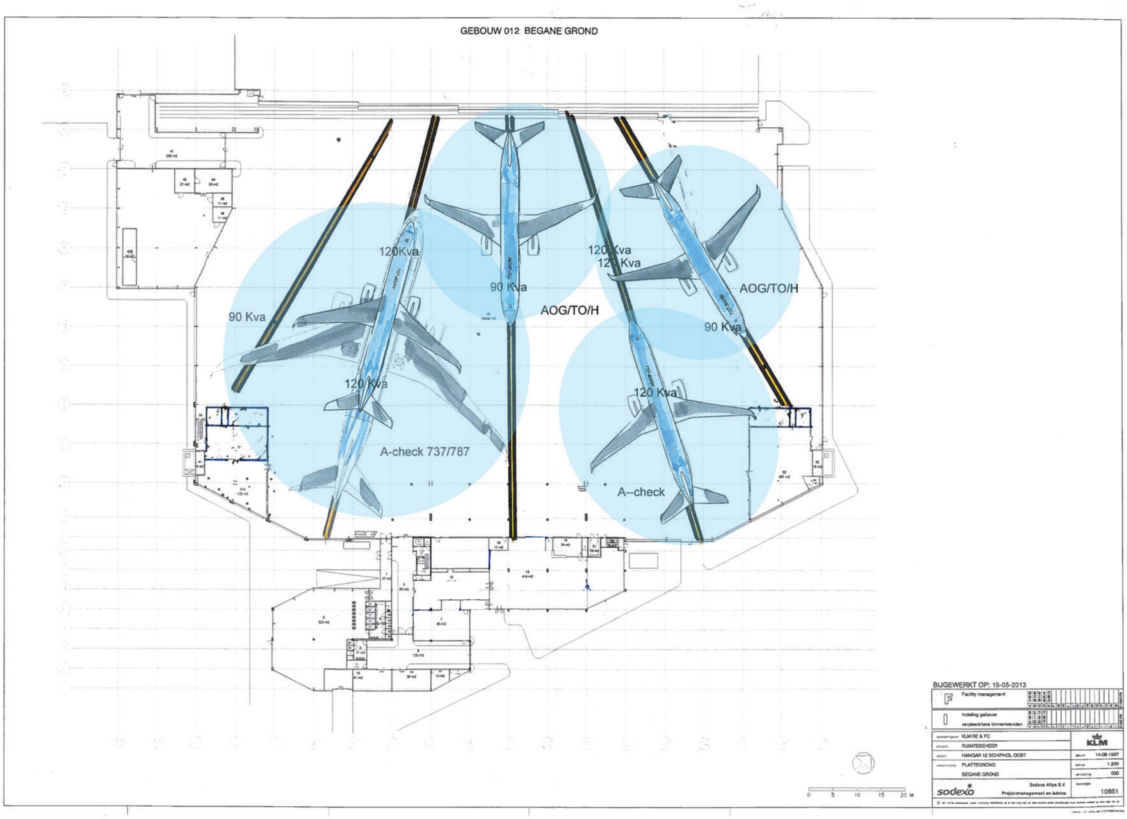
## Option 1. Three aircraft



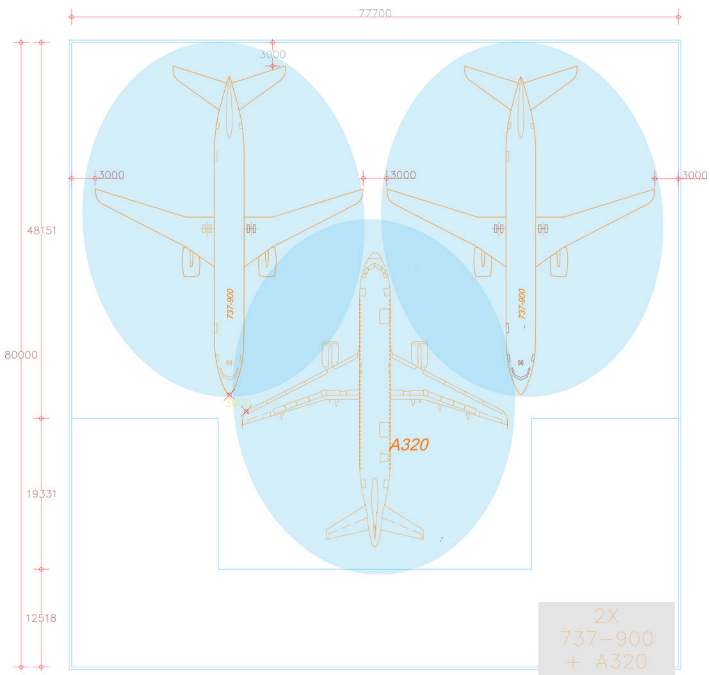

## Option 2. Four aircraft



## Option 3. Chosen option




## Limits positioning



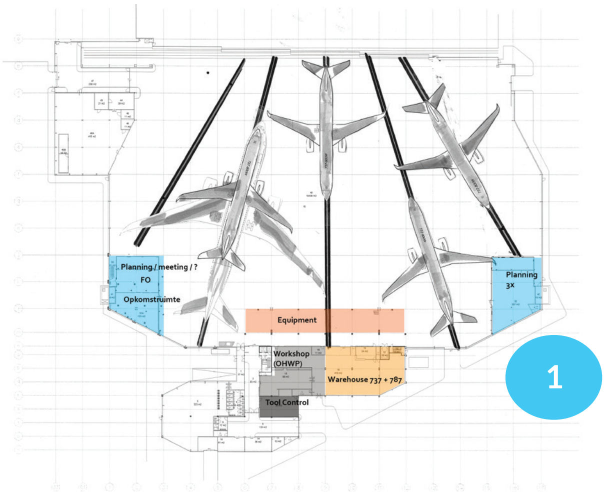

## Conclusion

The final decision for the position of the aircraft in the new H12 is option 3. The main reason for this is that the water channels for wastewater are already present in this position, Changing this would require a large renovation of the concrete floor which would be expensive and would prolong the process.

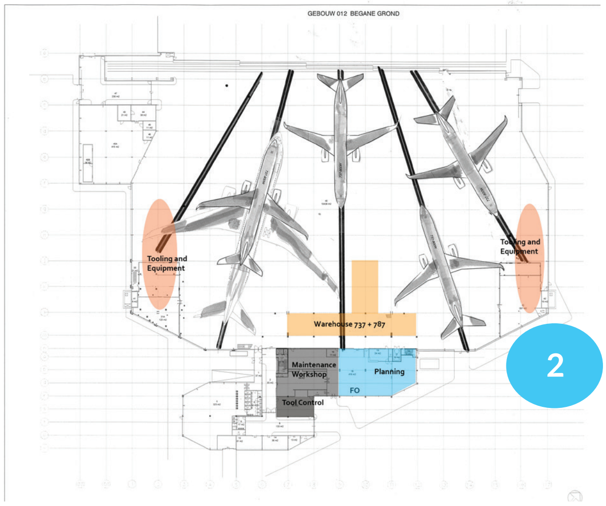
It is possible to position four 747 types next to the 787 in the hangar. KLM however requires only 4 positions for aircraft and it would be difficult to manouvre the planes therefore option 2 will not be executed.

# 5.6 Options floorplan

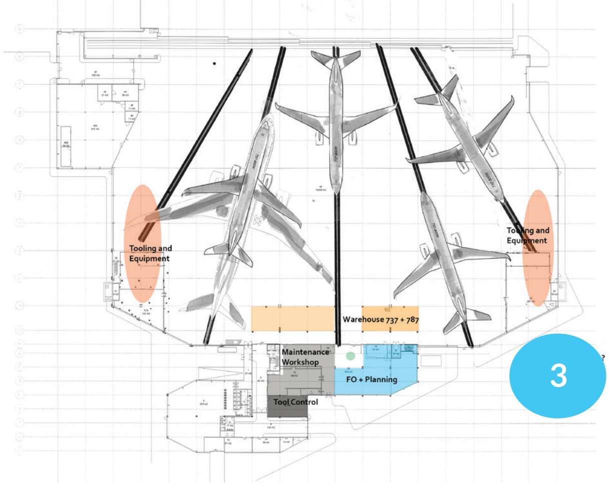
## Option 1. Traditional



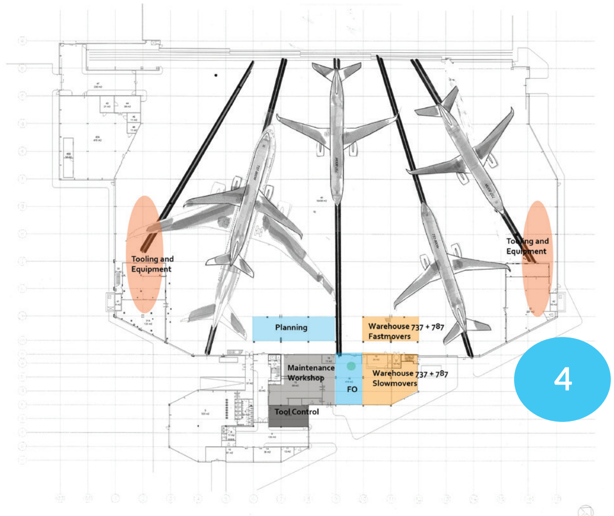

## Option 2. Central warehouse



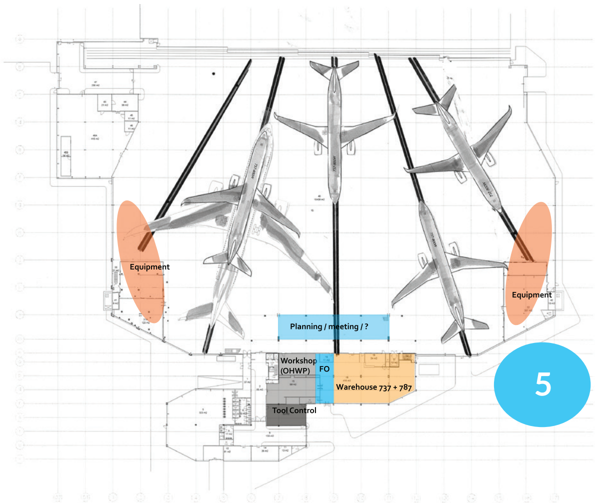

## Option 3. Warehouse central



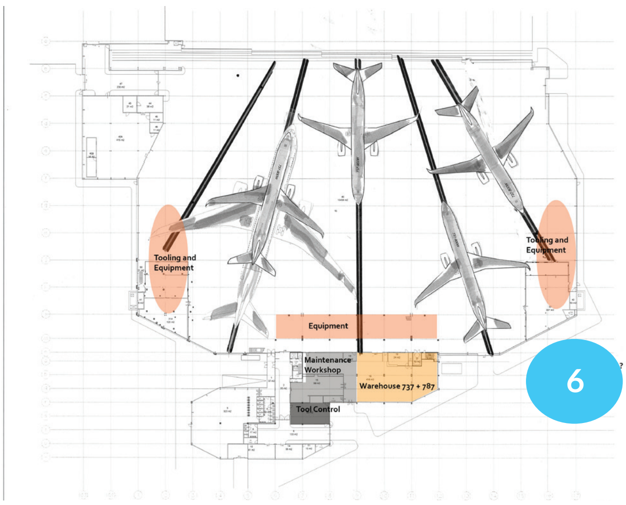

## Option 4. WH split in two



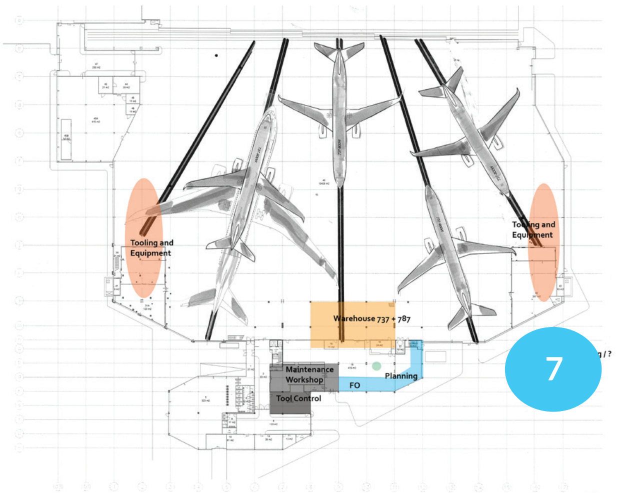

## Option 5. Offices central



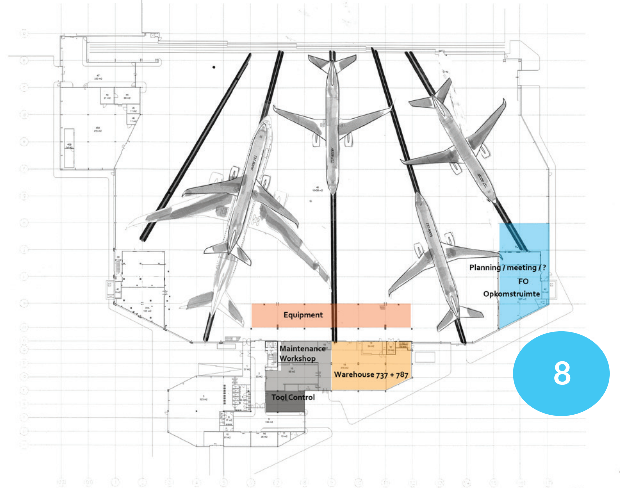

## Option 6. Empty ground floor



## Option 7 Offices on edge




## Option 8. Offices right




## Matrix options

| Matrix options | 1. Traditional | 2. Central warehouse | 3.Warehouse in the middle | 4.Warehouses split in two | 5. offices central | 6. Empty GF | 7. Offices on edge | 8. Offices on the right |
|---|---|---|---|---|---|---|---|---|
| Daylight | 4 | 3 | 2 | 2 | 2 | 4 | 3 | 4 |
| Walking distance | 3 | | 4 | 3 | 3 | 1 | 2 | 2 |
| Overview | 4 | 4 | 1 | 4 | 4 | 4 | 2 | 3 |
| Space | 4 | 3 | 4 | 2 | 3 | 2 | 3 | 1 |
| Costs | 4 | 2 | 1 | 2 | 3 | 2 | 1 | 3 |
| Innovative | 1 | 3 | 4 | 3 | 3 | 3 | 4 | 2 |
| total | 20 | 15 | 16 | 16 | 18 | 16 | 15 | 15 |

## Valued rating options

| Matrix options | 1. Traditional | 2. Central warehouse | 3.Warehouse in the middle | 4.Warehouses split in two | 5. offices central | 6. Empty GF | 7. Offices on edge | 8. Offices on the right |
|---|---|---|---|---|---|---|---|---|
| Daylight | 24 | 3 | 12 | 12 | 12 | 24 | 18 | 24 |
| Walking distance | 15 | | 20 | 15 | 15 | 5 | 10 | 10 |
| Overview | 4 | 4 | 1 | 4 | 4 | 4 | 2 | 3 |
| Space | 16 | 12 | 16 | 8 | 12 | 8 | 12 | 4 |
| Costs | 8 | 4 | 2 | 4 | 6 | 4 | 2 | 6 |
| Innovative | 3 | 9 | 12 | 9 | 9 | 9 | 12 | 6 |
| total | 70 | 32 | 63 | 52 | 58 | 54 | 56 | 53 |

## Values 1-6

| Rating | |
|---|---|
| Daylight | 6 |
| Walking distan | 5 |
| Overview | 1 |
| Space | 4 |
| Costs | 2 |
| Innovative | 3 |

## Conclusion analysis floorplan options

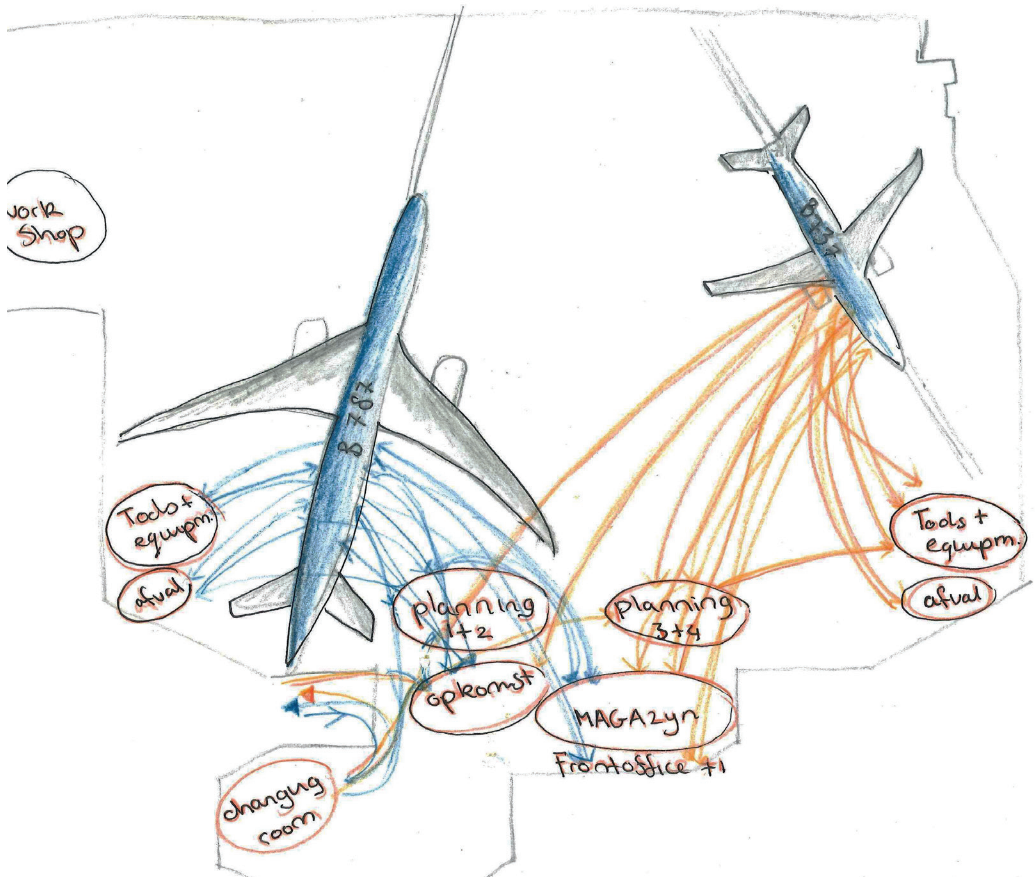
**Eight** options for the floorplans were analysed, these floorplans are based on the flowchart of the processes and the List of Requirements of today and the future that lead to **a List of requirements of Tomorrow.** The List of requirements was then linked to m2's.

The different options were rated on 6 criteria mentioned in the table above. Option 2 and 6 already fall off the possible solutions since some functions such as the front office are required on the ground floor. Option 6 is not possible because it would require the movement of the fire distuinguisher installation which would be a very costly activity.

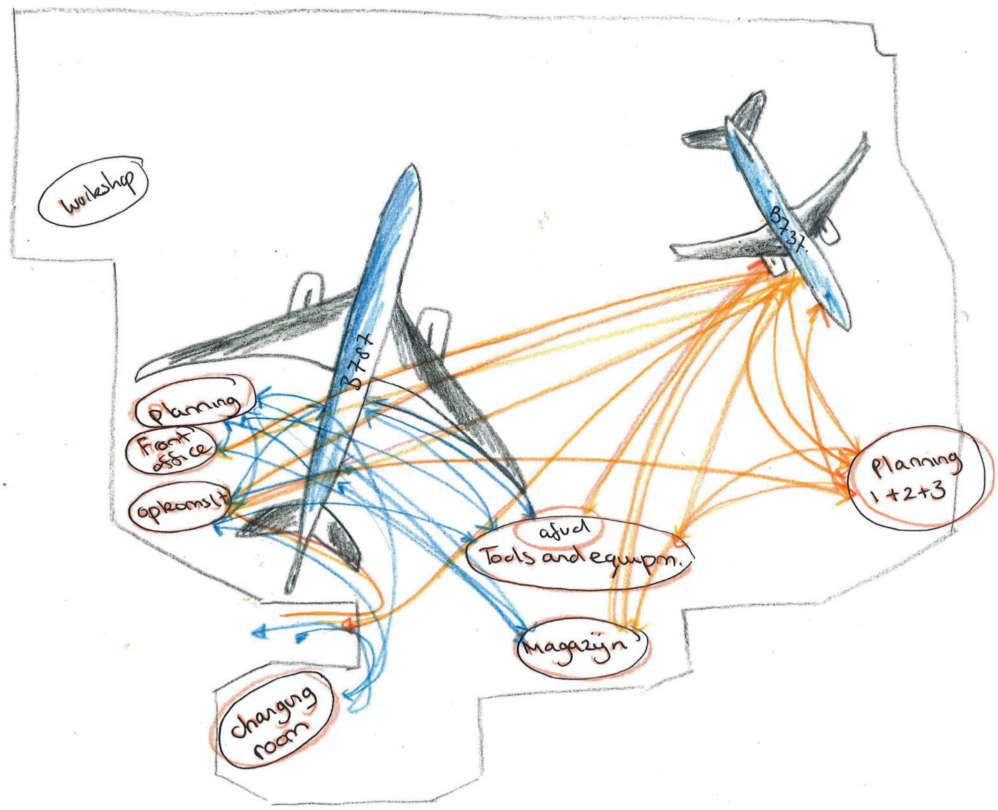
When we look at the matrix option 1. and 5 score best. Otion 1 is the way the hangar looks like now nd option 5 positions the offices in the centre of the hangar. In the second table a value is added to the different subjects the hangars are compared to. Also after addding different values the **options 1 and 5 score best**. It seems logical to conclude that we then should continue with option 1 as it has the highest amount of points. The 6 subjects however did not cover all the aspect such a design choice should look at. Therefore I will investigate the plus and downsides of option 1 and 5 further. Please read this analysis on the following pages.

## Spagetti chart movement flows Today

### Option 1. Central Today




### Option 2. Sides Today

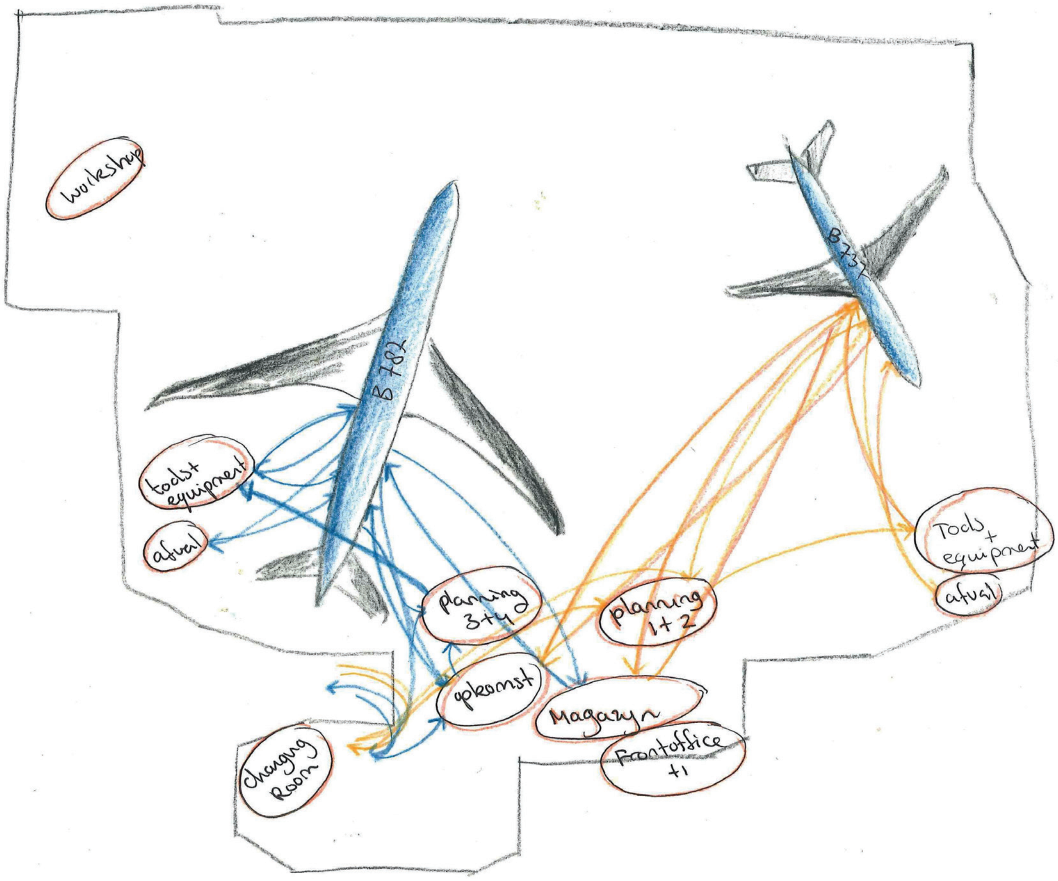



PERFORMED ACTIONS

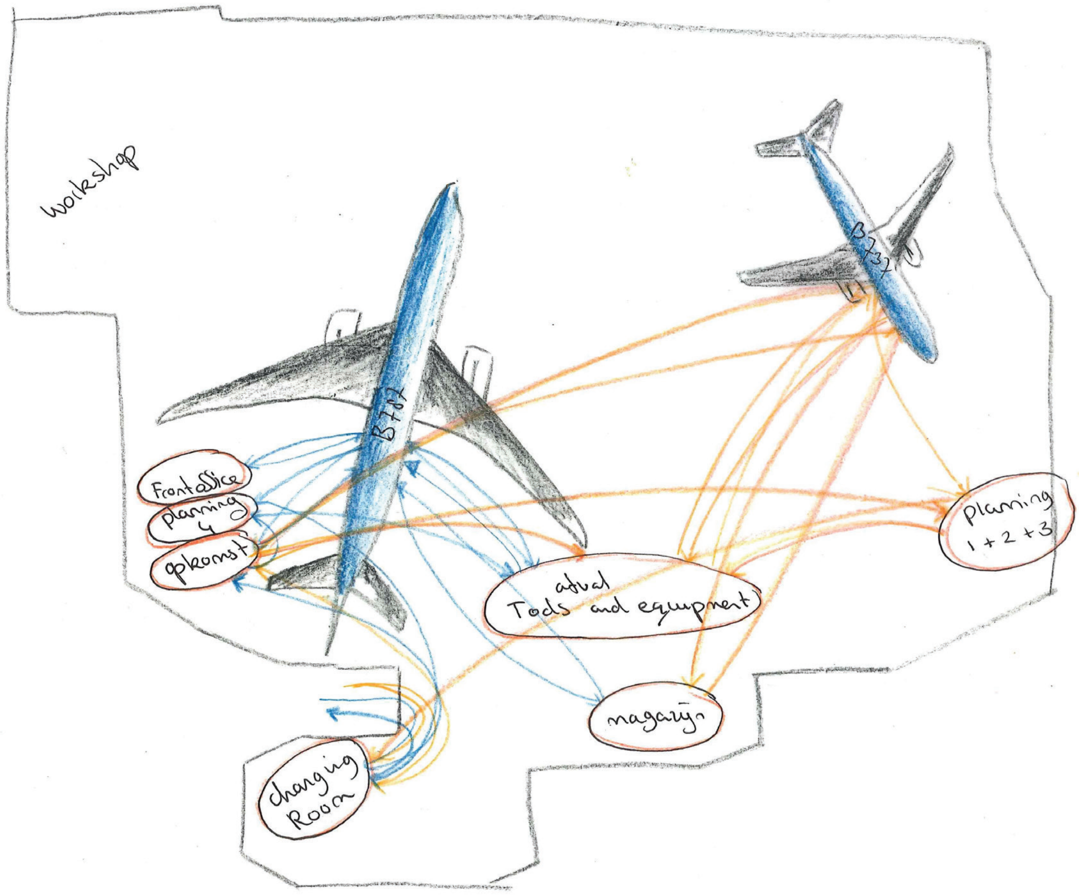
- enter hangar 12
- change clothes
- coffee @ opkomstruimte
- check in @ planruimte
- check material
- order new material
- start tasks
- get material @magazijn
- continue tasks
- (dinner) break
- continue tasks
- move to trash area
- check out @ planningsruimte
- change clothes
- Go home

## Spagetti chart Future movement flows

Option 1. Central Future




Option 2. Sides Future



# Positions offices in the hangar

## 2 options: Offices Central or on the sides

### Comparing Two options

**Pro's option 1. Side offices**
- Central area for tooling and equipment
  > Can be shared by all aircraft in H12
- Old buildings can be re-used
- Empty space on the sides of the hangar are used efficiently
- enough space on GF

**Contra's option 1. Side Offices**
- No central space and overview
  > unclear typology and wayfinding
- Longer walking distance to the "opkomstru-itme from the airplanes on the right side
- Mix equopment 787 + 737's
- Messy central area with equipment + tools
- Demolishing costs existing offices 1st floor.

**Pro's option 1. Central offices**
- Central space and overview
  > clear typology and wayfinding
- Feeling of unity between employees
- Statement architecture
- Clear separation tools equipment 737 787
- Short walking distance to all fascilities that are placed centrally
- Flexibility in future use of the rooms

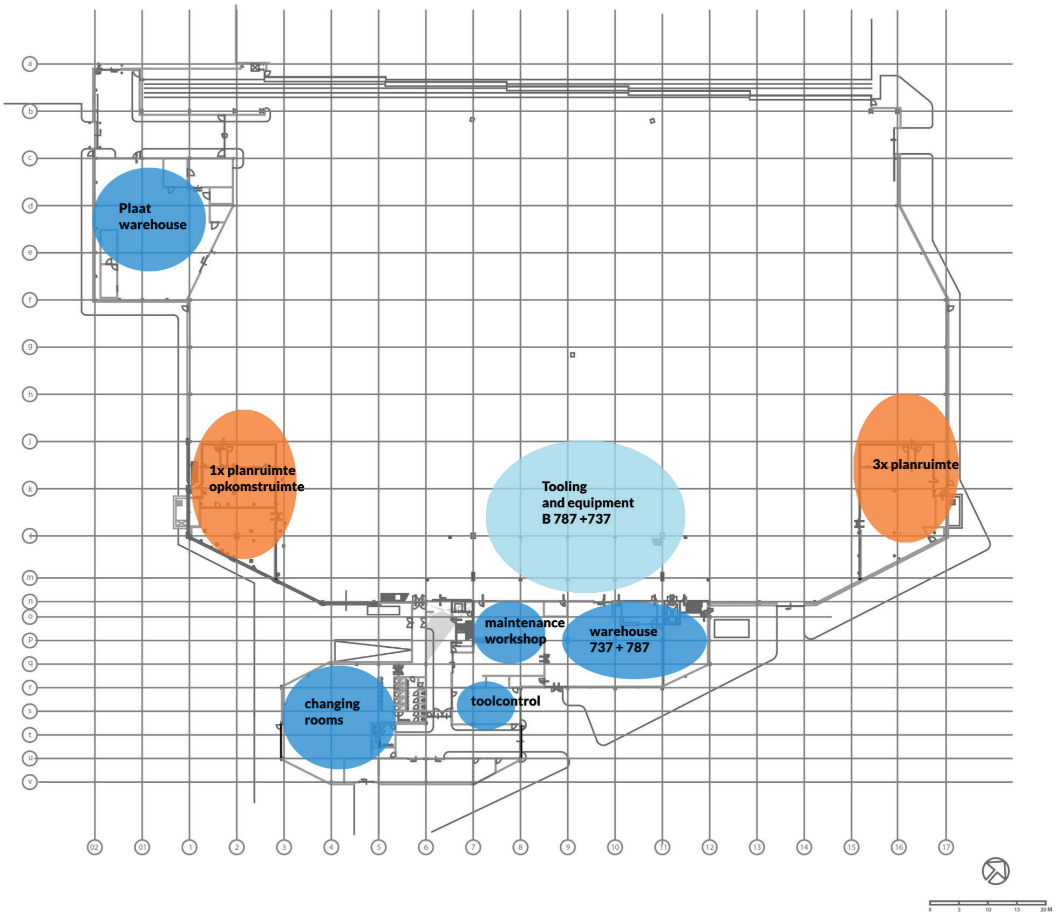
**Contra's option 1. Central Offices**
- No direct daylight offices
- Demolishing costs side existing rooms on the sides
- Sides are not an optimal position for sharing tools and equipment 787 - 737
- Not enough space GF> functions lifted to 1st floor > less open less contact

### CONCLUSIONS SPAGETTI CHART

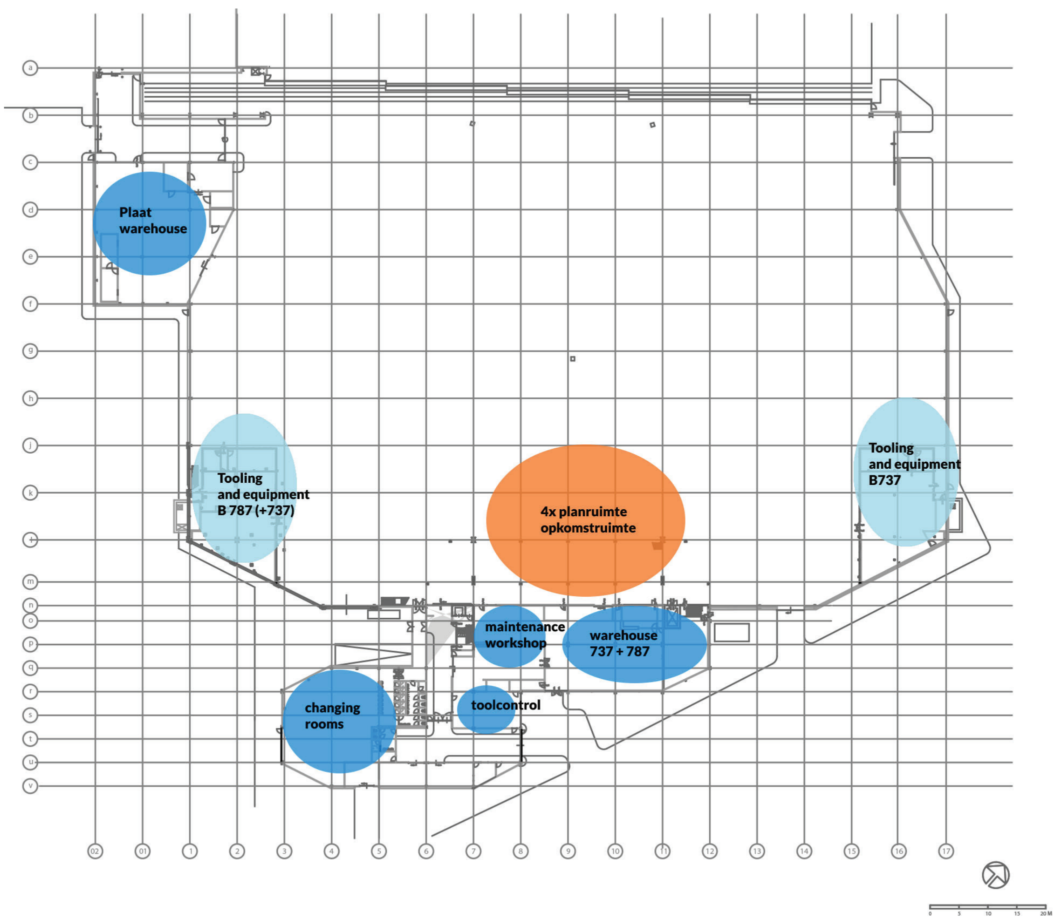
Taking the changes of the future into consideration, the location of the equipment and tools is more important than the location of the offices. The reason is that the offices will be used much less when tablets or laptops are available, whereas the equipment and tools will be of almost equal importance in the future. The 787 however will need more ITdriven maintenance due to its electrical system and less frequent maintenance because of the composite materials.

- Distance to Tools and Equipment is equal in both options
- Distance to Front office is much larger in the Sides option
- Tools and Equipment cannot be shared when not places centrally
- Distances in the Future will become shorter
- No significant distance differences between the two options.

## OPTION 1. OFFICES ON THE SIDES




## OPTION 1. OFFICES IN THE CENTRE



## 5.2 CONSTRUCTION H12

The firm Hollandia BV received a request on the 11th of August 1977 from KLM to compete with other companies to realize a new KLM hangar. Attached to this request was a global design for the hangar as visible in the figure.

Hangar 12 exists out of a square that has dimensions of **115x74 meters with a height of 38,4 meters.** On the short side and the south side of the hangar a lower part is built with a height of 28,3 meters to connect to the existing H11.

The following aspects were importent for the construction
1. The door opening had to be at least 103 meters and a free height of 25 meters to make sure the Boeings 747 could enter the hangar. In the definitive design this became 105x25 meters.
2. In the main area of the hangar a crane of 10.000kg had to be placed that could be used in the entire hangar.
3 size of the truss above the doors and the roof of the central area in the hangar that has to span 115 meters.

the systemsize of the roof is 114,45x73,35 meters. The roof exists out of a steel plate with isolation above this and on top a layer of bitumen. The purlingdistance could be 4 meters. the roof rests on several support points but not on the walls of the hangar.

Different span directions were investigated, but in the end the solution KLM already proposed turned out to be the best. The reasons for this were for example the different trus sizes that were easier to transport or cheaper to produce in this final option or the trusses of equal size that lowered the productioncosts.  The final construction is visible in the figure.

The most profitable span distance was calculated at 16,35 m. The truss head is designed as a fully clamped portal truss with a free span of 105 x 25 meter. To avoid big foot-moments a portal truss is laterally held by a heavy windcross at the doorwalls. The horizontal forces on the backside are supported by the two V collumns. Stability in the other direction is created by the crosses in the two walls on the sides of the doors.

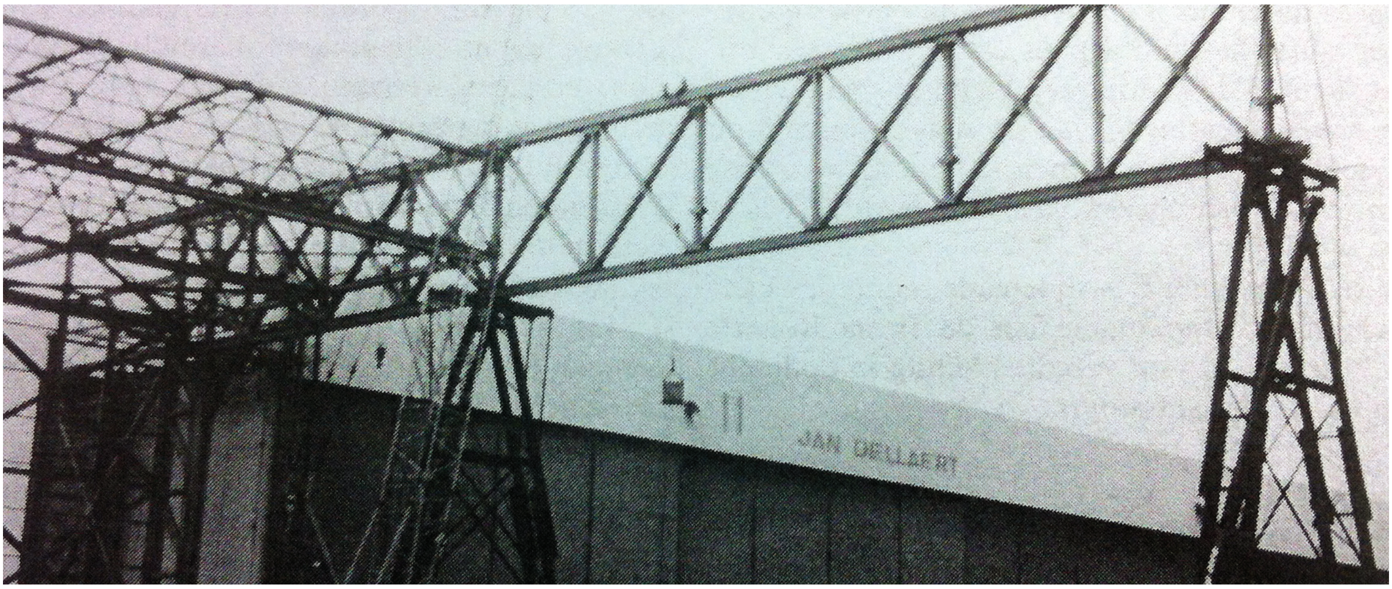
***Ir.C.D.J.Overhoff 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20

**>25m**
min height of hangar

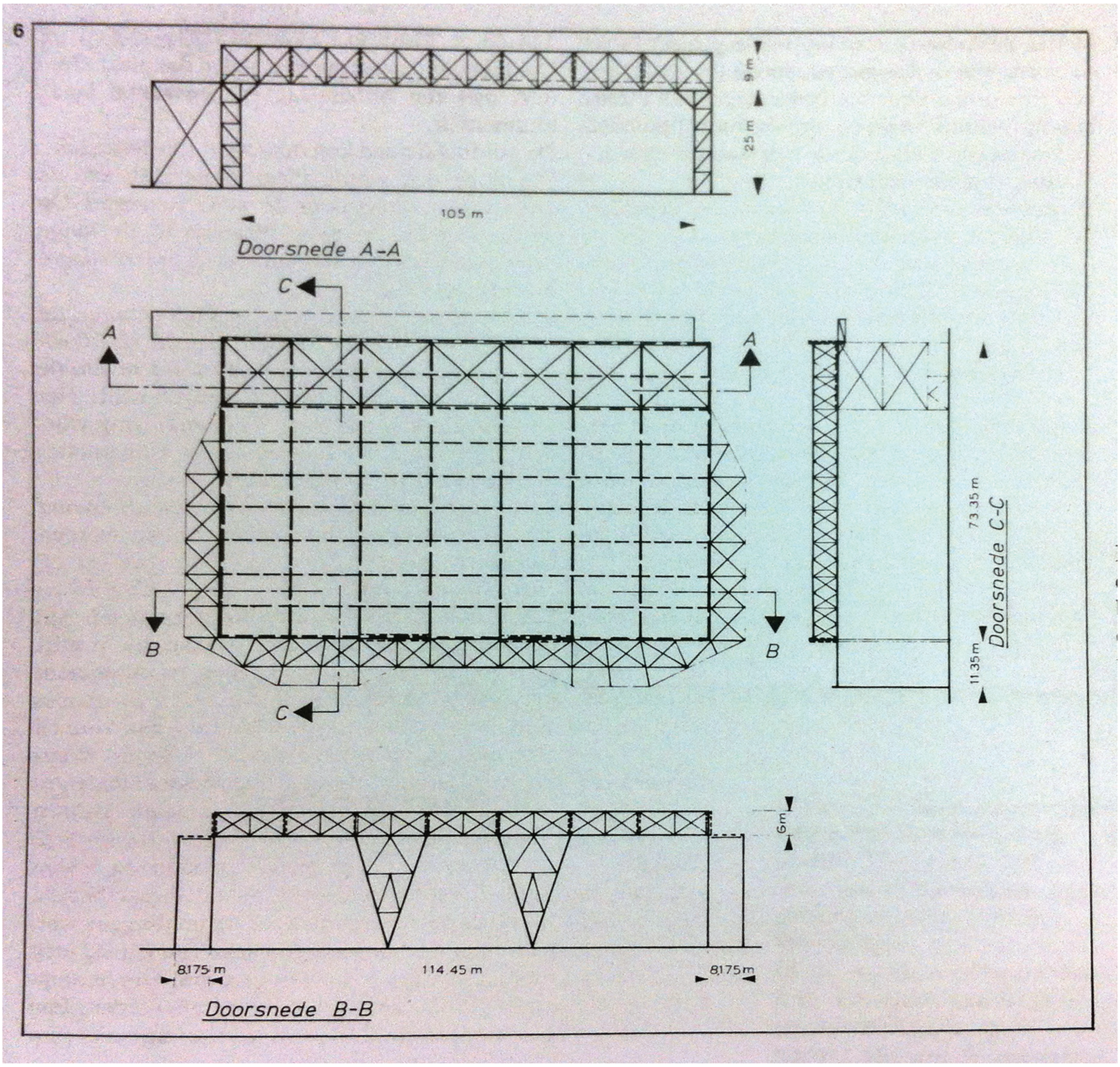
**2 B747**
Aircraft H12 was designed for

**35 m**
height of hangar

## Placement of the 16m trusses




## Construction H12




Source: 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20-29

## MAIN CONSTRUCTION

The main truss is 9 meters high and is located above the doors.The forces in this truss can reach up to 20.000 kN in the girder, 25.000 in the stanchion and 10.000 kN in the foot of the spant. The edges of the spant are therefore made out of linked HE and IPE profiles 600 series, see fig.  The diagonals are again these profiles and all the connectoins are bolted so that they could easily be transported to Schiphol. The 73 timbers (spanten) all have a construction height of 6 meters.

On the 16 trusses in the roof the purlins are located h.o.h 4,075 meters from each other that carry the steel roofskin.
In the walls the collumns are located 8meters h.o.h. from each other. The facade is linked to a horizontal construction (regels) that are connected to the construction by pull props (trekschoren) the lowest 2,4 meters exist out of prefab concrete elements with a window.

The taildocks are 26 meters high and are adjustable. This allows the hangar to be used for several different types of aircraft.

## EGGBUILDINGS OF H12

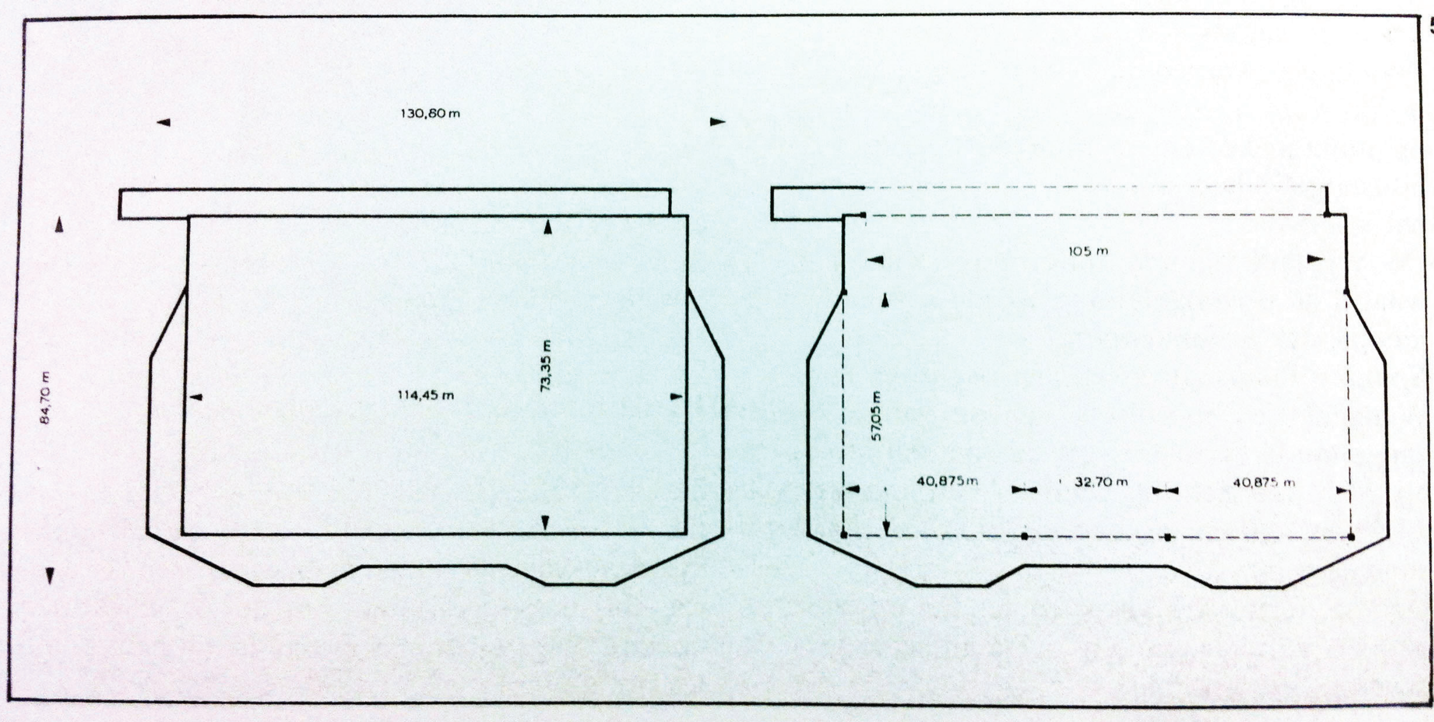
On the South side of the building  on the bataviaweg the offices are located. In the lower area (40mx20m 6 meters high)  a transport corridor is designed. In a three stories high part (50x20m 14 metres high a cantine and offices are located. The cantine is closed today.

The construction of these buildings exist out of a steel skeleton with concrete floorsprefab wallplates and Durax roof. The buildings are separated  because the fundations are realized seperatel and the 14 meter high buildings is realized seperately form H 12 because it would otherwise start following the relatively large movements of the large hangar. The 6 meters high buidings has two spans of 10,2m , the 14 meter high building has spans of 8, 10 and 15 meter. The montagetime was about a month.*

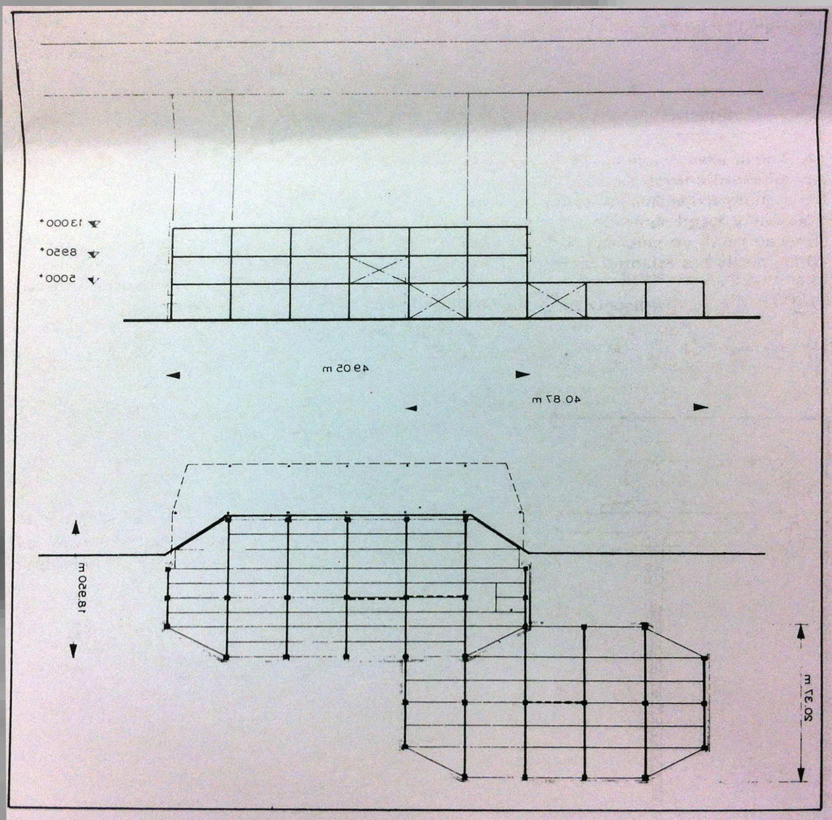
***Ir.C.D.J.Overhoff 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20

**115x73m**
**measuremnets hangaar hall**

## Scheme of H12




## Backside buildings H12



**Algemene gegevens staalconstructie**

Totaal constructiegewicht hangar 12, inclusief achterbouwen, deuren en staartdokken ± 3.000 ton.

| | |
|---|---|
| Materiaalkwaliteit | Fe 360 |
| Datum aanvraag | 11 augustus 1977 |
| Datum aanbieding | 26 september 1977 |
| Datum opdracht | 11 oktober 1977 |
| Aanvang montage hangar 12 | 4 september 1978 |
| Montage laatste spant | 8 december 1978 |
| Opdrachtgever – | KLM Afdeling Gebouwen |
| Ontwerp en vormgeving – | KLM Afdeling Gebouwen |
| Engineering – | Hollandia-Kloos N.V. |
| Berekenen, tekenen, leveren en monteren – | Hollandia-Kloos N.V. |

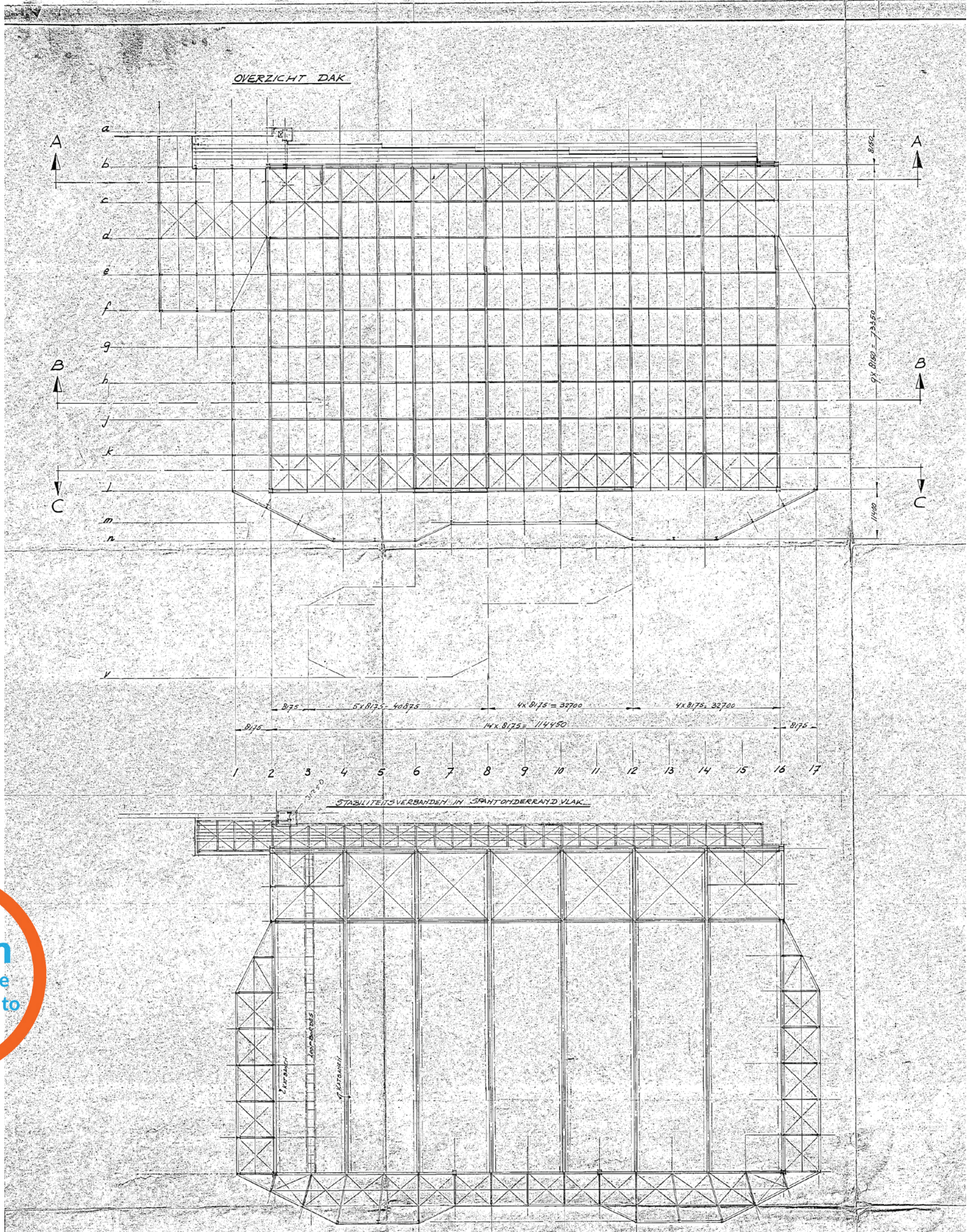
Onderaannemers:

| | |
|---|---|
| – staalconstructie | – H.C.W. |
| – elektrische installatie | – Croon & Co. |
| – hemelwaterafvoeren | – Heuvelmans B.V. |
| – liften | – Schindler |

Het bouwkundige deel is door de KLM, Afdeling Gebouwen, opgedragen aan de N.V.-S.L.S., waarbij de N.A.C.O. als adviseur optreedt.

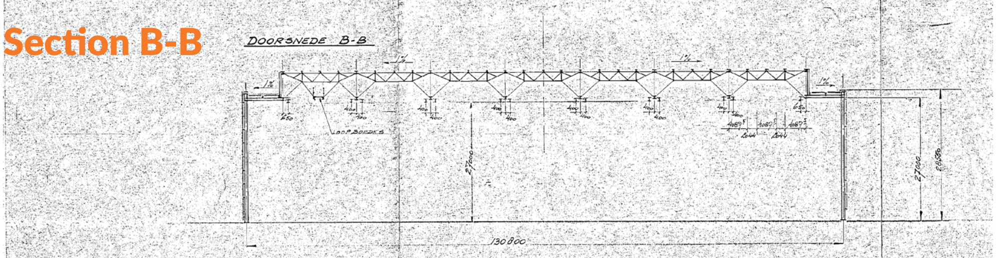
Source image: Ir.C.D.J.Overhoff 'Hangar 12', Bouwen met staal , No.48. 1979, pp 20

## Roof view H12

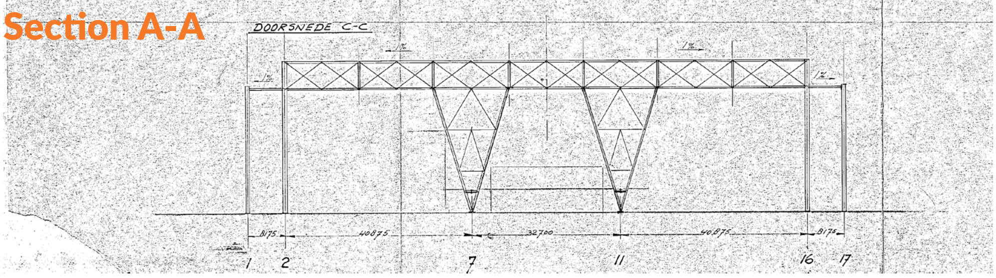


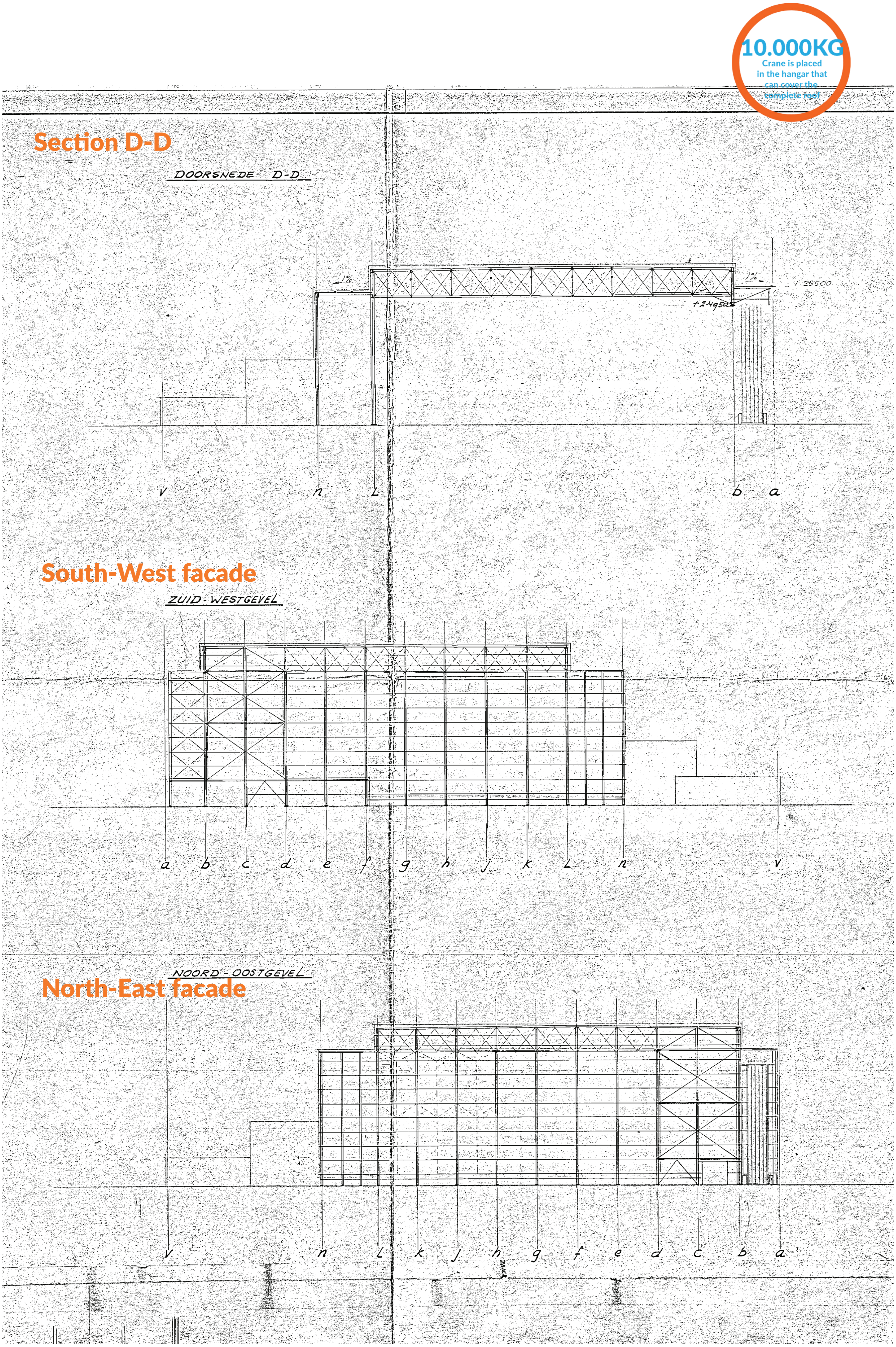

**>103 m**
min. size of the doors opening to place 2 B 747

## Section B-B



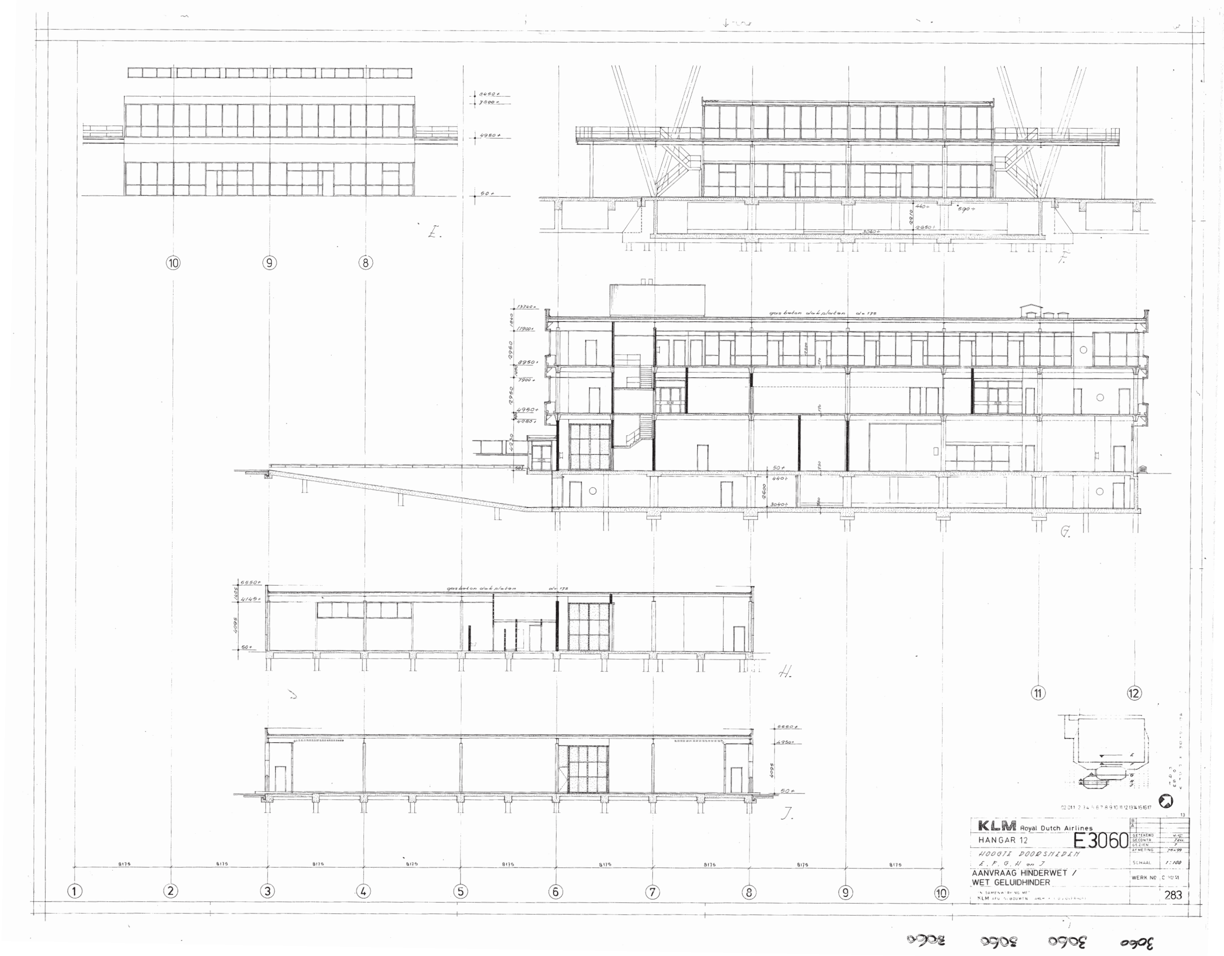

## Section A-A



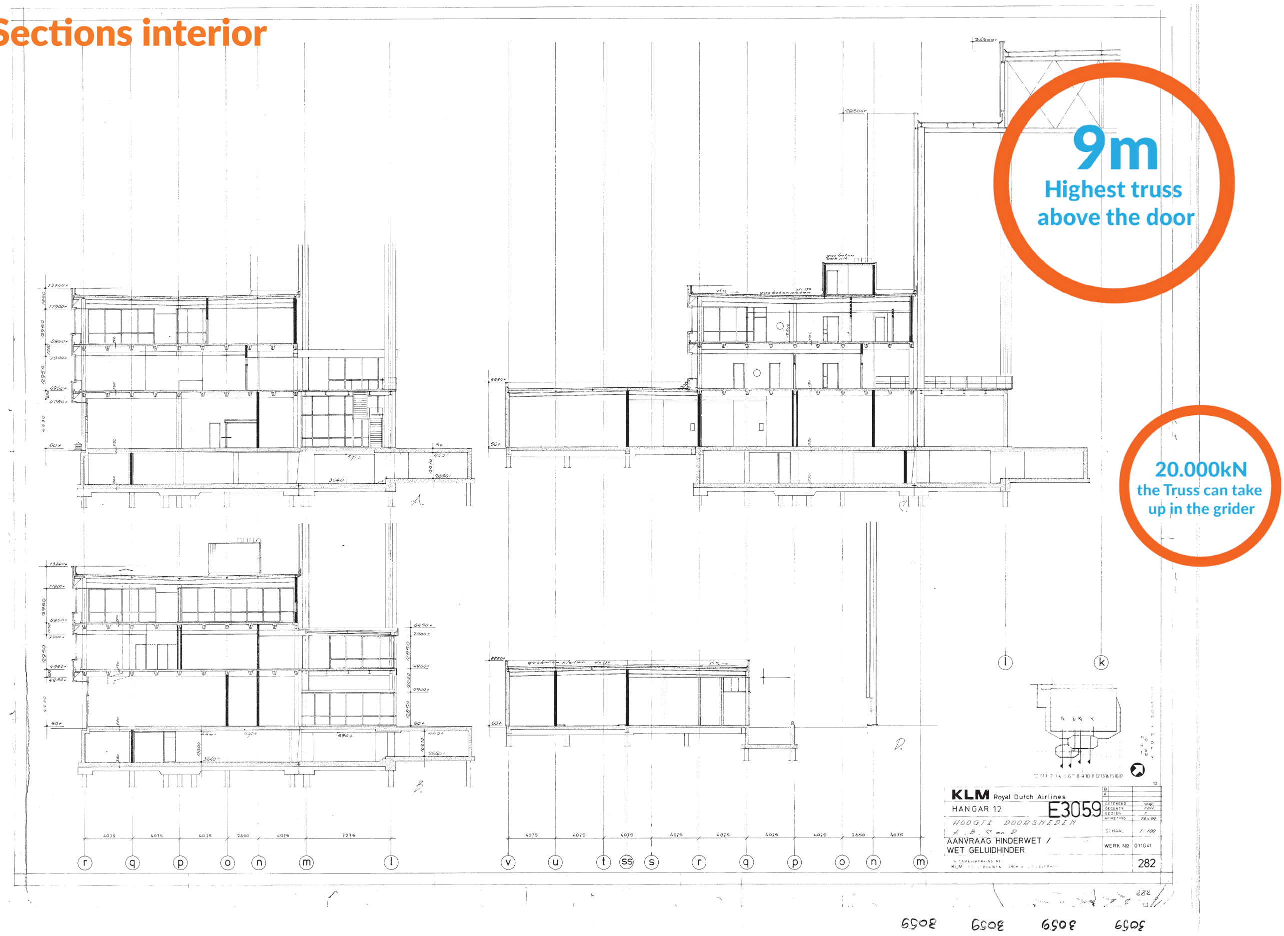



SourceKLM archive 1979 drawings Hollandia

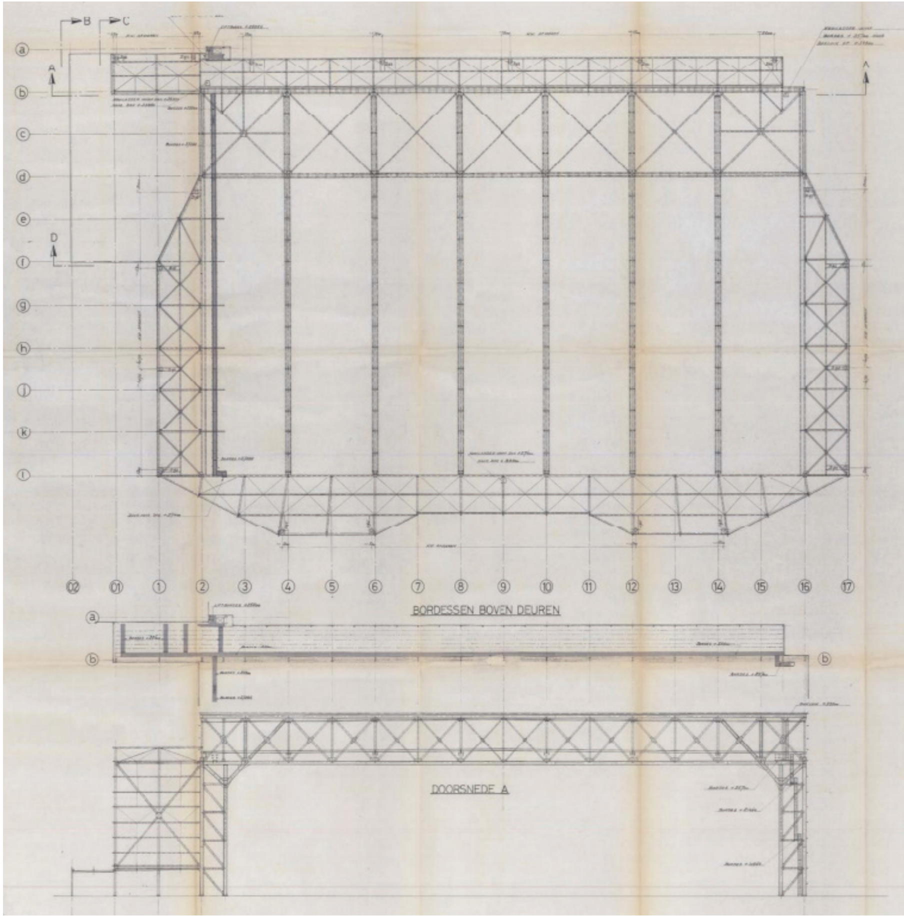
## Section interior



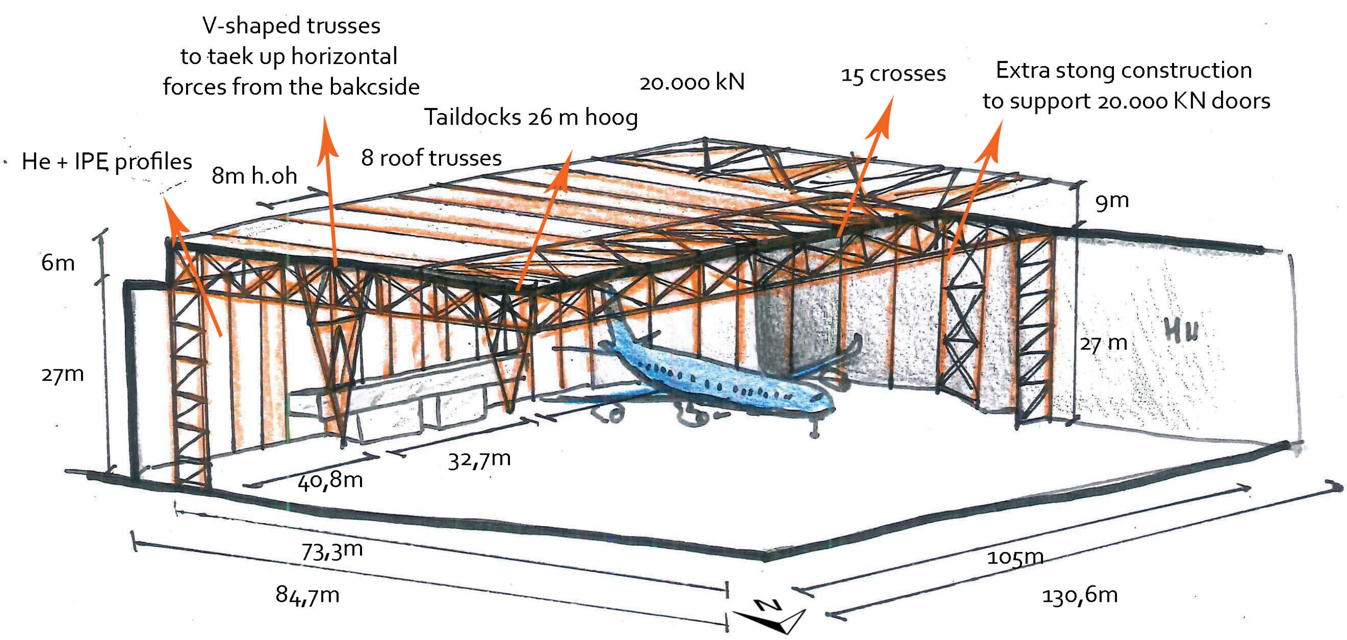

## Sections interior



## Roofview + Section A and door construction




## 3D analysis drawing



# 7.4 Noise

Sound waves are produced and spread in all directions. When the sound wave comes in contact with a hard surface, part of the wave is absorbed and part is reflected. The harder the surface, the larger the percentage of sound that is reflected and this causes reverberation in the room. The amount of reverberation is expressed in reverberation time. This is the time in seconds it takes for sound to decrease 60 dB in strength.
A longer reverberation time results in poorer acoustics and in both the hangar and the office, we expect an that he desired reverberation time will be exceeded.

## Advice Hangar

The acoustics in the room can be improved by the application of sound-absorbing materials. The reflections of noise are reduced by the application of sound-absorbing materials, and the reverberation time will be shortened.

### Reflections and reverberation time

The reduction of reflection is most effective in the immediate vicinity of sound sources but can also be reduced by using noise absorbing material. The farther the sound-absorbing surface is removed from the source, the more material is needed in order to achieve a positive result.

The shortening of the reverberation time is also carried out by the application of sound-absorbing materials and is in fact based on the same principal. It requires relatively large amounts of material to shorten the overall reverberation time in the space. The ceiling would provide the most suitable surface.

### Solutions and materials

In addition to acoustic properties, we also recommend things like durability and fire safety. It would be wise for the acoustics of the hangar to make a combination between acoustic measures under the ceiling and on the wall. In the offices the ceiling is the most effective surface. Depending on the final classification additional or more effective absorbent surfaces can be accomplished by also placing wall panels or acoustic room dividers.

### Hangar

In the hangar, it would be an option to use industrial ceiling islands as an acoustic measure. These islands are locally modular system with a visible profile in white and fitted between trusses, steel structures, etc. The ceiling islands can be mounted about 800 mm below the ceiling.

Additionally, it is recommend to place sound absorbing material on the bottom half of both short walls in the hangar. A combination of a durable and aesthetic solution is could be the use of perforated cassettes in the colour white provided with a sound absorbent pad based on polyester wool. The cassettes are placed at or between the horizontal girders. A photo can be printed on these panels as well. Combinations with light (backlight) are possible. To achieve the desired acoustics of about 2.5 seconds, approximately 8,000 m2 ceiling islands will be necessary as well as 2000 m2 of wall panels.

## Office

An option for the acoustics in the offices would be to apply Pyracoustic cylinder baffles. These cylinders are manufactured from high grade melamine foam. They have a diameter of 150 mm and a length ranging from 40 to 120 cm. these cilinders will still show the concrete ceiling with piplines that emphasize the industrial feeling of the hangar.

In order to achieve the desired reverberation time of 0.5 to 0.6 seconds 6quired. If varying lenghts are used, for example 40 and 80 cm, extra efficiency is realized since more frequencies can be absorbed.

Source: KLM Health Services and interview
noise advisor Easy Noise 01-06-2015

**Tabel 2. inschatting dagdosis, alleen van activiteiten waarvan verwacht wordt dat de dagdosis, door de bijdrage van geluidsbelastende activiteiten en/of de duur van de activiteit hoger dan 80 of 85 dB(A) uitkomt.**

| Procesnaam | ProcesNr. | Bron | Geluid (gem.) Leqw d(BA) | Piek (gem) | Duur werk | Lex, t* Bijdrage van de werkzaamheid | Lex, T * Dagdosis | Opmerkingen |
|---|---|---|---|---|---|---|---|---|
| **Klinken kleine nagels** | 1557 1514 | Klink hamer | 94,7 | 125,2 | Zeer wisselend, 1 uur /dag gem. | 86<br>1 uur 95 → 86<br>7 uur 70 → 69,4 | 86,1 | |
| **Klinken grote nagels** | 1557 1514 | Slaghamer | 103,3 | 133,9 | Dagelijks, ca. 5 min | 83,2 | 83,4 | |
| **Plaatwerk** | 1557 1514 | Cirkelzaag | 91,3 | 116,5 | 1,5 h/dag | 83,7 | 84 | Bij plaatwerk is de verwachting dat men meerdere werkzaamheden met schadelijk geluid uitvoert*. Geluidsniveau > 85 |
| **Plaatwerk** | 1557 1514 | Lintzaag | 95,4 | 117,9 | 0,5 h/dag | 83 | 83 | |
| **Hydraulic power** | 1515 | Hydr. blower | 99,7 | 116,6 | 15 min/week --> 3min/dag | 78 | 78,6 | |
| **Proefdraaien** | **1689** | **Draaiende motoren** | **95,5**<br>**108,8 (hoog vermogen)** | **119,6**<br>**126,7** | **15 min./test**<br>**10 min/test Aantal vliegtuigen wisselt per dag** | 80,9<br>94 | 81,3<br>94 | Uitgaande van min. 1 proefdraai per dag 15 min. ONDERSCHATTING |
| **Idle** | 1689 | Stationair opwarmen | 86,6 | 88,9 | Ca. 10 min/vl.tuig 5 vl.tuig/dg =60 min. | 78 | 79 | |
| **Cranken 777** | 2179 | Motor | 117,4 | 132,3 | 5 min/dag max. 12x/24 uur | 103,6 (uitgaande van 20 min) | 103,6 | 3 min /motor bij Engine water wash |
| **Cranken 737** | 2179 | Motor | 105,3 | 109 | Ca. 4-5 min. per keer, circa 4/wk | 85,5 | 85,6 | Uitgaande van worst case, 1x dag Engine waterwash→ buiten |
| **ADP** | 1515 | Pomp motor | 106,4 | 117,4 | 6 keer/dag 20 min. totaal | 92,6 | 92,6 | |
| **Jetstarter** | 2179 | Diesel pomp | 90,3 | 97,3 | 10 min. | 73,5 | 75,1 | Starten wordt gevolgd door proefdraaien motor. + proefdraaien hoog verm. > 85 |
| **Hogedruk-spuit** | 1564 1569 | Spuit | 85,8 | 91,2 | 2 uur per dag | 80 | 80,3 | |

Rood = > 85 dB(A) → Verplicht dragen van gehoorbescherming (en toezicht wg), markeren bronnen/werkplaatsen en schriftelijk plan van aanpak verminderen geluidsniveau

## Most noise producing activities in maintenance

| Geluidsbron | Leqw dB(A) | Lpiek | Demping Otoplas-tiek | Gedempt tot x dB(A) | Demping Oorkap | Gedempt tot x dB(A) | Blootstellingstijd min/dag |
|---|---|---|---|---|---|---|---|
| Cranken 777 | 117 | 132 | 22 | 95 | 25 | 92 | Wisselend (20 min.) |
| Proefdraaien | 109 | 127 | 22 | 87 | 24 | 85 | 10-15 |
| Lintzaag | 94-110 | 110 | 26 | 84 | 40 | 70 | Wisselend (min. 5 minuten..) |
| Slaghamer | 103 | 134 | 20 | 83 | 17 | 86 | 5 min |
| ADP | 106 | 117 | 23 | 83 | 27 | 79 | 6/dag (20 min) |
| Cranken 737 | 105 | 109 | 24 | 81 | 31 | 74 | 4-5 min. |

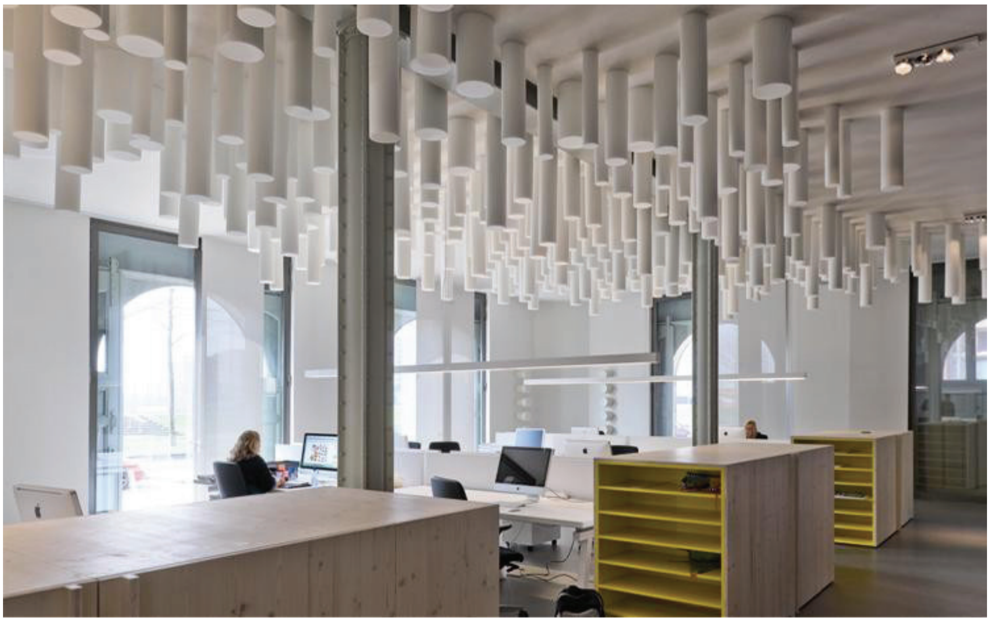
**>80db**

10 activities produce >80db
which is the max healthy level

## Estimated reverberation time (nNagalmtijd)

| | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | Gem. |
|---|---|---|---|---|---|---|
| **Hangaar** | 4,5 – 6,5 | 4,5 – 6,5 | 4,5 – 6,5 | 4,5 – 6,5 | 4,5 – 6,5 | 4,5 – 6,5 |
| **Kantoor** | 1,0 – 1,2 | 1,0 – 1,2 | 1,0 – 1,2 | 1,0 – 1,2 | 1,0 – 1,2 | 1,0 – 1,2 |

Source: advisor Easy Noise 01-06-2015
CSR report KLM 2009

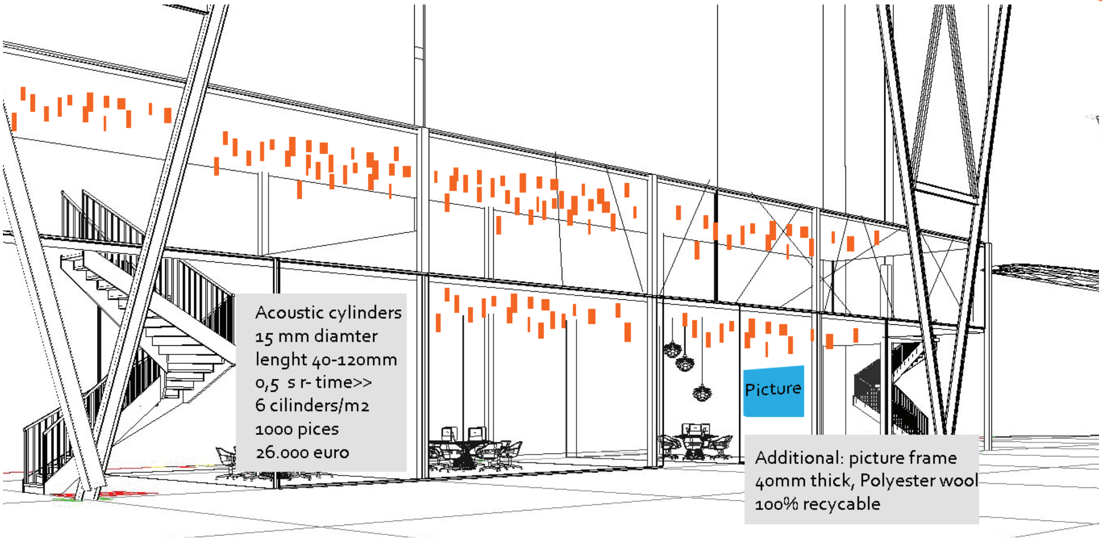


## Prices

| | | |
|---|---|---|
| **Pyracoustic Cilinder baffle 400 – 600 stuks**<br>- Op basis van wit melamineschuim<br>- Afmeting Ø x L = 150 x 400 mm<br>- Voorzien van plug + haak<br>**Richtprijs** | **€** | **9.000,-** |
| **Pyracoustic Cilinder baffle 600 – 600 stuks**<br>- Op basis van wit melamineschuim<br>- Afmeting Ø x L = 150 x 600 mm<br>- Voorzien van plug + haak<br>**Richtprijs** | **€** | **12.000,-** |
| **Montage**<br>- Inclusief reiskosten /reisuren<br>- Projectbegeleiding<br>- Uitgaande van normale werktijden / werkdagen<br>**Richtprijs** | **€** | **5.000,-** |
| **Totaal**<br>**Prijs** | **€** | **26.000,-** |



## 3D cilinders in offices




## Conluding drawing Noise H12

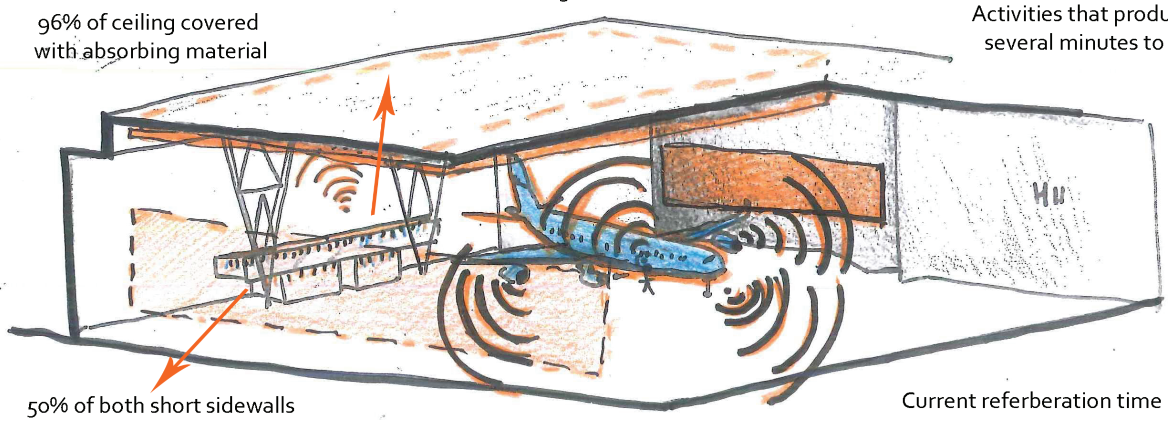
Activities with the highest level of noise:
1. Cranken (testing engine inside)
2. Proefdraaien (outside)
3. ADP
4. Plaatwerk

More then one
activity can be performed
by the same employee

Current referberation time offices 1s
desired time 0.5s

96% of ceiling covered
with absorbing material

Activities that produce noise are shor
several minutes to mac 2 hours/day



50% of both short sidewalls
covered with absorbing material

Current referberation time hangar 5 s

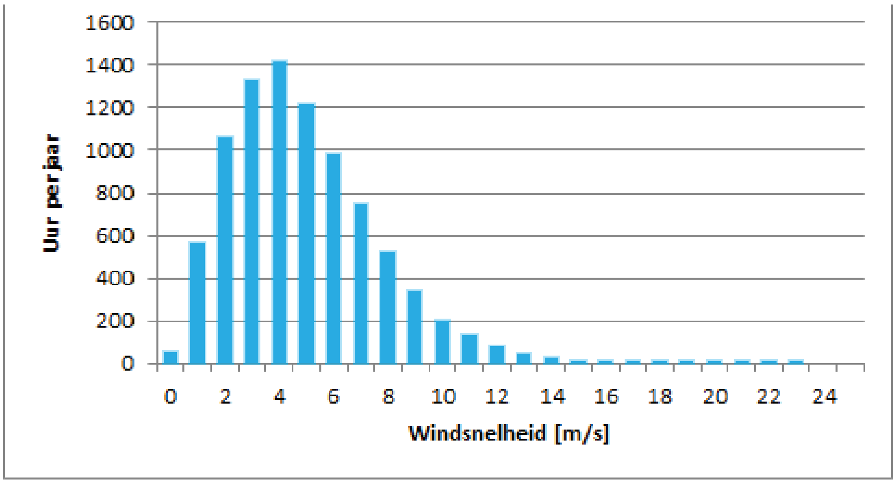
All measured activites produce noise over 80DB

Pek noise stays under 140PA

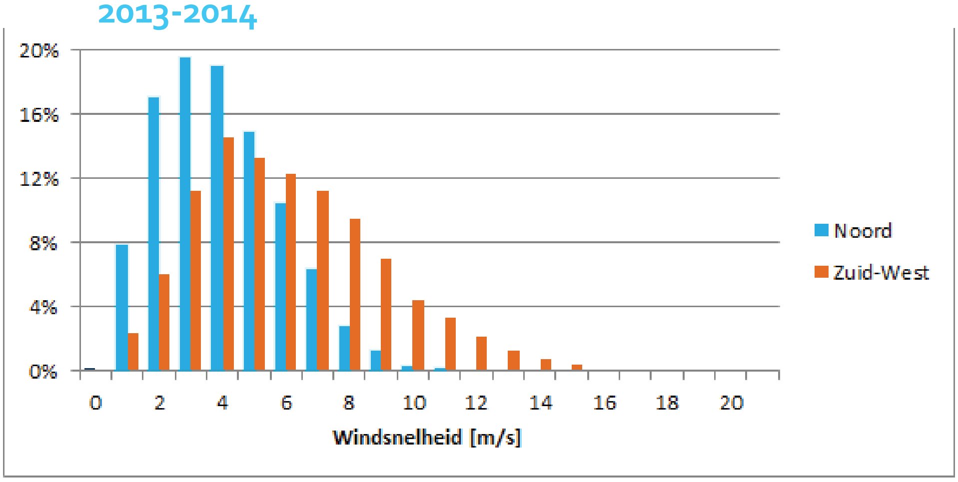
Daily noise has to be < 87 dB(A)
(incl. earprotection)

(report KLM : RI&E AM0015 Verdiepende RI&E Schadelijk geluid

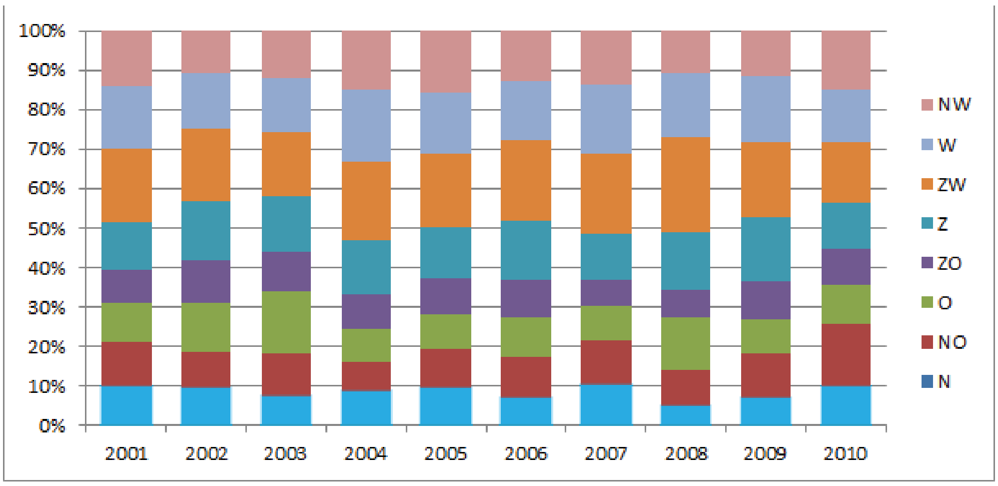
## Frequentie windsnelheden op Schiphol 2013-2014




## Rel. Frequente windsnelheden Schiphol 2013-2014




## Windrichting op Schiphol 2013-2014



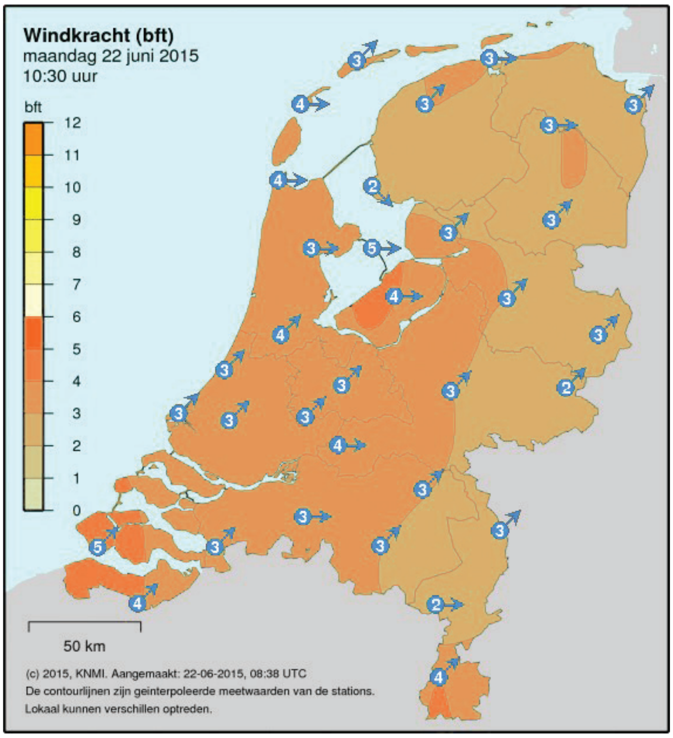

Source: Website KNMI.nl retreived on 28-06-2015

# 7.5 Wind

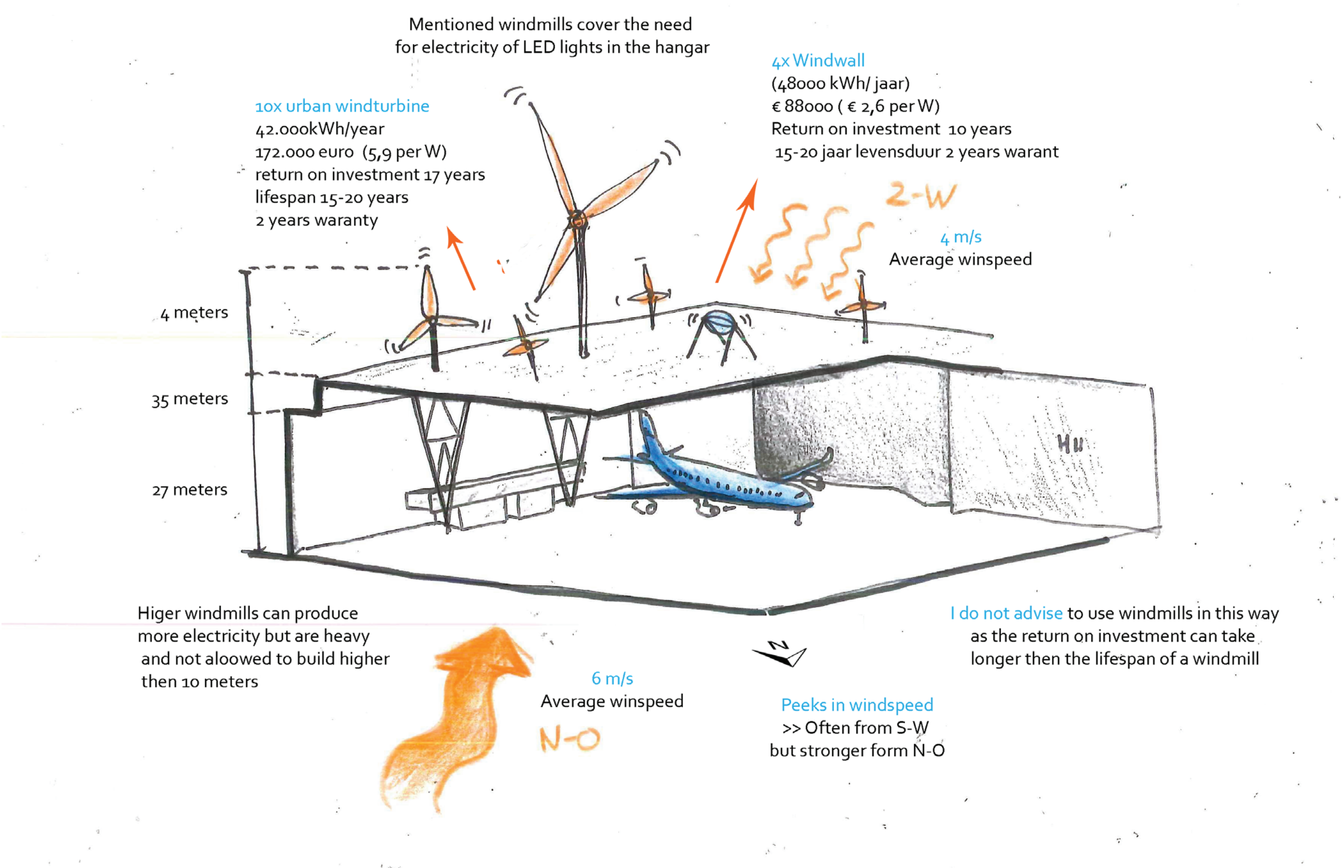
The KNMI (Koninklijk Nederlands Meet Insituut) gathers it's data about the wind at schiphol form a measurement centre at Schiphol. This station however is located at 10 meters height. The reason why this data is interesting for us is to get information on which type of windmill we could use to place on the roof or next to our hangar.

As the measurement station is located at 10 m height and our Hangar will be 35 meters high, I did extra measurements with a portable windmeter to validate the data. The average windspeed is around 5 m/s d but differences excist as the N-O wind is much stronger then the Z-W wind.

## Windkracht in Nederland 22 juni 2015




## 3D visualisation of findings Wind and windmills



# 7.6 Hangar doors

The KLM doors in H12 are old and require large maintenance, this will cost about 3 million euro. Therefore other options for hangar doors were also investigated as this would be a good moment to switch to a new system. The 5 doors of  20 meters each are 27 meters high and currently work with a sliding sytem. An option is to remove the current system and switch to a doorsystem that works vertically in stead of horizontally as it is today. After consulting a hangar in Germany where this ‘ megadoor’ system is used it turned out that it was not a good solution. The maintenance of this new system is much higer then the current simple sliding method.

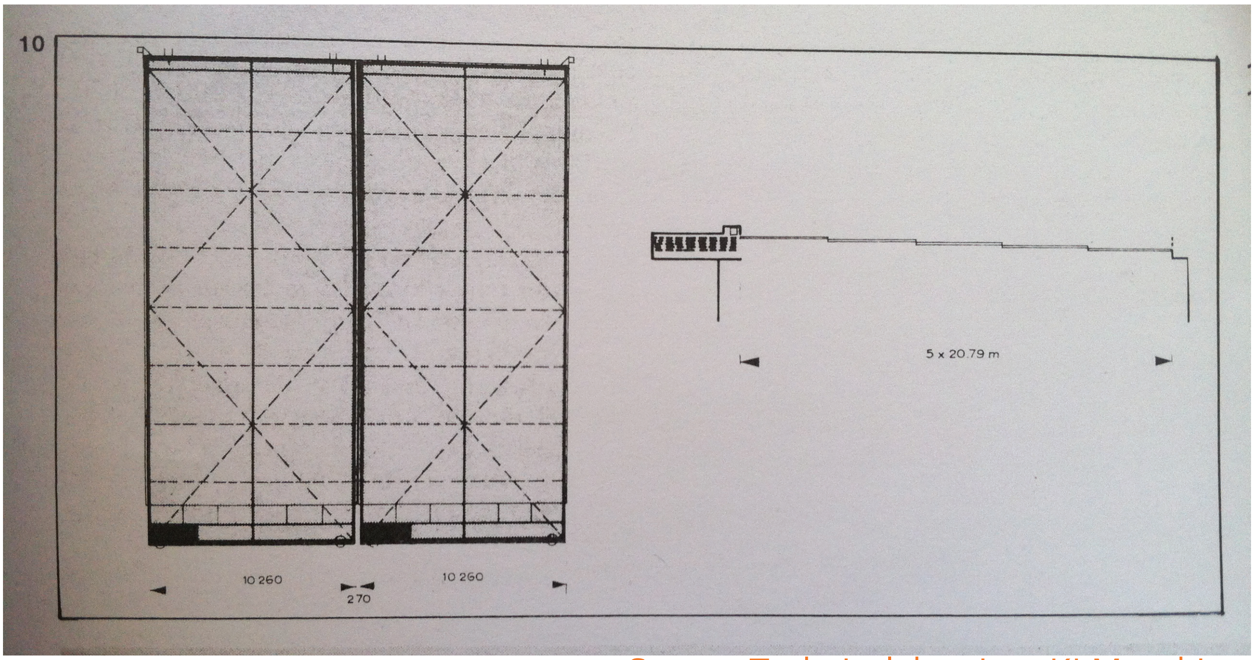
Probably KLM will replace the current door panels with transparent material and keep the current system.

**Current hangar doors H12**

**20 m**
size of one door

**27 m**
height of the doors

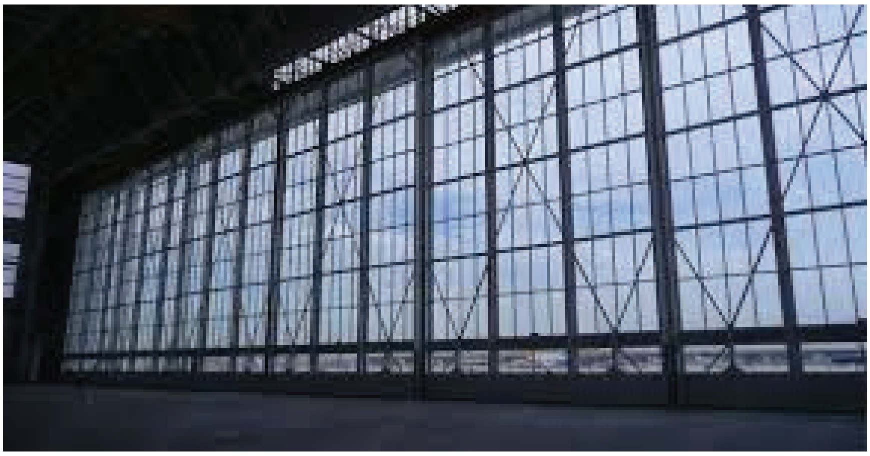
**Drawing one hangar door + overview total**



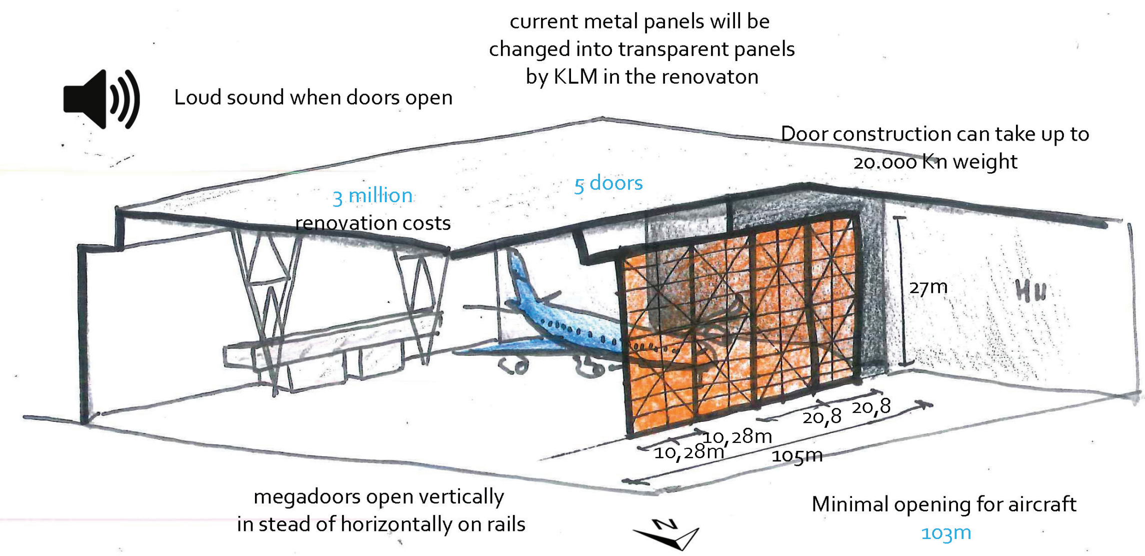

Source: Technical drawings KLM archive

## Explanation of Mega door system

## Visualization of transparant door system



## 3D oview of current door system



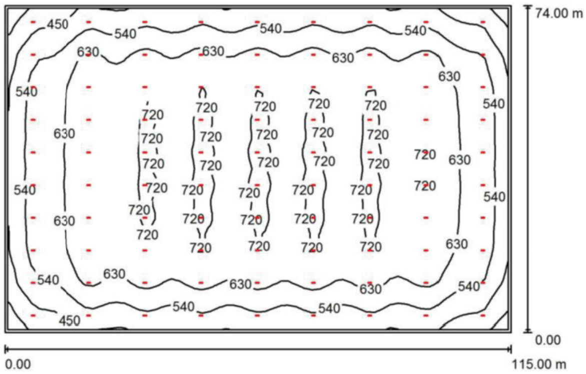
# Lights

Currently the hangar has gasontladingslampen which do not provide enough light on the workarea and have a very warm orange colour (Ra 25, lux 400)

KLM could replace these lamps with a system that is called Green Horizon. This means that the current system is preserved but the lamps are changed. In stead of 173 lamps only 103 would then be necessary. This system improves the light color and amount of lux but is far from ideal. It does save energy and therefore costs.

Another idea is to change the system to LED, this will be a larger investment and has an extra 4 year return on investment time. It will have the same financial consequences but a better quality in light.

## Current lights H12




Raster: 64 x 64 Punten

| $E_{gem}$ [lx] | $E_s$ [lx] | $E_{max}$ [lx] | $E_s$ / $E_{gem}$ | $E_s$ / $E_{max}$ |
|---|---|---|---|---|
| 407 | 86 | 601 | 0.212 | 0.143 |

## Lux on workground

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 128 | 179 | 230 | 240 | 274 | 286 | 277 | 309 | 293 | 293 | 307 | 274 | 291 | 276 | 265 | 285 | 251 | 238 | 225 | 143 | 112 |
| 157 | 220 | 290 | 299 | 344 | 356 | 335 | 394 | 371 | 367 | 395 | 338 | 360 | 343 | 317 | 355 | 318 | 296 | 282 | 173 | 134 |
| 198 | 274 | 353 | 355 | 400 | 420 | 404 | 466 | 439 | 435 | 467 | 394 | 419 | 405 | 377 | 416 | 372 | 348 | 331 | 217 | 169 |
| 235 | 311 | 393 | 386 | 436 | 445 | 435 | 492 | 454 | 458 | 488 | 421 | 459 | 433 | 410 | 452 | 393 | 378 | 364 | 250 | 210 |
| 292 | 357 | 433 | 426 | 461 | 470 | 439 | 502 | 473 | 464 | 502 | 437 | 471 | 455 | 425 | 472 | 427 | 407 | 405 | 291 | 258 |
| 352 | 402 | 463 | 438 | 463 | 469 | 438 | 497 | 471 | 460 | 500 | 432 | 471 | 456 | 429 | 481 | 434 | 426 | 428 | 327 | 315 |
| 393 | 435 | 484 | 455 | 477 | 467 | 443 | 489 | 459 | 454 | 487 | 438 | 480 | 459 | 439 | 482 | 432 | 432 | 438 | 367 | 361 |
| 426 | 461 | 502 | 464 | 470 | 472 | 432 | 498 | 464 | 454 | 497 | 435 | 474 | 468 | 436 | 486 | 442 | 444 | 469 | 383 | 390 |
| 442 | 471 | 513 | 467 | 473 | 474 | 445 | 509 | 482 | 468 | 510 | 449 | 485 | 469 | 443 | 493 | 451 | 458 | 483 | 405 | 409 |
| 447 | 478 | 511 | 467 | 483 | 483 | 468 | 526 | 494 | 487 | 520 | 465 | 508 | 481 | 454 | 499 | 450 | 460 | 481 | 423 | 430 |
| 446 | 473 | 512 | 467 | 477 | 499 | 491 | 557 | 519 | 518 | 548 | 475 | 510 | 488 | 462 | 507 | 463 | 477 | 510 | 428 | 429 |
| 435 | 466 | 504 | 465 | 488 | 488 | 505 | 594 | 526 | 524 | 556 | 474 | 525 | 491 | 456 | 502 | 472 | 495 | 518 | 437 | 435 |
| 406 | 442 | 480 | 447 | 488 | 483 | 500 | 580 | 513 | 507 | 523 | 455 | 503 | 476 | 442 | 484 | 459 | 486 | 494 | 424 | 426 |
| 366 | 413 | 450 | 422 | 458 | 478 | 466 | 525 | 460 | 450 | 467 | 399 | 445 | 425 | 404 | 449 | 423 | 464 | 468 | 388 | 391 |
| 283 | 343 | 394 | 364 | 383 | 404 | 376 | 397 | 359 | 331 | 338 | 307 | 336 | 334 | 350 | 379 | 371 | 408 | 417 | 331 | 305 |
| 223 | 281 | 324 | 295 | 308 | 334 | 299 | 298 | 272 | 250 | 247 | 232 | 250 | 256 | 297 | 306 | 301 | 344 | 356 | 279 | 235 |

74.00 m
0.00
0.00
115.00 m

Hoogte van de ruimte: 35.000 m, Montagehoogte: 27.000 m, Behoudfactor: 0.85

Waarden in Lux, Schaal 1:951

| Vlak | ρ [%] | $E_{gem}$ [lx] | $E_s$ [lx] | $E_{max}$ [lx] | $E_s$ / $E_{gem}$ |
|---|---|---|---|---|---|
| Werkvlak | / | 407 | 86 | 601 | 0.212 |
| Vloer | 20 | 402 | 87 | 606 | 0.218 |
| Plafond | 70 | 75 | 40 | 93 | 0.527 |
| Muren (4) | 50 | 104 | 41 | 385 | / |

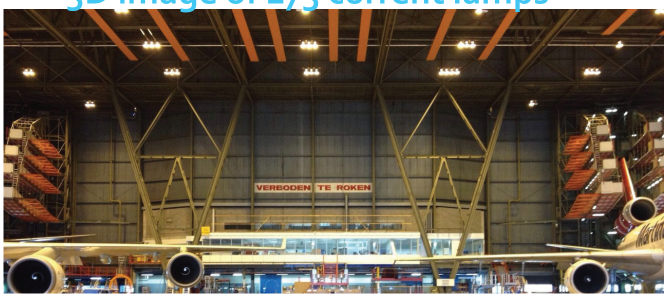
**Werkvlak:**
Hoogte: 0.100 m
Raster: 64 x 64 Punten
Randzone: 0.600 m

**Armaturen stuklijst**

| Nr. | Stuk | Type (Correctiefactor) | Φ (Armatuur) [lm] | Φ (Lampen) [lm] | P [W] |
|---|---|---|---|---|---|
| 1 | 173 | DOUBLE LUX klokarmatuur 300W, 45 graden (1.000) | 24764 | 31412 | 307.9 |
| | | | Totaal: 4284088 | Totaal: 5434276 | 53266.7 |

Specifiek vermogen: 6.26 W/m² = 1.54 W/m²/100 lx (Oppervlakte: 8510.00 m²)

## 3D image of 173 current lamps




## Specifications Green Horizon lamps

HUIDIGE ENERGIE VERBRUIK **ZONDER** DE GREEN HORIZONS ENERGIE BESPARENDE TECHNOLOGIE

| Locatie | Werkuren | Daadwerkelijk verbruik per lamp (watt) | Aantal armaturen | Jaarlijkse energie kosten per lamp | Jaarlijkse kosten alleen voor de lamp (€ 50) | Jaarlijkse kosten hoogwerker & arbeid (€1000+1600/173) | Totale jaarlijkse kosten per armatuur | Totale jaarlijkse kosten |
|---|---|---|---|---|---|---|---|---|
| Hangar 12 | 24 x 7 | 440watt | 173 | € 385,44 | € 50,- | € 15,- | € 450,44 | € 77.926,12 |

ENERGIE VERBRUIK **MET** DE GREEN HORIZONS ENERGIE BESPARENDE TECHNOLOGIE

| Locatie | Werkuren | Daadwerkelijk verbruik per lamp (watt) | Aantal armaturen | Jaarlijkse energie kosten per lamp | Jaarlijkse kosten alleen voor de lamp (€ 50/2 jaar) | Jaarlijkse kosten hoogwerker & arbeid (€1000+1600/173/2) | Totale jaarlijkse kosten per armatuur | Totale jaarlijkse kosten |
|---|---|---|---|---|---|---|---|---|
| Hangar 12 | 16 x 7 | 240watt | 140 | € 142,46 | € 25,- | € 7,50 | € 174,96 | € 24.494,40 |

## 600 lux futuristic twistable arioled

| VarioLed XL 3.0 | |
|---|---|
| Vermogen | 180 Watt, 300 Watt |
| Kleurtemperatuur | 5500 Kelvin |
| Lumenoutput | 180 Watt Ca. 18000 Lumen<br>300 Watt Ca. 33000 Lumen |
| Uitstralingshoek | 90° |
| Verstelbaarheid | 100° - 270° |
| Powerfaktor | >0.94 |
| Kleurweergave Ra-CRI | >75 |
| Materiaal | Aluminium |
| Driver | Meanwell Class I/ Tüv |
| Spanning | AC 100-240V |
| IP Class | IP 65 |
| Garantie | 5 jaar |
| Levensduur | >50000 uur |
| Keuring | CE- RoHS |


## Specs Varioled Kloklamp

| | 80 Watt | 120 Watt | 150 Watt | 200 Watt | 300 Watt |
|---|---|---|---|---|---|
| **Afmetingen HxB** | 477x160mm | 484x200mm | 494x200mm | 524x200mm | 594x240mm |
| **Bevestiging** | Pendel | Pendel | Pendel | Pendel | Pendel |
| **Kleurtemperatuur** | 5500 Kelvin | 5500 Kelvin | 5500 Kelvin | 5500 Kelvin | 5500 Kelvin |
| **Lumenoutput** | Ca. 8000 Lumen | Ca. 12000 Lumen | Ca. 15000 Lumen | Ca. 20000 Lumen | Ca. 29000 Lumen |
| **Artikelnr 45° Reflektor Φ 420 mm** | DL41580DL | DL415120DL | DL415150DL | DL415200DL | DL415300DL |
| **Artikelnr 120° Reflektor Φ 500 mm** | DL51580DL | DL515120DL | DL515150DL | DL515200DL | DL515300DL |
| **Systeem vermogen** | 89 Watt | 132 Watt | 162 Watt | 218 Watt | 325 Watt |
| **LED chip** | Bridgelux | Bridgelux | Bridgelux | Bridgelux | Bridgelux |
| **Powerfaktor** | >0.95 | >0.95 | >0.95 | >0.95 | >0.95 |
| **Kleurweergave Ra-CRI** | >80 | >80 | >80 | >80 | >75 |
| **Gewicht** | Ca. 6.2 Kg | Ca. 7.8 Kg | Ca. 9.3 Kg | Ca. 9.9 Kg | Ca. 16.8 Kg |
| **Materiaal** | Anodised aluminium/ Steel | Anodised aluminium/ Steel | Anodised Aluminium/ Steel | Anodised Aluminium/ Steel | Anodised Aluminium/ Steel |
| **Driver** | Meanwell Class I/ Tüv | Meanwell Class I/ Tüv | Meanwell Class I/ Tüv | Meanwell Class I/ Tüv | Meanwell Class I/ Tüv |
| **Spanning** | AC 85-265V | AC 85-265V | AC 85-265V | AC 85-265V | AC 85-265V |
| **Dimbaar** | optioneel | optioneel | optioneel | optioneel | optioneel |
| **IP Class** | IP 65 | IP 65 | IP 65 | IP 65 | IP 65 |
| **Bedrijfstemperatuur** | -40°C-+55°C | -40°C-+55°C | -40°C-+55°C | -40°C-+55°C | -30°C-+45°C |
| **Garantie** | 5 Jaar | 5 Jaar | 5 Jaar | 5 Jaar | 5 Jaar |
| **Levensduur** | >50000 uur | >50000 uur | >50000 uur | >50000 uur | >50000 uur |
| **Keuring** | CE- RoHS | CE- RoHS | CE- RoHS | CE- RoHS | CE- RoHS |
| **Verpakking** | 1St./Karton | 1St./Karton | 1St./Karton | 1St./Karton | 1St./Karton |
| **Geproduceerd volgens EN 55015:2006/A2:2009 EN61000-3-2-2006/A2:2009; EN 61000-3-3-:2008 EN 61547:2009** | Ja | Ja | Ja | Ja | Ja |

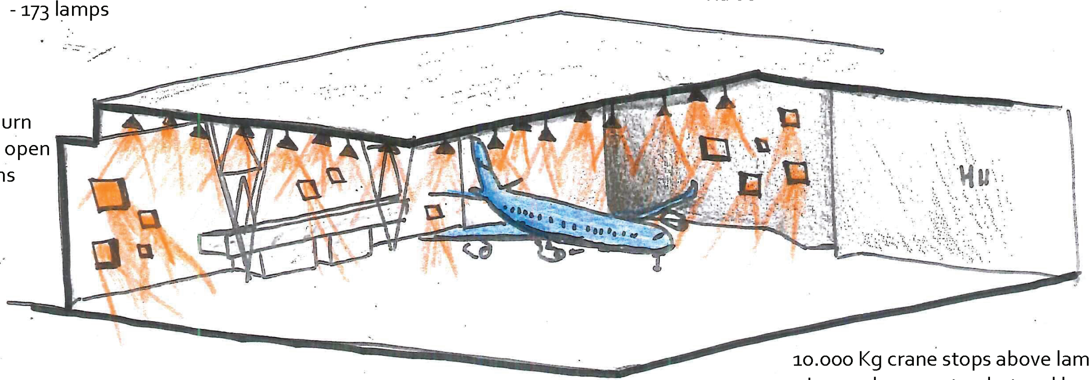
## 3D Overview Lights H12

optie 2 DoubleLux LED
- 325 W
- 50.000 hours lifetime
- placing takes 9-10 days
- 600 lux
- Ra 80
- 120.000 per jaar
16 kg per lamp
(kan op bestaande constructie)

Current Gasontladingslamp
- 400 watt
- orange light Ra 25
- 24 hours on
- 400.000 kWh/year
- 173 lamps

Luxe: VarioLEd
- 90 - 270 degrees
- Dali daylight system
- 300 W
- 1050 euro per lamp
- 600lux
- Ra 80

Lights should all burn at night when doors open for safety reasons



10.000 Kg crane stops above lamps
> Lamps become too hot and break

Daylight system> saves power

Currently no daylight in hangar while this is desired by the mechanics

cooperation between KLM and Phillips
>> new lamp is coming

# Solar energy

The hangar of the future has to be able to function withouth energy support of the outside world and even create more energy then it needs. It should be selfsustainable.

For KLM this was an unachievable goals as it is too expensive. They will place a strip of 75 panels on the roof of H12.
These panels are 260 Watt and will produce 17160 kWh/ jaar. It is an investment of 20.000 euro that will have a return on investment wihtin 5.5 years. Just like other panels the warranty is 15 years and the lifespan is beteen 25 and 30 years.

For the hangar of the future we could complement the KLM “Golden option” wich is transparant solar cells. These could be implemented in the roof or facade. The efficienty of these panels however is much lower.

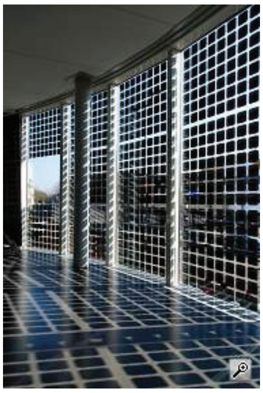
**400.000**Watt
**Needed for LED system**

## Solar energy 1 row KLM

## Solar energy 1 row KLM

## Transparant panels

## facade panels

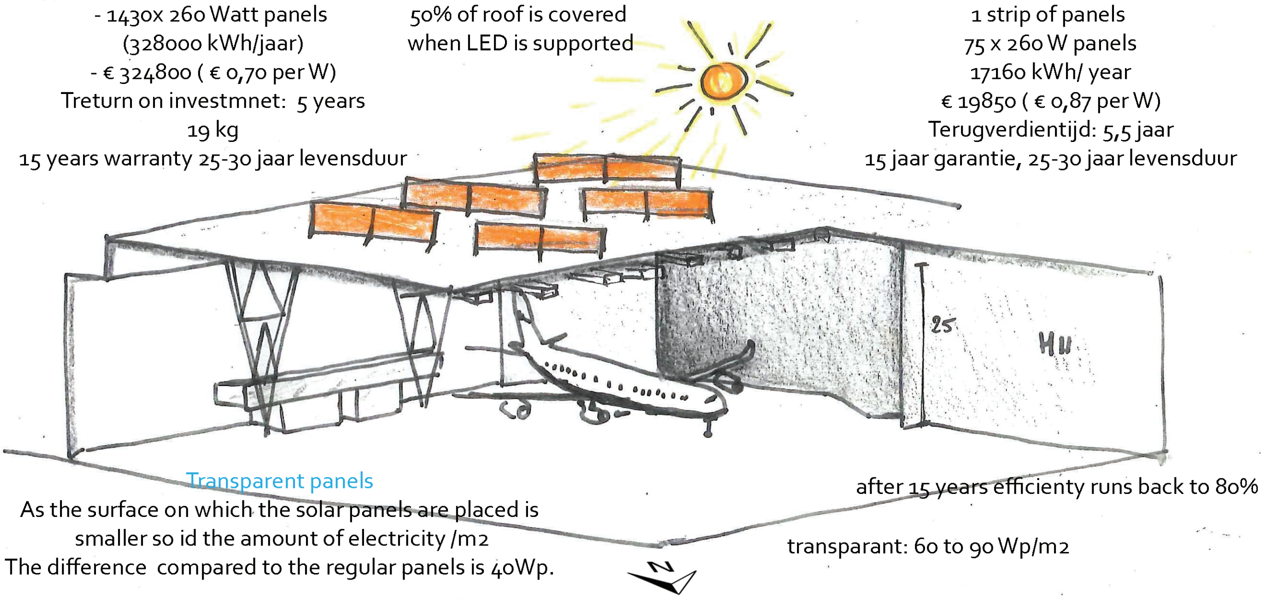


## Overview drawingsolar energy

Panelsystem to support LED fully
- 1430x 260 Watt panels
(328000 kWh/jaar)
- € 324800 ( € 0,70 per W)
Treturn on investmnet: 5 years
19 kg
15 years warranty 25-30 jaar levensduur

50% of roof is covered
when LED is supported

KLM solution
1 strip of panels
75 x 260 W panels
17160 kWh/ year
€ 19850 ( € 0,87 per W)
Terugverdientijd: 5,5 jaar
15 jaar garantie, 25-30 jaar levensduur




Transparent panels
As the surface on which the solar panels are placed is
smaller so id the amount of electricity /m2
The difference compared to the regular panels is 40Wp.

after 15 years efficienty runs back to 80%

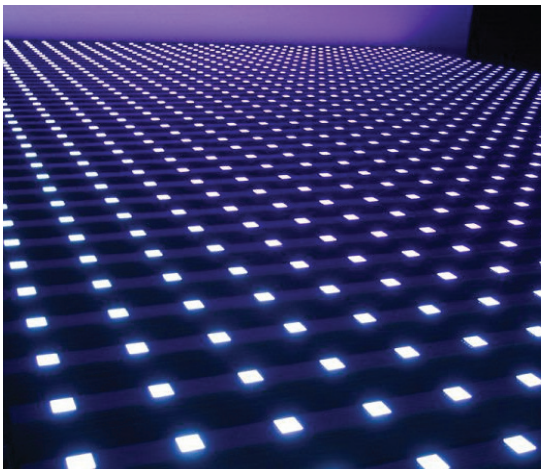
transparant: 60 to 90 Wp/m2

# LED Light and Daylight

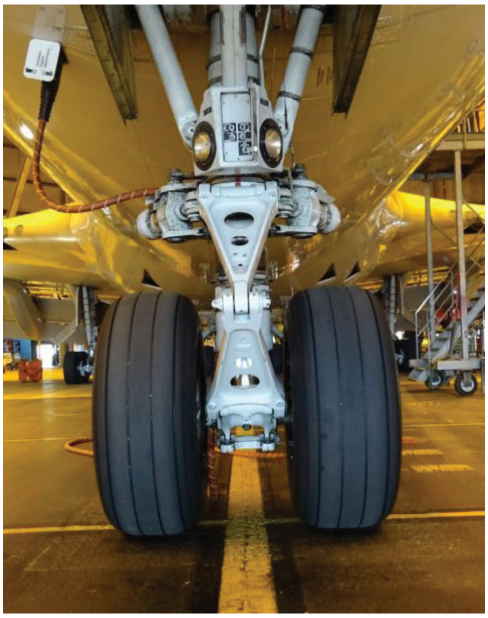
The area underneath the wings is very dark, as the wings block the light from the lamps on the ceiling. I propose to make three strips of LED under the front wheel of the aircraft for KLM. Only under the front wheel because the sizes of the aircraft differ but the front wheel is always placed on the same line. So by doing this the leds will be compatible with any type.

It would be possible to make three openings in the concrete floor and place three strips besides the wheel and in the middle. For the Hangar of the future a floor filled with lights can be made that creates a hangar flexible to maintenance all type of aircraft.

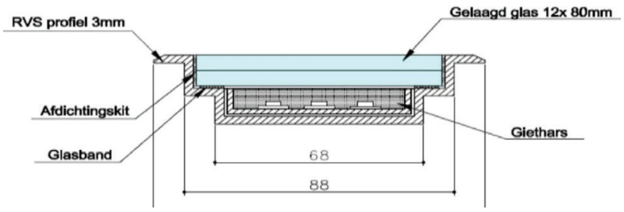
## Dark area under landing system + References



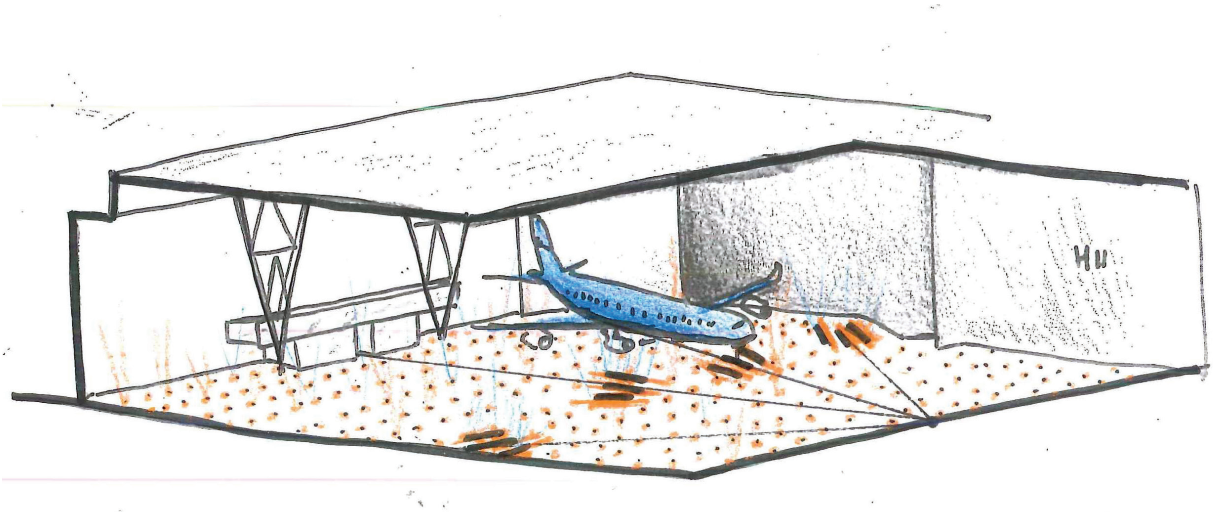
## implementation



## Detail

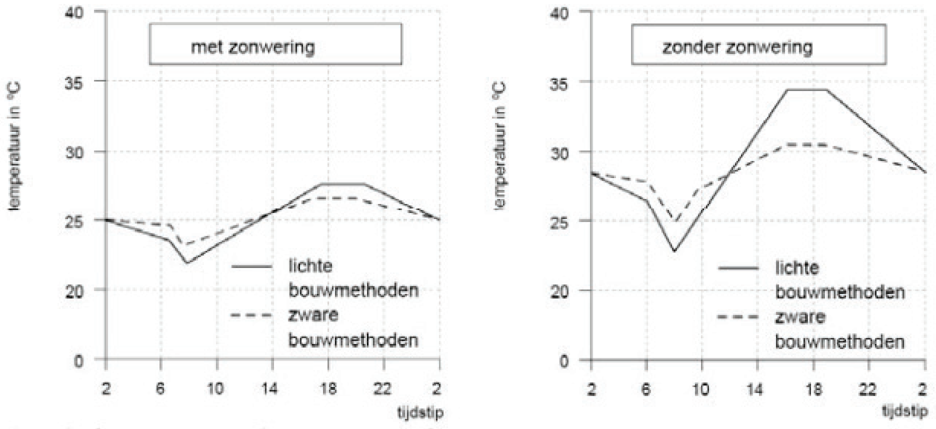



## Overview drawing LED floor lights



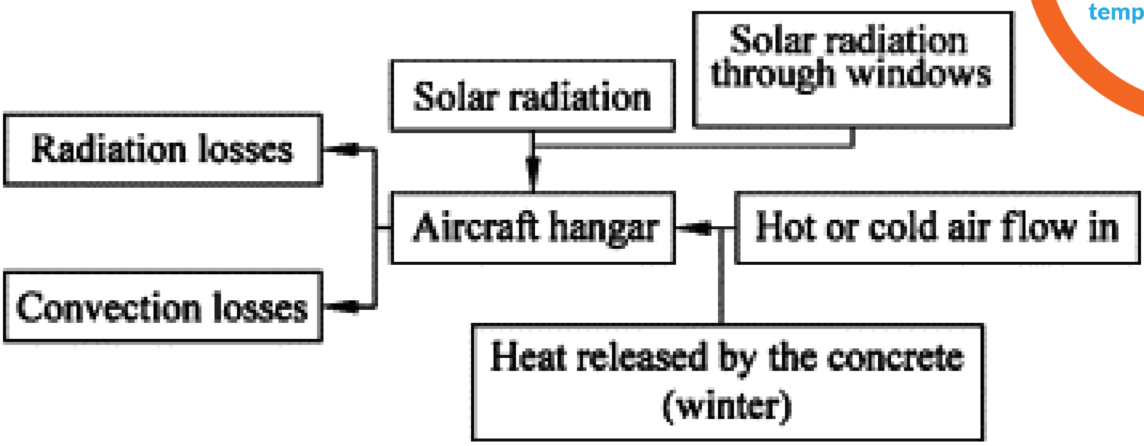
# Hangar Heating

The current heating system of H12 exists out of radiant heating via heating strips in the ceiling. The heating system is hung up at 25 meters, just below the lamps. the 10.000 kg crane runs below the two systems.
Much heat is lost when the large doors open.  The air is circulated to the ground by blowers which blow the air down where the men work. This is not efficient in the future the optimal temperature of 16 degrees could also be reached by using floor heating.




**16** **degrees**

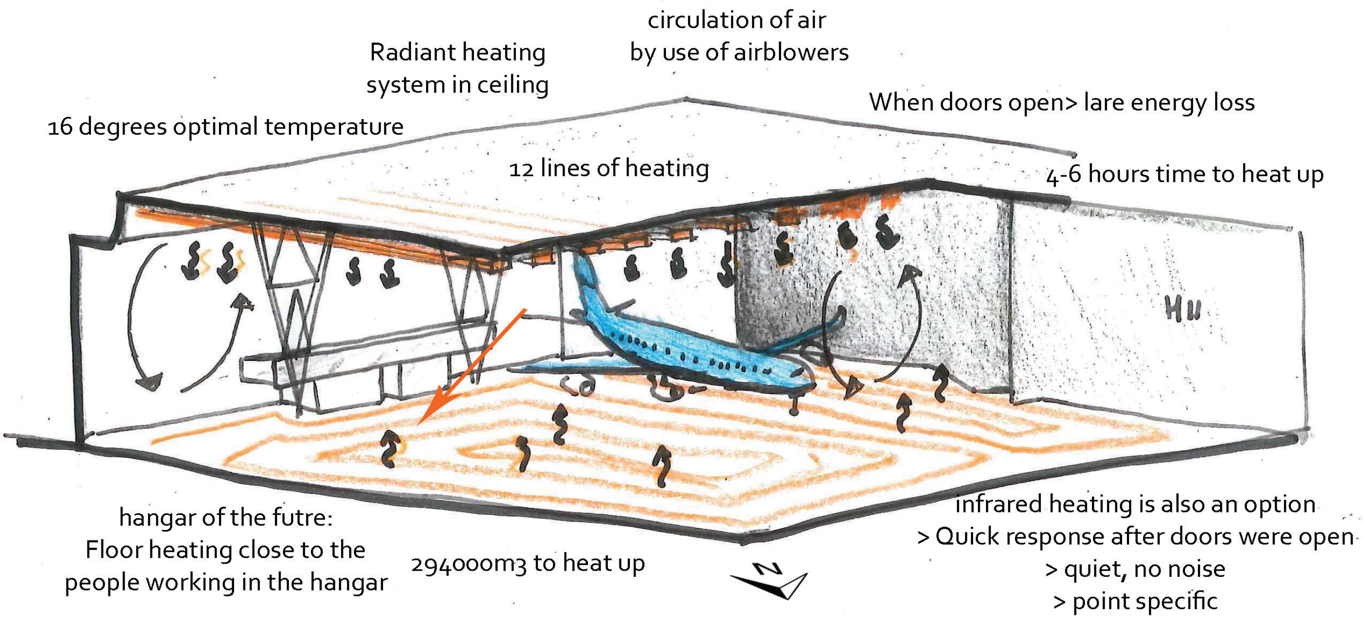
**desired temperature in hangar**




**Source:** Pei, Y., Bai, Y., Shi, Y., Zhu, D., & Wang, Y. (2008). Temperature distribution in a long-span aircraft hangar. Tsinghua Science & Technology, 13(2), 184-190.

## Picture heating H12 KLM


## Overview heating



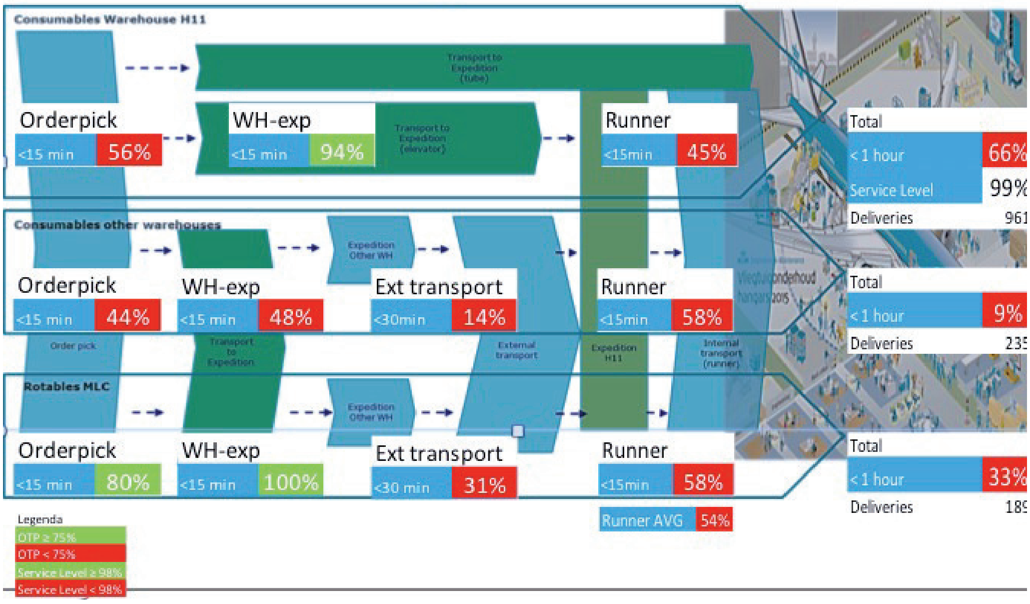
# Tooling&Equipment / Material

Material that is needed for performing a certain check is orderen in advanced in placed into the ' stellingen' that are visible in the right middel picture. However, 25% of all deliveries of material and equipment is sent back and 80% of the times material is missing. Some of the time is lost by slow delivery by runners, the small cars that drive from hangar to hangar to supply them with ordered material. (picture top left)

Another weak point in material circulation is the manned warehouse. It is difficult to get the planning right, the peak times in aircraft maintenance should be supported by large crew at the warehouses. At the moment there is a lot of maiting time.

We should look into the ways to support the maintenance processes and optimise them with the use of architecture.

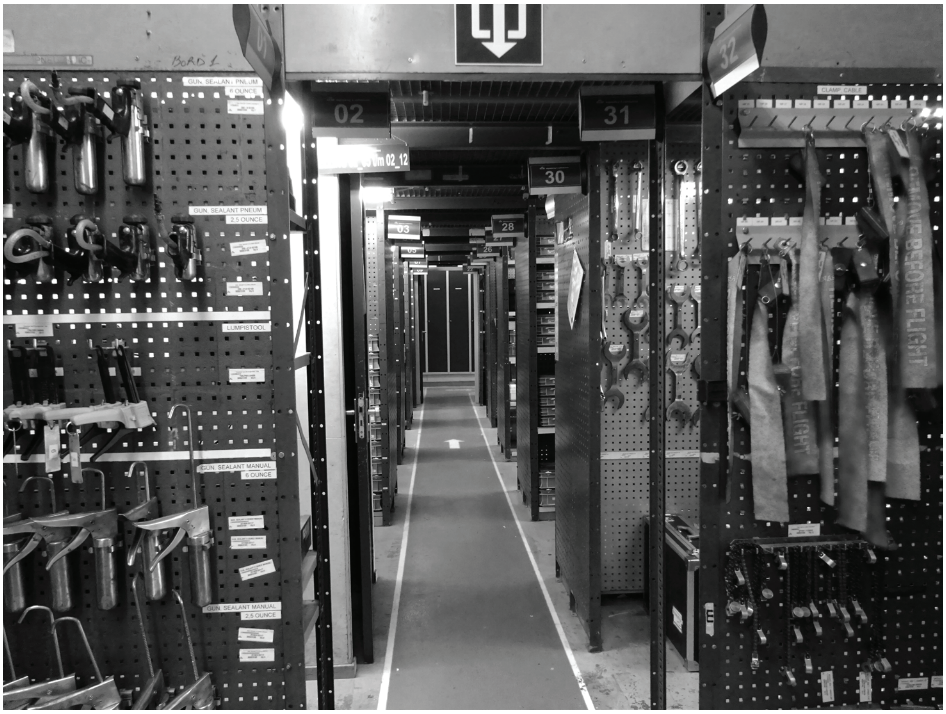
## Scorechard delivery time March 2015



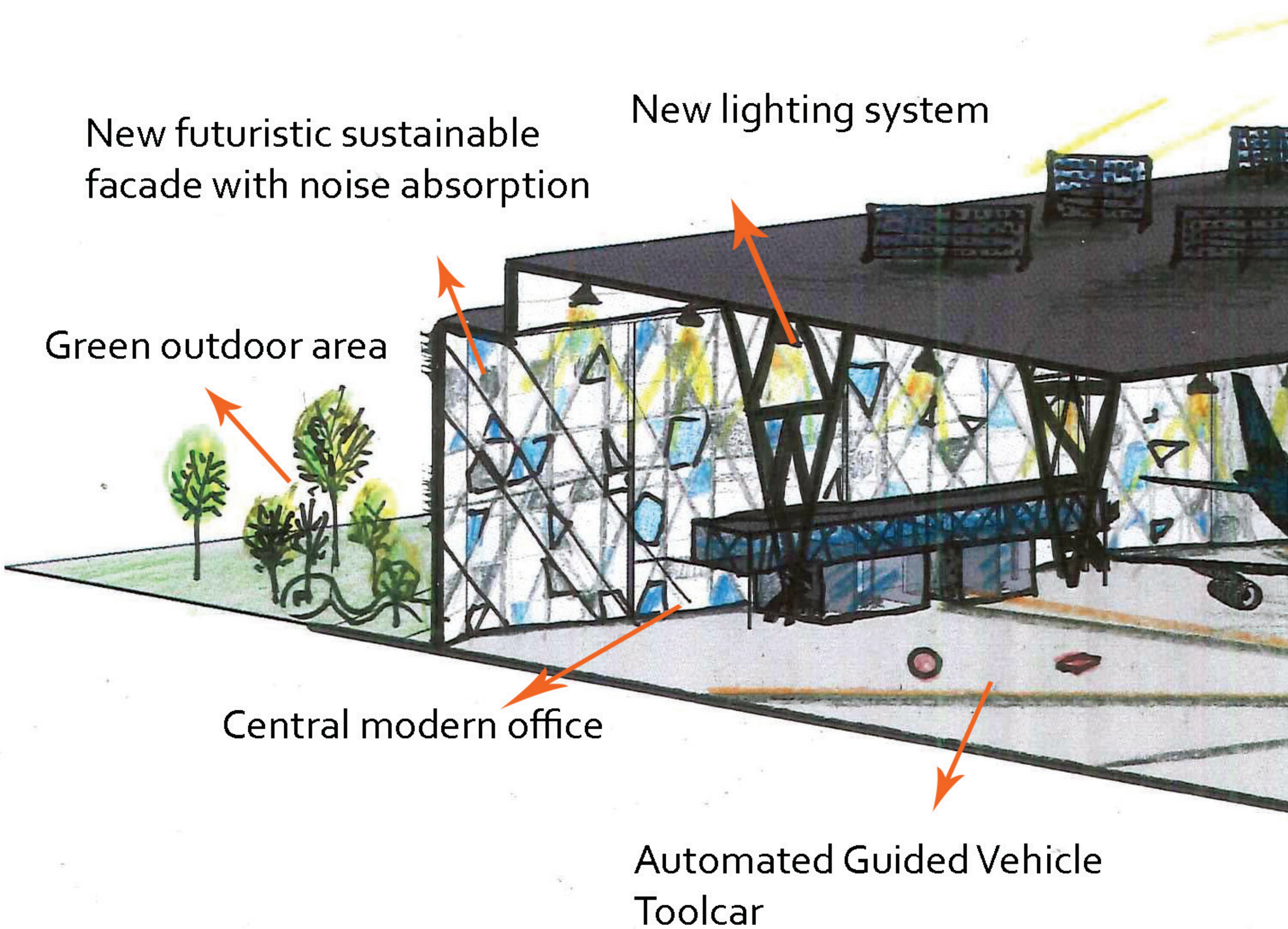

Source : Research report Materials TU Delft 2014 Rutger Greefhorst

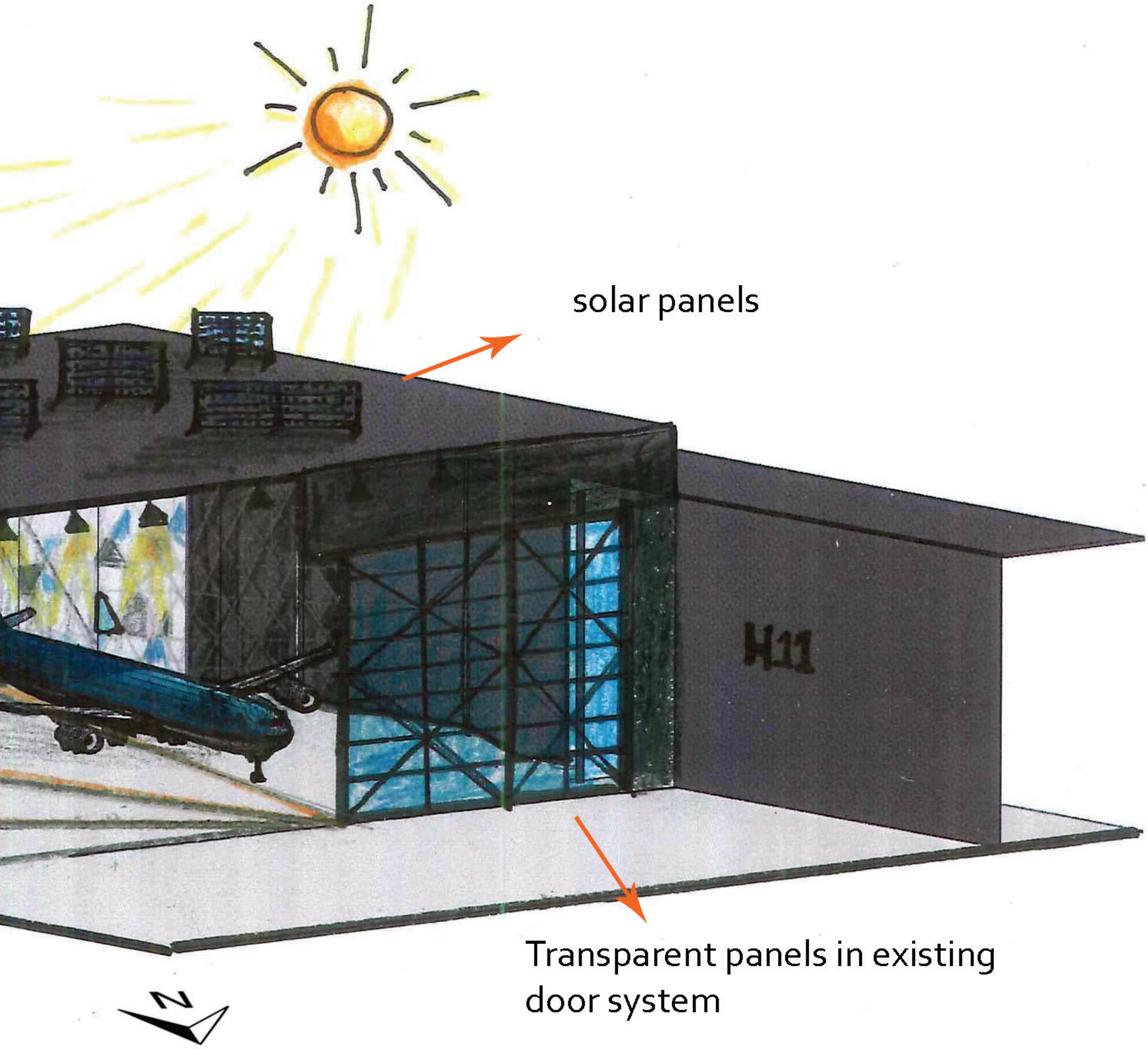

10P3
PAPIER
BAK


FA
M02


02
31
30
32
GUN SEALANT PNEUM
2.5 OUNCE
LUMPISTOOL
GUN SEALANT MANUAL
2.5 OUNCE

# Concluding drawing
# Design proposal Renovation H12




solar panels
H11
Transparent panels in existing door system

# The numbers of H12

**35 m**
height of hangar

**10.000KG**
Crane is placed in the hangar that can cover the complete roof

**>103 m**
min. size of the doors opening to place 2 B 747

**400.000Watt**
Needed for LED system

**>80db**

**0.5 s**
desired reverberation time

**20 men**
average per shift work in the hanagr

**2 years**
before full digitalisation >> change functions

**1916**
year that Schiphol started

**27 m**
height of the doors

**20.000kN**
the Truss can take up in the grider

**5 men**
average per team work in the hanagr

**3**landings
banen nodig

**20 m**
size of one door

**115x73m**
measuremnets
hangaar hall

**1852**
Haarlemmermer
was turned into
land

**2s**
desired
reverberation time

**16**degrees
desired
temperature in hangar

**3 ton**
weight of
the construction

**1979**
Hangar 12
was built

**52**years
Average Age KLM
Employees

**12km**
Average walking
distance 1 shift

**2016**
sept planned
completion
renovation

**9m**
Highest truss
above the door

**>25m**
min height of
hangar

# CHAPTER 8.
# Hangar analysis

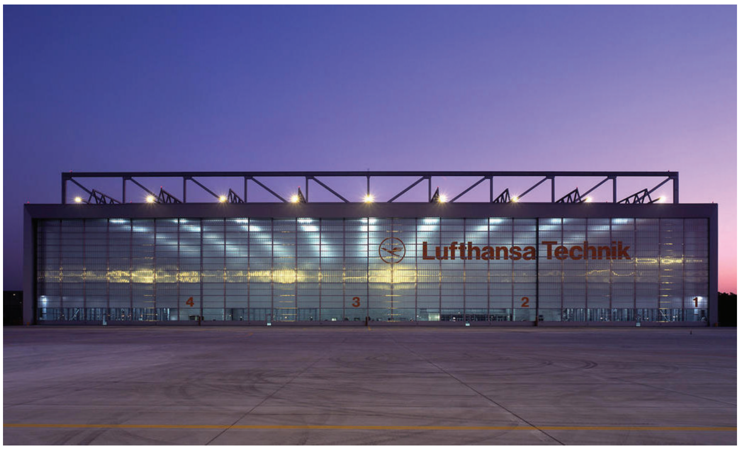
# A380 Lufthansa Maintenance Hangar

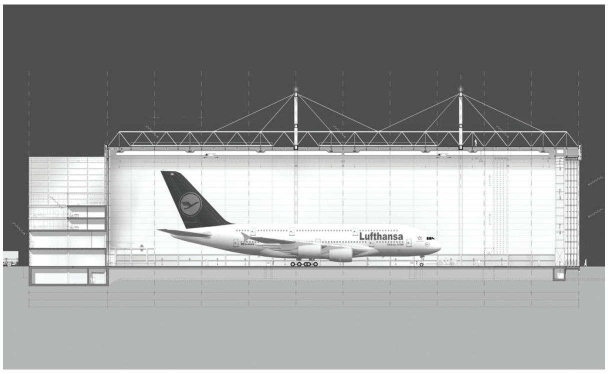
## Frankfurt, Germany

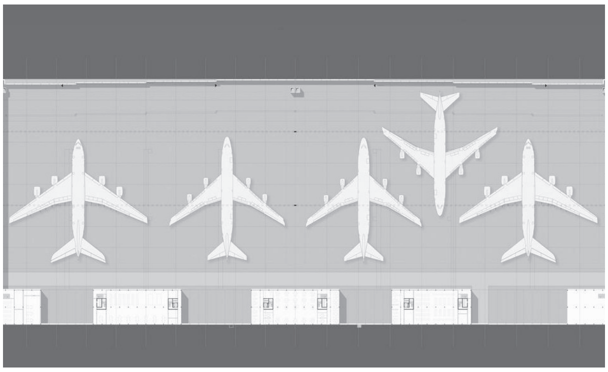
2007

4/6

**Architect** Volkwin Marg, GMP
**Construction:** Schlaich Bergermann
**m2** 60,000 $m^2$
**Height** 27,5m
**volume** 1,300,000 $m^3$
**Buildingcosts** -
**Type airplanes** 4A380 / 6 B747
**Status:** in use





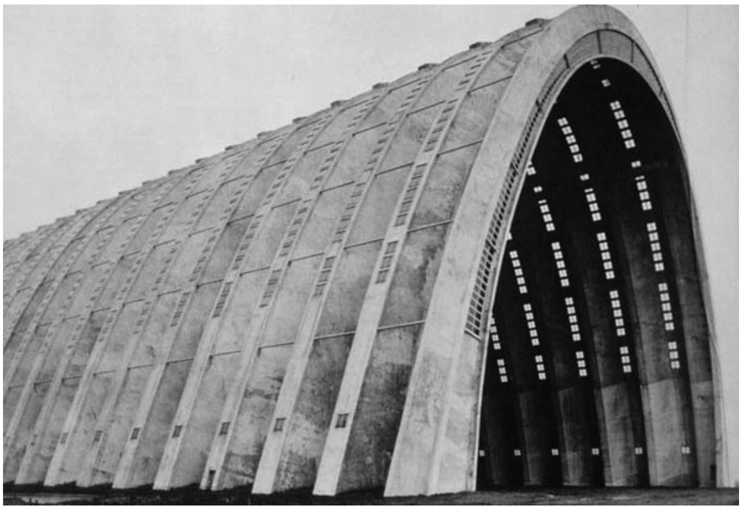
The new hangar is mainly dedicated to the maintenance of Lufthansa's new wide-bodied aircraft Airbus A380. At one time the building provides cover for 4 Airbus A380 or six Boing 747. Lufthansa staff is employed to ensure immaculate technical conditions of the planes, working in three shifts, 365 days a year.The Hangar measures 350 m x 140 m, including a 20 m deep zone of administrati-on and other facilities, spanning the full length of the back of the hangar. The approximately 35 m high, light-silver clad building is supported by its characteristic structure. The delicate support structure has been moved to the outside, to reduce the enclosed volume.The sliding front gates of the hangar are facing North. The translucent fillings of their structure add to the natural lighting inside. The planes silhouette perceivable from the outside, define the elevation of the Lufthansahangar to the airfield.

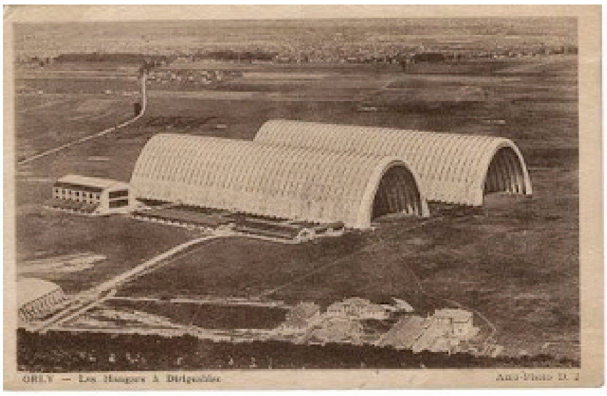
# Orly Hangar
## Paris, France

1923

1

**Architect** Eugene Freyssinet
**Construction:** thin-shell reinforced concrete parabolic shells
**m2** 15.925m²
**Height** 60
**volume** 955.500
**Buildingcosts** -
**Type airplanes:** airships
**Status:** not in use





The airship hangers at Orly, France were built by Eugene Freyssinet between 1921-1923.The program which Freyssinet needed to follow stipulated that a sphere with a radius of 25 meters had to fit, un-obstructed, within the hangar. The buildings dimensions were carefully determined so that they could house the airships without much extra space resulting in unneccesary additional costs and building stresses. The hangars were destroyed in WWII by American aircraft.

The building envelope was made up of a series of parabolic arches, each formed in the shape of a vault, that when connected, created an undu lating pattern, similar to that of corregated cardboard. Each individual arch was made from separate stacked components, 7.5 meters wide. These components tapered in depth and measured 4.4 meters deep at the arches' base and 3.4 meters at the crown. Th e complete span from base to base measured 86 meters. Windows were situated on the outermost part o f the arches starting at a height of 20 meters and were constructed of a special reinforced yellow colored glass that was used to provide light and to protect the airships from harmful radiation.
The moulds for the components were made of pinewood planks. The concrete that was poured was reinforced with steel and the moulds themselves were stressed with tension rods running through the elements to create prestressed concrete. The concept of prestressed concrete was later patented by Freyssinet in 1928.

# Lufthansa-Wartungshalle V

## Frankfurt, Germany

1972 6-14

**Architect** ABB Architekten
**Construction** Dyckerhoff & Widmann
**m2** 32000m2
**Height** 23-43m
**volume -**
**Buildingcosts** -
**Type airplanes** 6 B747/14 B707
**Status:** in use


The Lufthansa Maintenance Hangar V at Frankfurt Airport has a spectacular form that results directly from the load-bearing structure, which consists of two suspended roofs. The thin pre-stressed concrete bands forming the roof surface are supported by cables spanning between large truss-like support structures..

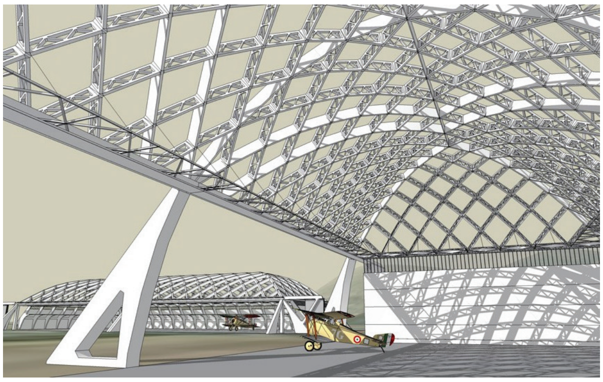
It is well-known for its size and capacity as well as its spectacular form. With its length of 320 meters, width of 100 meters and height of 23-43 meters, it can hold six Boeing 747 jumbo jets, or alternatively 14 Boeing 707 long-distance jets. In 1972, when the hangar was built, that was a world record. Its form results directly from the load-bearing structure, which consists of two suspended roofs. The thin pre-stressed concrete bands are supported by cables spanning between large truss-like support structures.

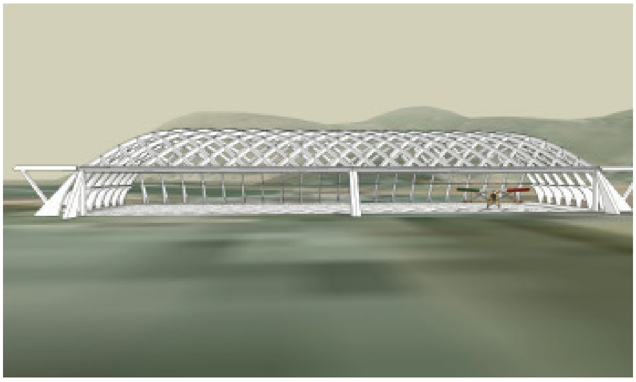
The shape of the roof is determined by the forces, which act on the structure. The roof consists of 10 lightweight concrete bands (width b = 7.5 m, material thickness t = 90 mm) with 30 steel cables (S500) embedded into each band, spanning across a distance of 130 m. Between the adjacent concrete bands there is a glazed opening. The loads to be considered for the roof are the concrete band (wgk = 1.85 kN/m2) and snow (wsk = 1.0 kN/m2).

# Piere Luigi Nervi Hangar
## Orv

1935 4

**Architect** Pierre Luigi Nervi
**Construction** Binnewies, Hamburg; Schlaich Bergermann und partner
**m2** 4884 $m^2$
**Height** -
**volume** -
**Buildingcosts** -
**Type:** -
**Status:** destroyed





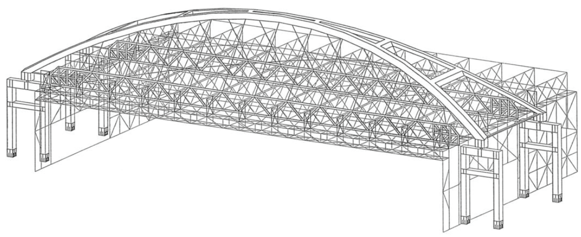
Between 1935 and the years of the War, Nervi and his company constructed various airplane hangars in reinforced concrete for the Regia Aeronautica militare (Italian Royal Air Force). Eight are the result of the development of a unique project for a ribbed vault with a geodetic structure, constituted of a series of arches overlapping one another at 45°, with a maximum span of 50 meters. Nervi arrived at this solution after a series of successive elaborations, initially studied for the Ciampino Airport [in Rome] in 1935, beginning with much more traditional schemes based on a portal and overlapping trusses. For the first time in the work of Nervi, the verification of the appropriateness of the structural concept and the refinement of the construction drawings made use of small scale models realized by the Politecnico di Milano, under the supervision of Guido Oberti. The first two hangars (1935-38), entirely site-cast, were realized for the military airport in Orvieto; the successive six hangars (1939-42), located between Orvieto, Orbetello and Torre del Lago, used the same geometric matrix as the first two, while proposing a drastic reconsideration of the building processes: realized by assembling the lightweight elements of the structure, prefabricated in the building yard, with the sole integration of strengthening ribs in solid walls in the areas most subject to loading, anticipating the widespread use of structural prefabrication pursued by Nervi during the post-war period.

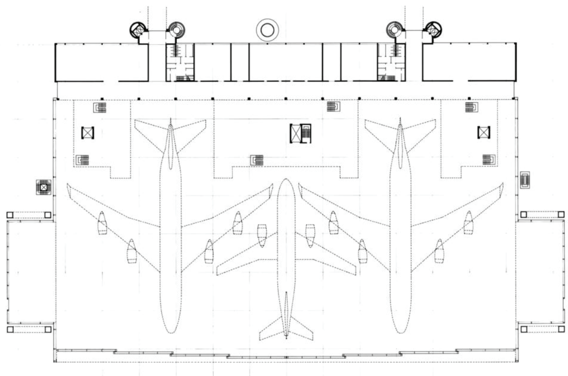
# Jumbo Hangar Lufthansa
## Hamburg, Germany

1992

3

**Architect** Meinhard von Gerkan und Karsten Brauer gmp architekten
**Construction:** Assmann
**m2** 18,000 m$^2$
**Height** 26
**volume** 468.000 m$^3$
**Buildingcosts** -
**Type airplanes:** B747 + A380
**Status:** in use



The maintenance hangar on the southern side of the airport cannot be missed. With its hangar space 150 m long, 81 m deep and a clear working height of 26 m, two Jumbo Jets and an Airbus can be dealt with simultaneously.

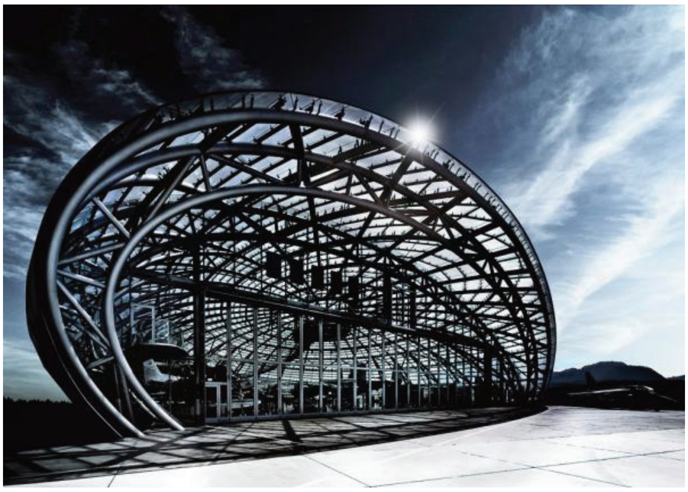
In order to provide a column-free gigantic hall, a primary structural system is created by two bows leaning against one another having a total span of 175 m. The whole roof hangs on these bows, the main load being transferred to two buttress constructions at the side of the hangar. The arch form is similar to a large suspension bridge and determines the appearance of the new hall, while the facades are covered with a silver grey metal cladding.

The hangar doors having a total length of 150 m and height of 22 m are totally glazed. This gigantic "window" allows passengers rolling past in an aircraft to look inside the massive workshop.

# Red Bull Hangar 7

## Salzburg Austria

2003 3



**Architect** Karsten Brauer
**Construction:** Assmann
**m2 12131**m²
**Height** 15m
**volume** 449.100 m³
**Buildingcosts** -
**Type airplanes:** B747 + A380
**Status:** in use (museum)

The 40 metre-long entrance and two cylindrical towers, providing space for offices, lounges and a restaurant, were cut into the elliptical glass shell. It presented Salzburg architect Volkmar Burgstaller with enormous static challenges as far as the supporting structure was concerned, because the steel supports were ultimately supposed to be as slim as possible. A complex static engineering concept, which met all the specifications and requirements, was finally developed using specially written 3-D simulation software.

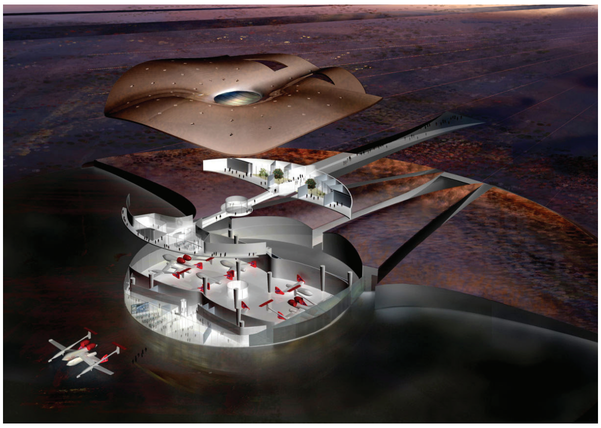
The team of architects furthermore succeeded in making all the cabling, heating and ventilation invisible. Visitors can also admire the mobile interior at various angles from three self-supporting ribs which span the hall – not an easy feat in a steel and glass construction, but important for experiencing the space in Hangar-7. The 1,754 panes of glass, which are all different sizes, provide a view of the impressive mountain panorama, and their transparency creates a different atmosphere in Hangar-7 depending on the weather or the time of day.

Hangar-7 has become what it is today because of these structural requirements: a place where technology, art and entertainment come face to face and naturally complement each other, and of course a garage that any airplane would love to call home.

The New Mexico Spaceport Authority Building.

New Mexico,


**Architect** SMPC Architects + Foster& partners
**Construction** URS Corporation
**m2** 3300 $m^2$
**Height** 25
**volume** -
**Buildingcosts** -
**Type:** A380
status: in use



The Foster + Partners and URS team has won an international competition to build the first private spaceport in the world - The New Mexico Spaceport Authority Building. The sinuous shape of the building in the landscape and its interior spaces seek to capture the drama and mystery of space flight itself, articulating the thrill of space travel for the first space tourists. Making a minimal impact on the environment, the scheme will be the first facility of its kind and a model for the future.

The Spaceport lies low within the desert-like landscape of the site in New Mexico and seen from the historic El Camino Real trail, the organic form of the terminal resembles a rise in the landscape. Using local materials and regional construction techniques, it is both sustainable and sensitive to its surroundings.

Organised into a highly efficient and rational plan, the Spaceport has been designed to relate to the dimensions of the spacecraft. There is also a careful balance between accessibility and privacy. The astronauts' areas and visitor spaces are fully integrated with the rest of the building to convey the thrill of space travel.

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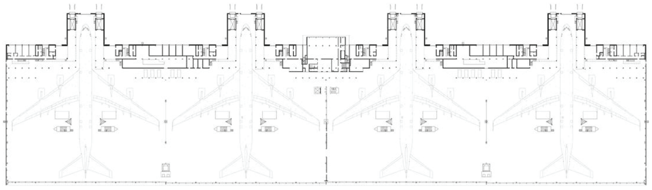
# Major Component Assembly Hall, Airbus A380

## Hamburg, Germany

2002 4

**Architect** Volkwin Marg with Marc Ziemons GMP architekten
**Construction** Binnewies, Hamburg; Schlaich Bergermann und partner
**m2** 58,890 $m^2$
**Height** 23
**volume** 1.354.470m3
**Buildingcosts** -
**Type:** A380
**Status:** in use



The Equipment Assembly Hall consists of four free standing interconnected assembly spaces, each with a width of 92.5 metres and a depth of more than 80 metres. An enormous administration building to the south accommodates office space. The nose of the Airbus "breaks through" this massive structure and is reflected by projections in the façade, the so-called nose scoops.

Four tail scoops located on the hall's roof provide the necessary height clearance. The external load bearing structure extends over the entire length of the hall as a ten meter high framework girder, supported by five main supports. Eight transverse framework girders with a height of nine metres rest on supports next to nose projections, cross the main support with a rigid connection and freely project 36 meters next to the tail scoops out over the north façade.

The entire length of the 370 meter-long glazed north façade is open to the Elbe River and its banks.  At night the anti-glare interior and exterior lighting causes the halls to shimmer and provides a view of the airplanes in the distance.

# Qatar airways maintenance centre
## Qatar, Doha

**Architect** Ghafari Associates
**Construction:** Thornton Tomasetti
**m2** 153.000 m²
**Height** 12-45m
**volume** 4600.000 m³
**Buildingcosts** 560 million
**Type airplanes:** all types
**Status**: in use

Qatari authorities have decided to build a new airport in the immediate vicinity of the existing facility in order to compensate for increased traffic that has saturated the existing airport. ADPI working for Bechtel is in charge of conducting the preliminary studies for all the buildings (except for the terminal) as well as the detailed studies of the Emir's pavilion.

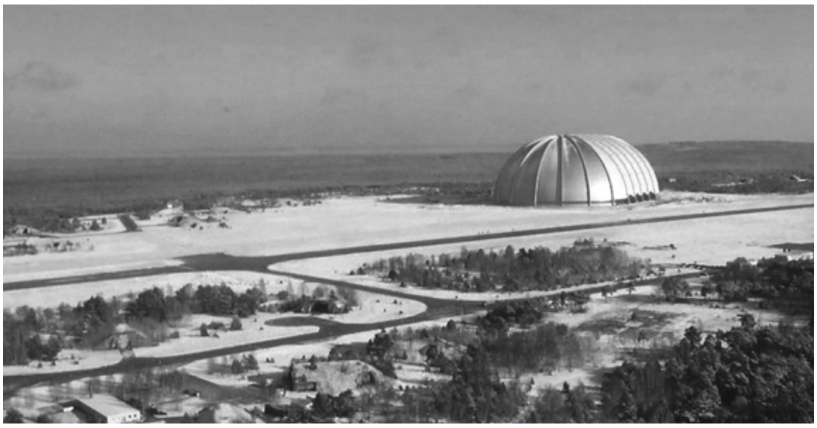
THE PROJECT : The future Qatar Airways maintenance centre consists of three main assemblies: two maintenance buildings and a logistical support building featuring all workshops, offices and plant rooms at the back. The centre will be able to simultaneously accommodate all types of aircraft for all maintenance requirements.

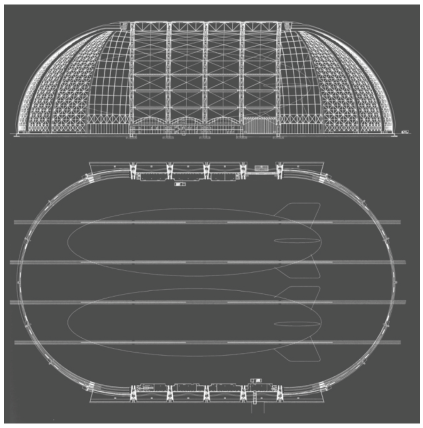
SERVICES PROVIDED: The plant's various volumes are derived from structural and operational requirements: high overhead volumes for the buildings to accommodate aircraft, and lower volumes for the logistics building. The facade materials selected are based on the experience acquired by ADPI architects from extensive hangar projects in Toulouse, Dubai and Seville. The large trestles will be covered in translucent polycarbonate, installed vertically in an "accordion" arrangement in order to capture the color of the sky while allowing the structures to be perceived behind them.other, and of course a garage that any airplane would love to call home.

# CargoLifter Hangar
## Krausnick, Germany

1996 2

**Architect** SIAT architects
**Construction** Ove Arup
**m2** 81700 m²
**Height** 107
**volume** 8,7 million
**Buildingcosts** -
**Type:** Zeppelin
**Status**: used as swimingpool





Another example for a revitalizing and stimulating approach is the hangar that was recently built for the CargoLifter. A good 60 years after the Hindenburg, the concept for the CargoLifter resembles a rejuvenated, high-tech version of dirigibles. Conceived as an airship for heavy and bulky loads (up to 160 tons) that could deliver cargo independent from infrastructural and geographical limitations on the ground, it was supposed to enter production in 2005. After an initial euphoria over the new technology at the turn of the millennium, however, the project was stopped well under way, mostly because of the formerly underestimated influence of heavy winds that would constrain the overall performance of the airship and thus its economic feasibility.

Although plans to construct the lifter were stopped in 2002, the hangar for its final assemblage had already been erected in Brand, 60km south of Berlin. The world's biggest airship was logically supposed to be housed in the worlds' largest single span structure, designed by SIAT architects and engineered by Ove Arup. The semi-cylindrical steel-tube system of the roof is covered by a PVC-membrane taking motives from the airships structure it was supposed to accommodate. Built on a former East German military base, it today remains as a witness of a disrespected technology.and provides a view of the airplanes in the distance.


10P3
0545
WORLDWIDE
KLM
RELIABILITY
PAPIER
BAK
5

# CHAPTER 10
# Output Specifications Hangar of the Future

The output specifications have been designed by using the knowledge of the research and combining this with the flowchart of the future. These two together provide the basis voor the Design og the O.S and thereby the Design.

In this chapter a bief version of the O.S can be found. a more detailed description written down by using the Brief Builder  O.S programma can be found in the appendix.

# 10. Output Specifications

**Key words: Flexible, inspiring, initiating**

Required rooms
- Changing area incl showers men 100m2
- Changing area incl showers women 25 m2
- Toilets 4 toilets men / 2 toilets women 18m2
- Lounge 40m2
- Techroom Ipads 20m2
- Committee rooms / flex rooms / innovation room> freely organised total 40m2
- Team rooms 4x/ Flex room large 10 people meeting / training room 60m2
- Outdoor area chilling 20 people 30 m2
- Presentation/relax/training room 50 people 100m2
- Private time area 10 m2
- Bike / vehicle stalling 10 m2
- Parking spaces 50x

Technical Maintenance support area's
- Warehouse 350m2 RFID (underground)
- Tool control 100m2
- Maintenance workshop 160m2
- Storage maintenance workshop 15 m2
- Washing area 15 m2
- Avio/cabine workshop 15 m2
- Environmental room
- Storage extra tools and equipment
- Maintenance hall 12000m2 25 m hoog min
- (design for 787 and 737 but should be flexible
- EHBO post 8m2
- Moonshine workspace 20m2

Necessary activities not room bound
- Supply to aircraft by runner
- Movement of aircraft in and out of hangar on platform
- Parking space employees hangar 30 cars
- Lifting up to 10.000 kg by crane
- 400HZ supply for the aircraft from the air or floor
- Movement to aircraft by movable stairs ground bound and from ceiling

**Key words: Flexible, inspiring, initiating**

Technical specifications

- Noise hangar:  required reverberation time 2.0-2,5 seconds
- Noise offices: required reverberation time 0,5-0,6 second 45 db
- Lighting office and hangar:
  600 lux on the ground or desk from a height of 25 meters RA 80
- Floor heating average temperature in hangar 17 degrees
- Cooling -
- Ventilation
- Electricity need: 500.00 kw/h lighting (LED)
- Energy: self-sufficient and extra by use of sun and wind energy
- washing equipment

Ambitions

- Inspiring surroundings
- Visual connection with the outside world
- Daylight in rooms where people stay more than 3 hours
- Visible futuristic character > image KLM as innovative company
- Support intrinsic motivation employees
- Support new organizational strategy of teaming
- Support intrapreneurship within KLM
- Flexible building: we cannot predict the future
- Integrated design with toolkit of the future
- Involve employees in processes
- Realistic design > KLM should be able to built it in 30 years.
- Sustainable > reuse and energy friendly
- Support innovation and creativity among the employees of KLM

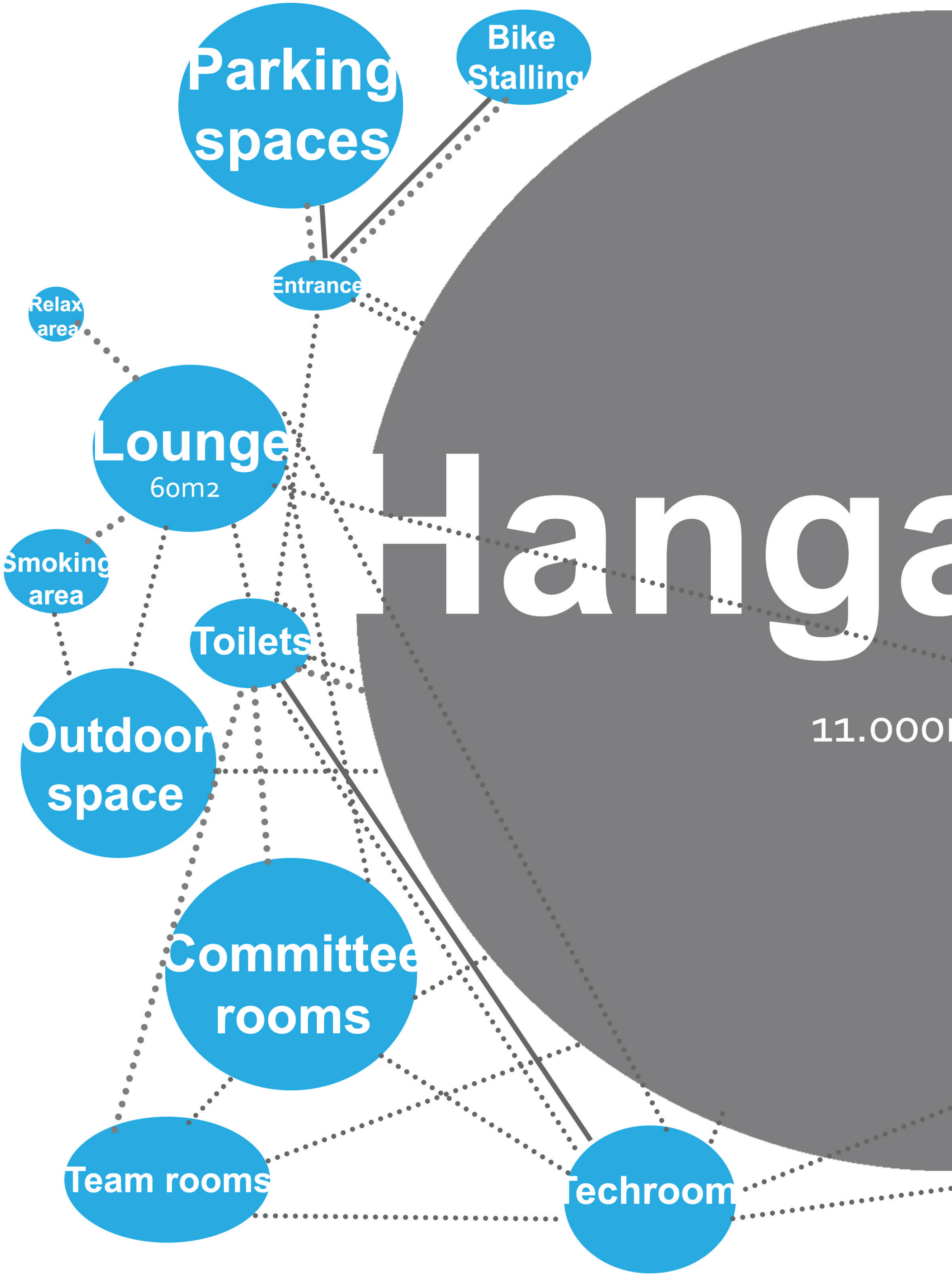
Technical ambitions

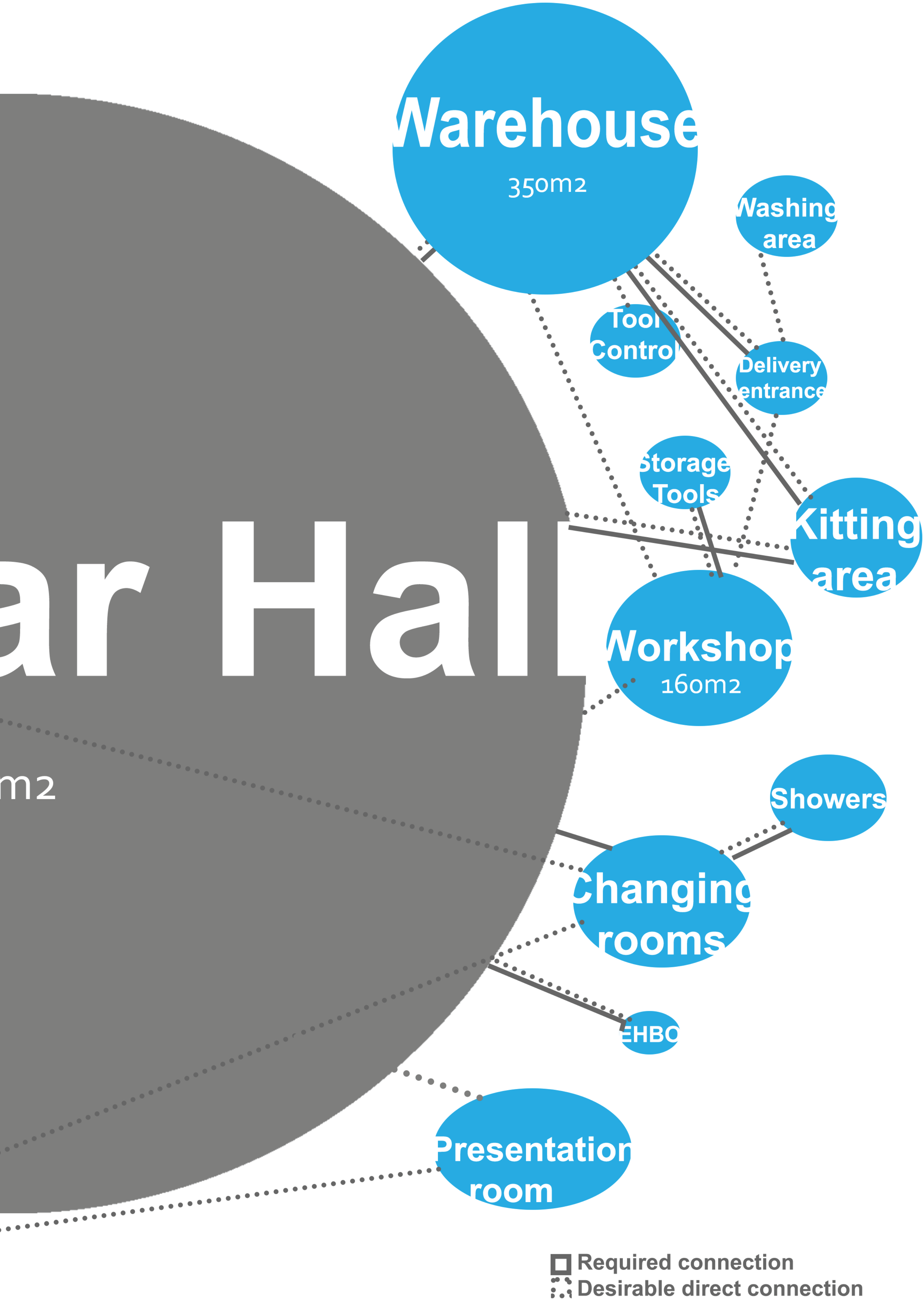
- 400hz kabels, 220hz cabels 230 volt electricity and air pop up from floor from floor
- Hands on metal should be supported by the design > short walking distance to tools and equipment.
- Reduce energy loss by opening doors
- Make use of large area above the airplane or reduce this.
- Place LED lights in the floor especially under the chassis next to the wheels. Preferably under fornt wheels or in a flexible system

kantoren ventialtie: 5 m3/m2.h of 50 m3/h per persoon

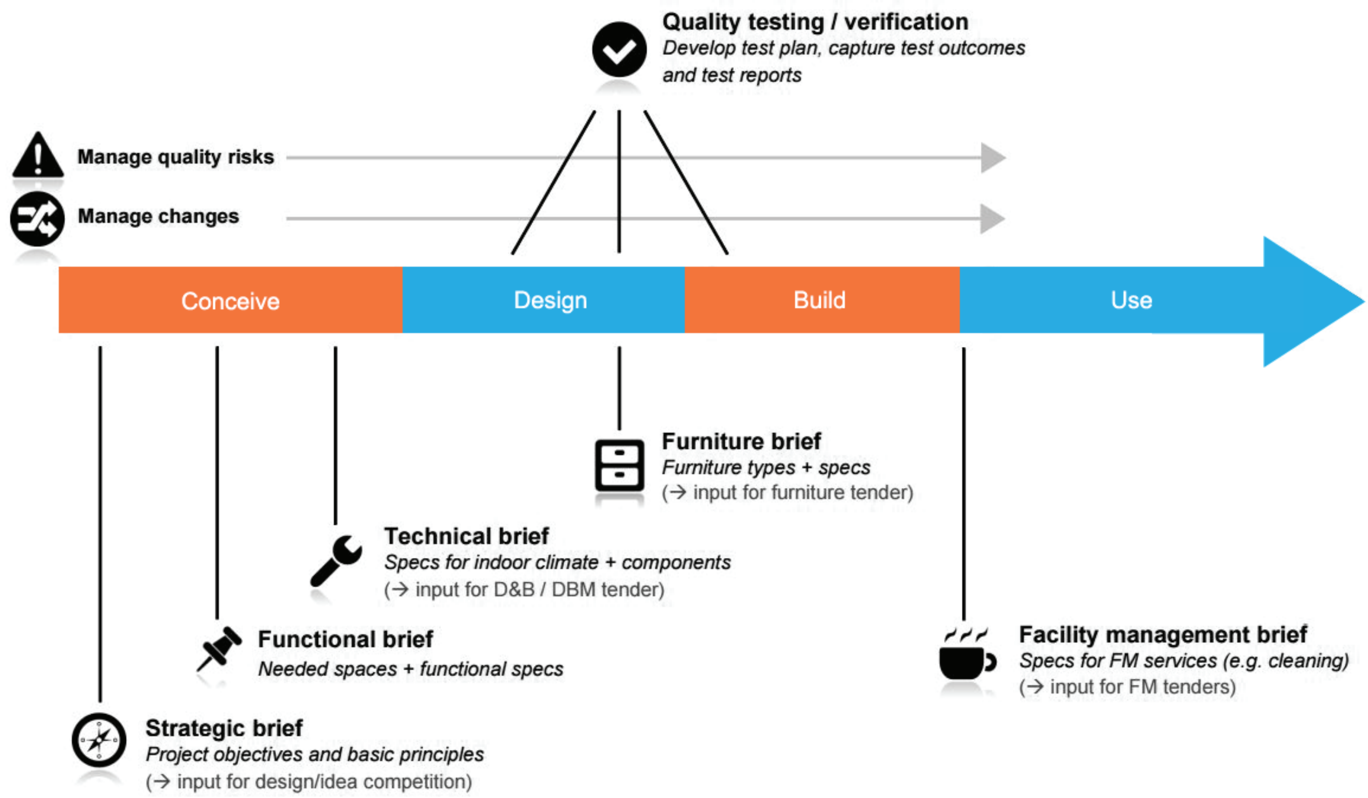
Meetingrooms 20 m3/m2.h of 50 m3/h per persoon
toilet : 35 m3/m2.h
CHanging area: 11 m3/h per m2 vloeroppervlakte
infrastructure support : 1 m3/h per m3

# Space relations

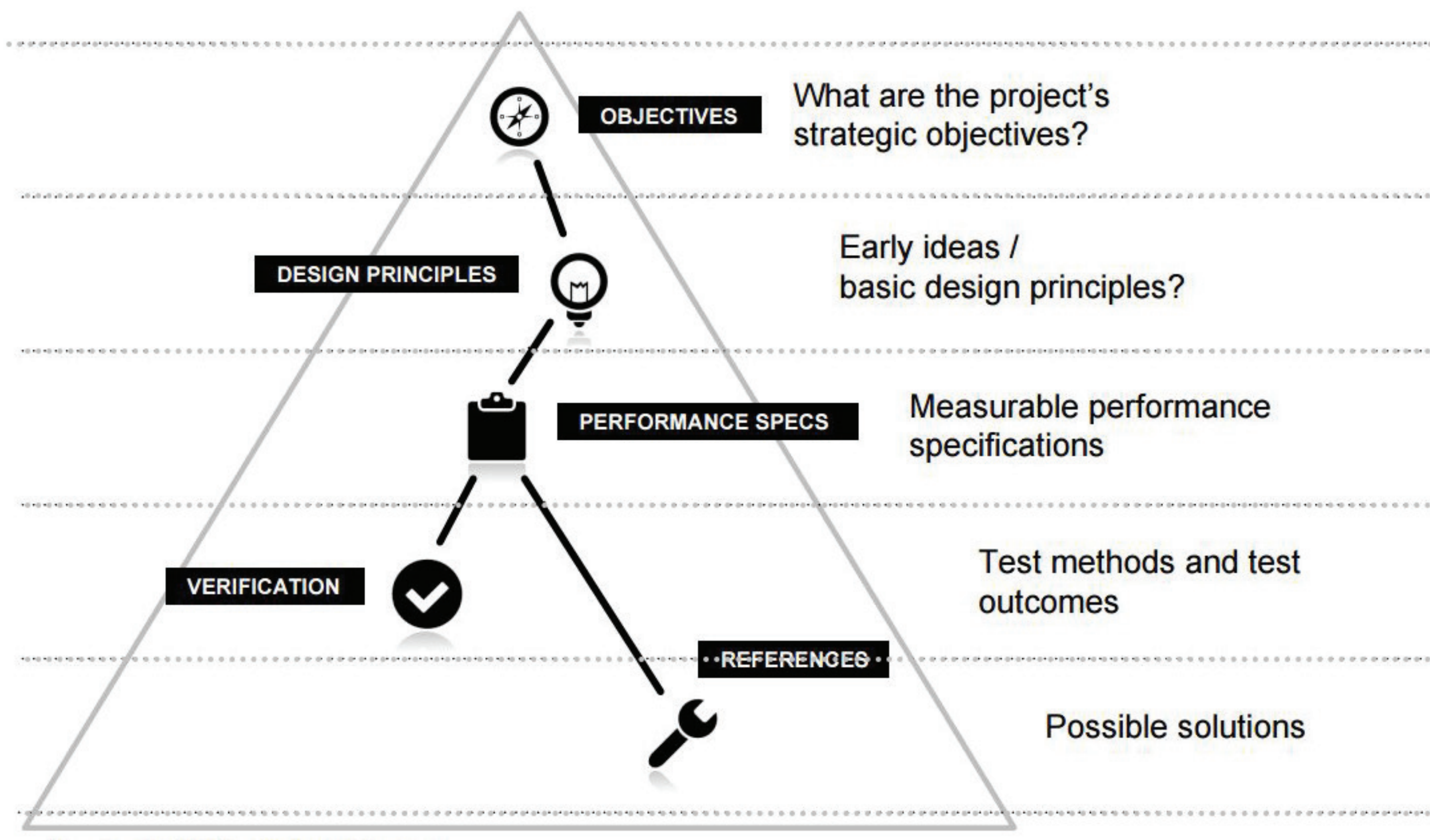



Warehouse
350m2
Washing area
Tool Control
Delivery entrance
Storage Tools
Kitting area
ar Hall
m2
Workshop
160m2
Showers
Changing rooms
EHBO
Presentation room
Required connection
Desirable direct connection

## Overview and Purpose Output Specifications General




## Overview Output Specifications Nordic Five Level Structure



It is importants to know what has to be built and what qualities different spaces require. Different levels of output specifications can be defined in order to give a complete discription of the project. The three most importants levels are the strategic, functional and Technical brief. Apart from these measurable performance specifications also design objectives and principles are important and should be mentioned in the brief. In the design process the brief can and should be used to test wether the design meets the requirements or not. If it does not, the design should be changed in order to meet the requirements. Sometimes not all requirements can be met. In this case decisions should be made considering the priorities of the different brief elements.

Het ruimtelijk-functioneel Programma van Eisen beschrijft de:
- strategische visie
- organisatorische analyse
- ruimtelijke eisen (soort, aantal en oppervlakte)
- functionele eisen en relaties tussen ruimten (relatieschema en vlekkenplan)
- globale kwaliteitseisen.

In de praktijk worden verschillende indelingen gehanteerd. Er is een norm voor het opstellen van Programma's van Eisen (NEN 2658) en een SBR richtlijn (SBR 258)
source: http://www.vastgoeddialoog.nl/diensten/programma-van-eisen/

> Support the Future maintenance processes in the hangar in an optimal way.
> Create a state of the art hangar with innocative technologies > image KLM

> The Energy Machine > Save and create energy
> Functional, practical design
> Supports the KLM organisation of the future

> **Technology:** Specifications concerning the building's technical components
> **Indoor climate:** Air quality,thermal and visual comfort, and acoustics.
> **Spaces**: the spaces that need to be provided in the building
> **Users:** The number and type of future users of the building
> **Activities:**Activities that need to be accommodated and facilitated

> Test if the design meets the requirements by running a full check
> Test if the design principles and concept are still holding and are met

> If the design does not meet the requirements the design has to be changed. Decisions have to be made while taking measurable specifications, strategic objectives and design principles into cosnideration.

# Research + Flowchart >>>

# >> Output Specifications

Three elements
From the O.S is becomes clear that three main elements are important for the design.
The design should be:

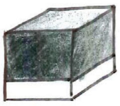
1. Functional
2. Pleasant workenvironment
3. Sustainable


REMOVE BEFORE FLIGHT

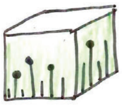
# CHAPTER 12
# Design Hangar

# 12.1 Concepts and first sketches

① THE BLACK BOX
- purely functional
- cheap
- Brutalistic architecture
- statement (light @ night → float)

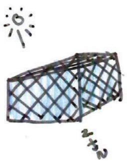


② CAMOUFLAGE facade print / real plants
- surprising sustainable image
- facade print grass/clouds
- Does not match KLM image



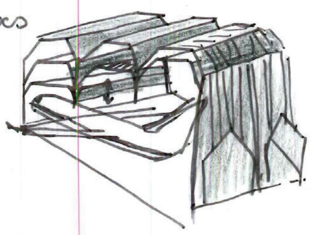
③ PTFE couchen facade (ALLIANZ stadion)
- special shapes possible
- fancy facade material
- low Rc value negative aspect
- light possible in facade.

④ THE MACHINE make use of heigt hangar to make energy
- concept of an energy machine → zonnepaneelen
- glass heats up air → warmtewisselaar afzuigen lucht
- use of height hangars.



⑤ EXOSKELETON
- external construction
- New hangar design
- not very praktical.

⑥ MOVABLE ROOF
- Roof can be chanched in height.
- only inner construction moves
- cranes + lights?
- saves energy.



Poortgebouw IPKW bt by
NL architects in Arnhem

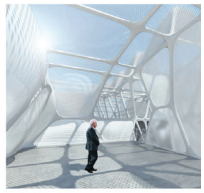
Pays des merveilles arctiques,
By Sarah Anne Johnson

Hopp house and studio,
Weimar 2003 — Max Dudler

Carl stahl Arkitectur, location unknown

Estates Office of Land Securities
on New Street Square Holborn by biatecture


Allinz arena Herog de Meuron in Munchen



National aquatics Center, Beijing, China
by PTW en CSCEC Shenzen Design Institute

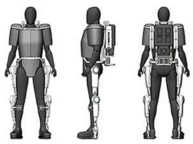
Para building
Tokyo hErzog de Meuron

Buckminster Fuller Biosphere Montreal

Centre Pompidou in Paris 1977
by Rogers and Piano.

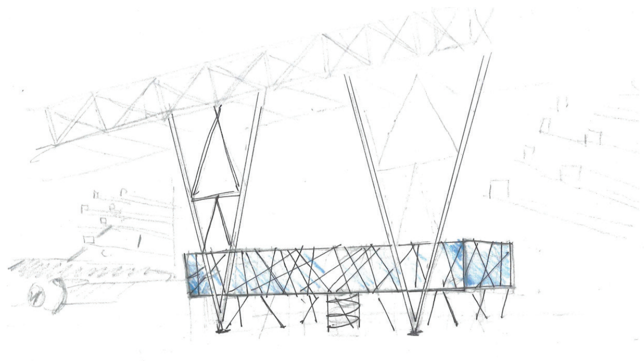
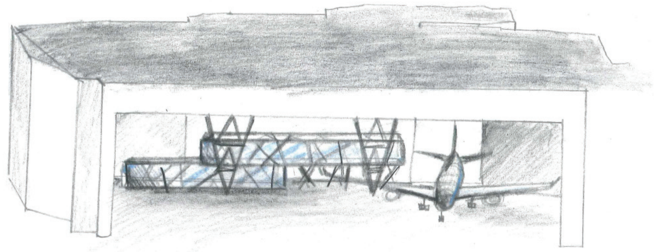
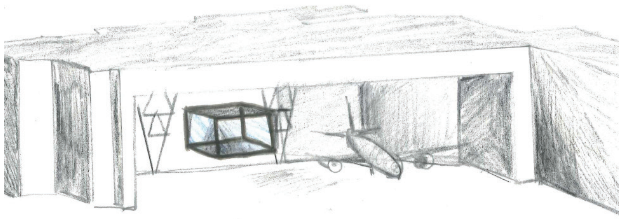
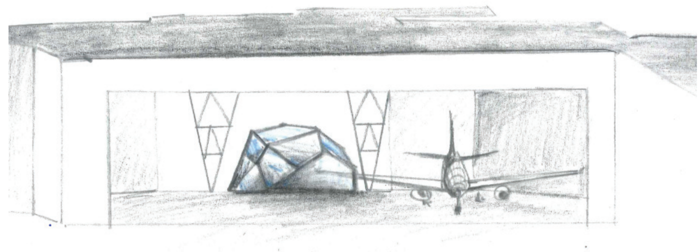
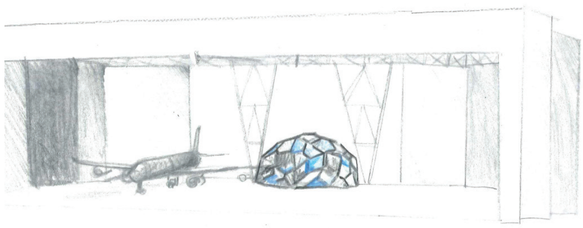
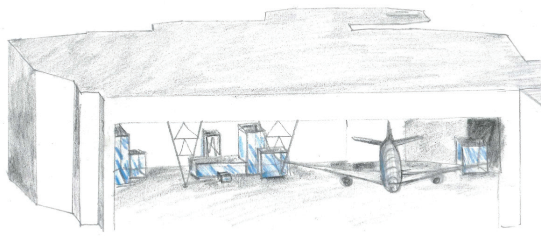
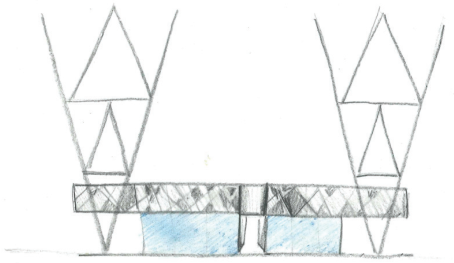
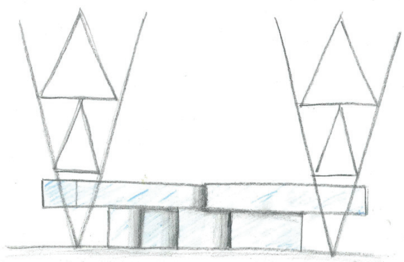
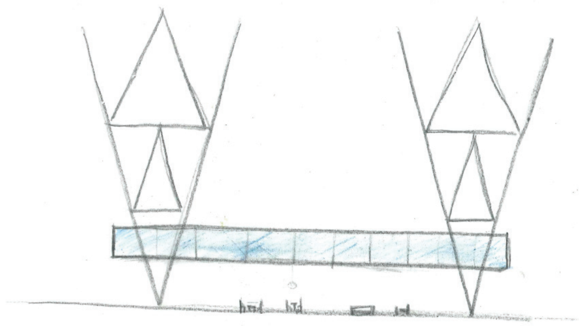
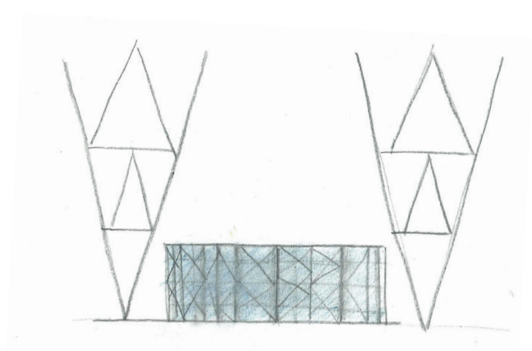
Unknown buiding

Lufthansa technnik hangar A380 Hamburg



Exoskeleton pricible

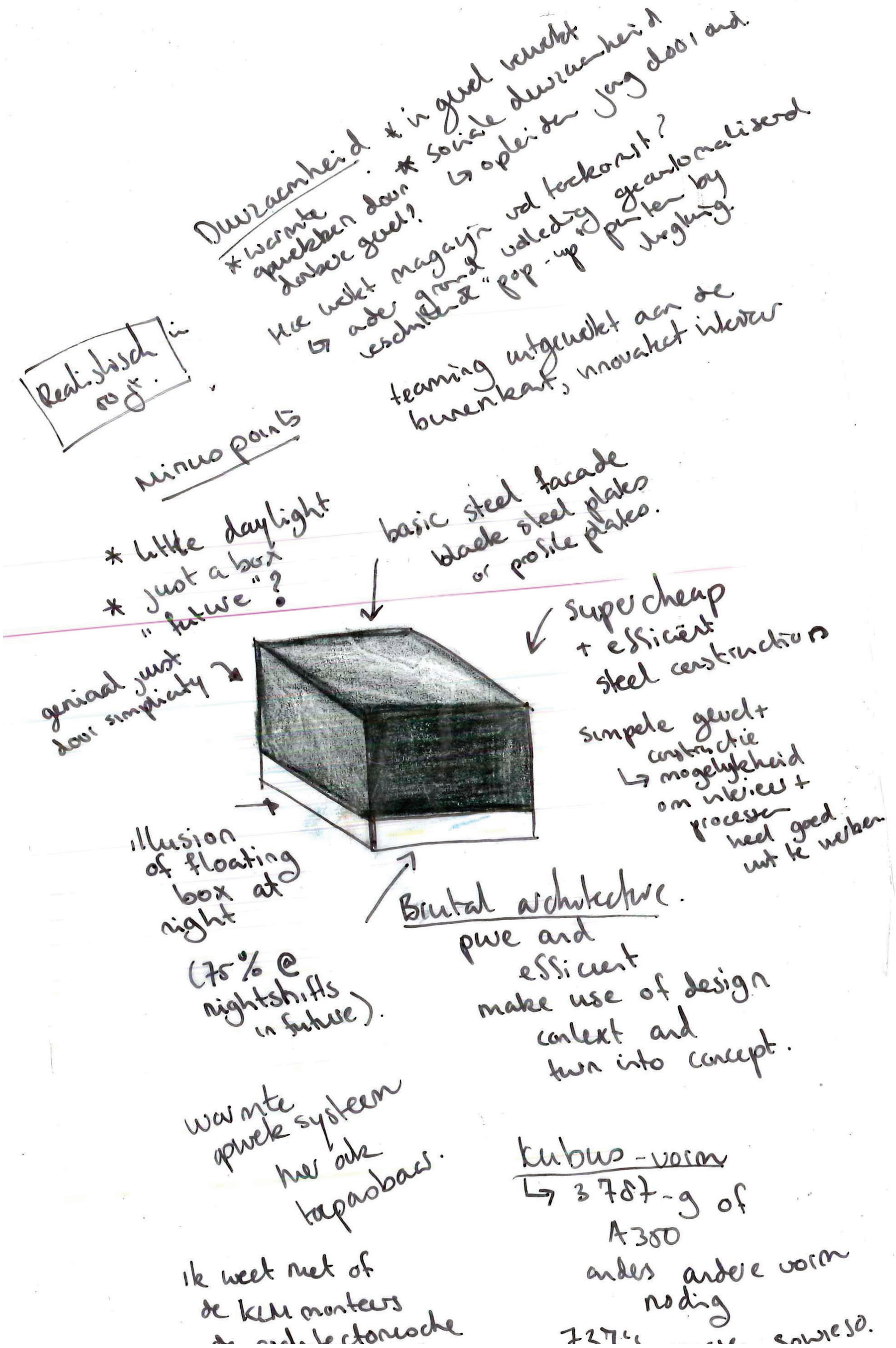
Hooiberg > movable roof

# Two final concepts - Machine is chosen

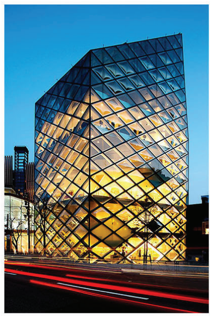
## The Black Box

Use limitations and functionalistic approach in the aviation industry to create Brutalistic architecture that makes a statement.



# The Machine

Make use of the height of the hangar to produce energy.The hangar will function as energy machine with solar panels and use of heated air that cumulates under the glass roof.

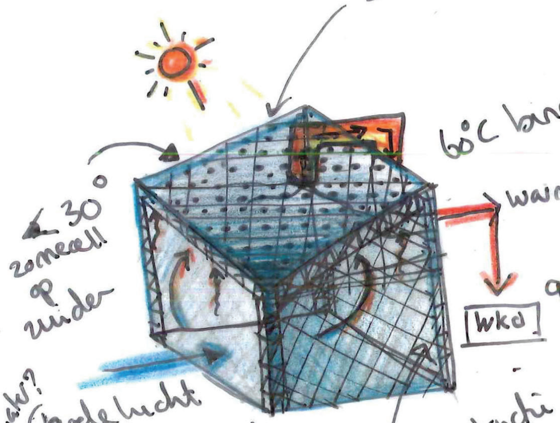


geothermie: 3km onder grond 110°C
debiet 100 m³/uur
- gasbesparing 3.000.000 m³/j
- elektra koeling 1.000.000 kwh/jr.
- niet financieel aantrekkelijk door lage gasprijs v KLM.

Pv cellen
* vermogen 7.500 kW piek
* jaaropbrengst 6.375 mwh/jr.
* 50.000 m²

1 prijs
gas [illegible] €/m²
elect 0,30 [illegible] €/kwh.
0,08
dal + piek afhankelijk
↳ gunstig om op te slaan en alleen van dal tarieven gebruik maken
Dal: 20:00 - 8.00.

Normally more heating than cooling required in hangar!



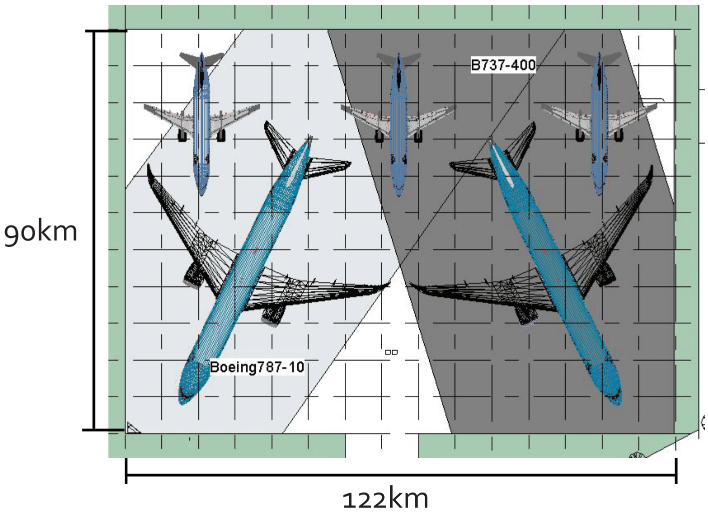

KLM ① gasuse reduced!
↳ emission reduce.
② produce electricity.
2% efficiency verbetering/jaar.

H12: gas 579.592 m³/jr
elektra 1.174.618 kWh/jr.
schiphol oost totaal aardgas: 6,4 milj m³/j
koudevraag 5 milj kwh
H102 + H201 + 410 + 411 + 700.

Sustainability!
* Green energy
* warmte koude opslag (WKO).
* wider thinking sustainable energy
↳ social aspects → architecture!

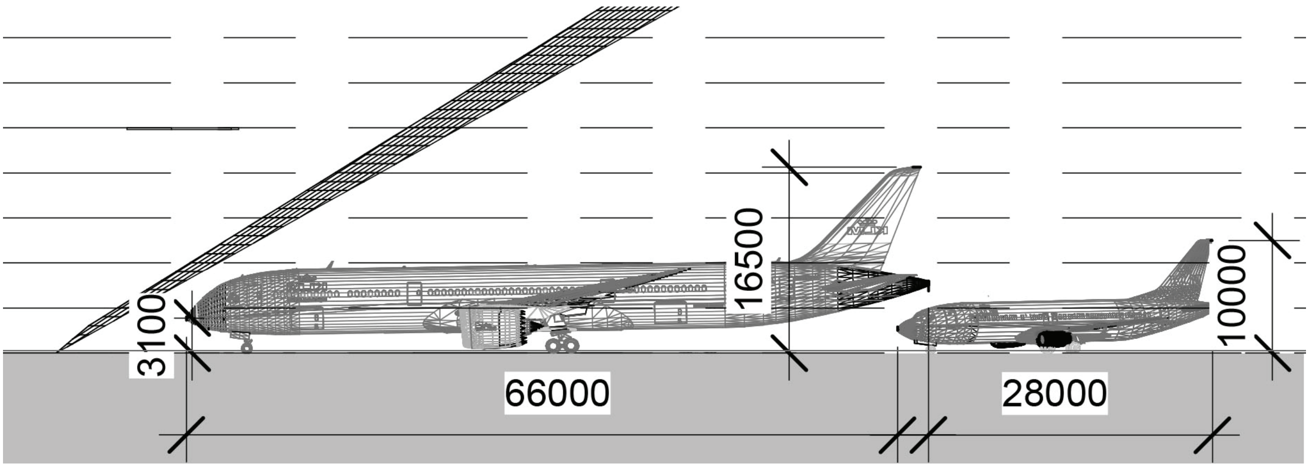
# 12.2 Restrictions and boundaries shape

### Foorprint boundaries 11.000m2

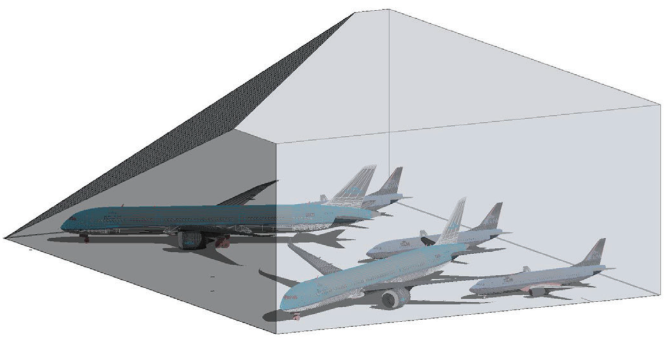



The boundaries for the **footprint** are **90x122 km.** This is based on maintenance on **two Boeing 787-10 and three B737-400 airplanes.** Also other models can be placed in the hangar. All 737 models and th A350 are also possible in this configuration. Larger airplanes are possible but 737's no not fit next to these planes.

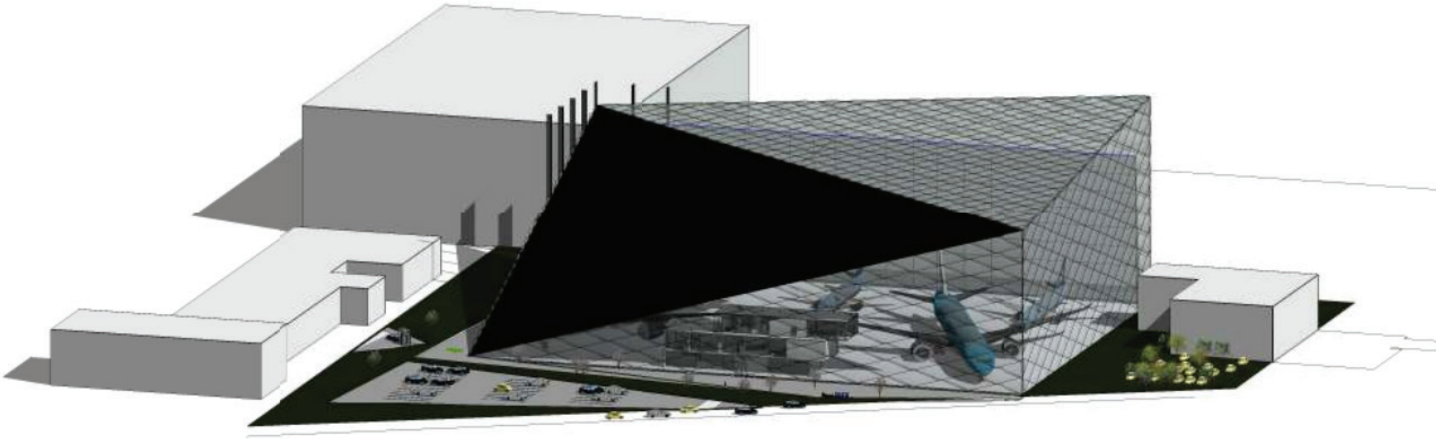
### Height boundaries by airplane

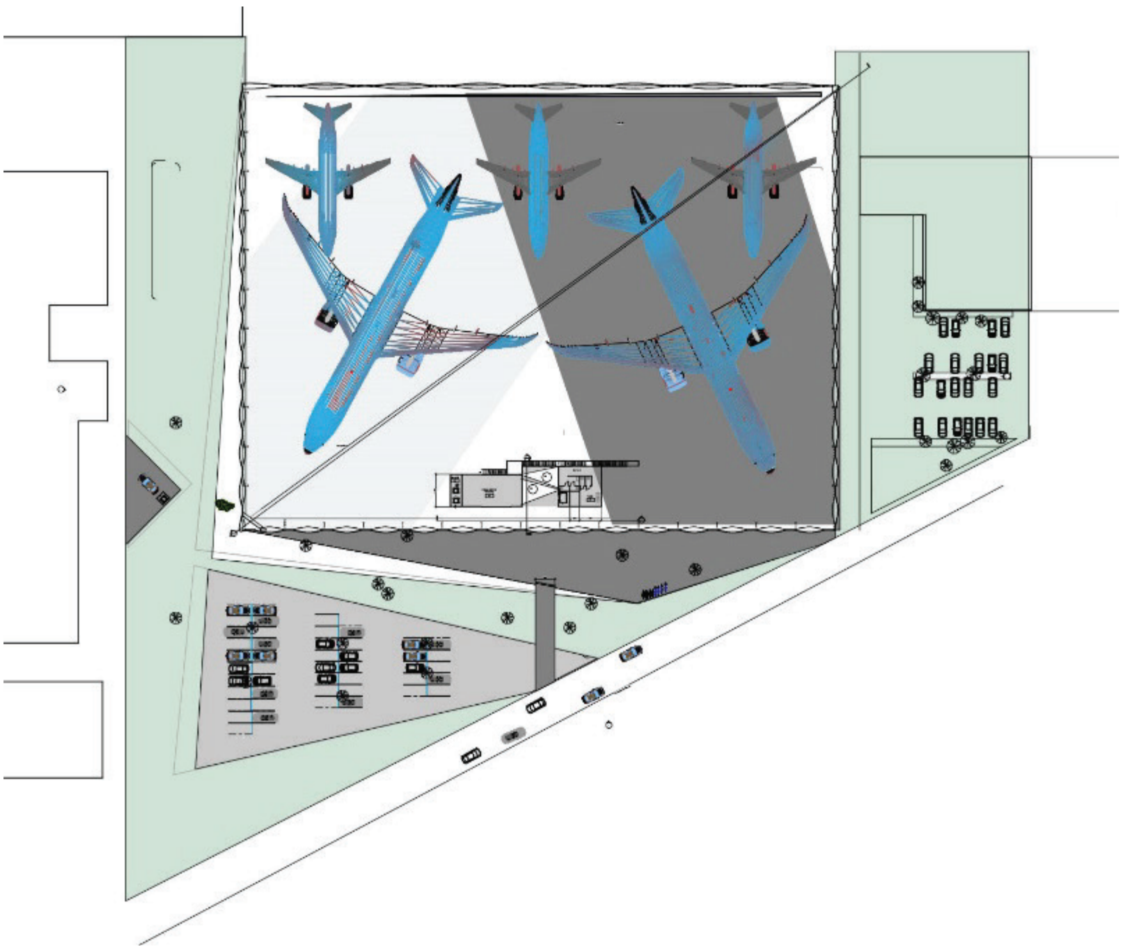


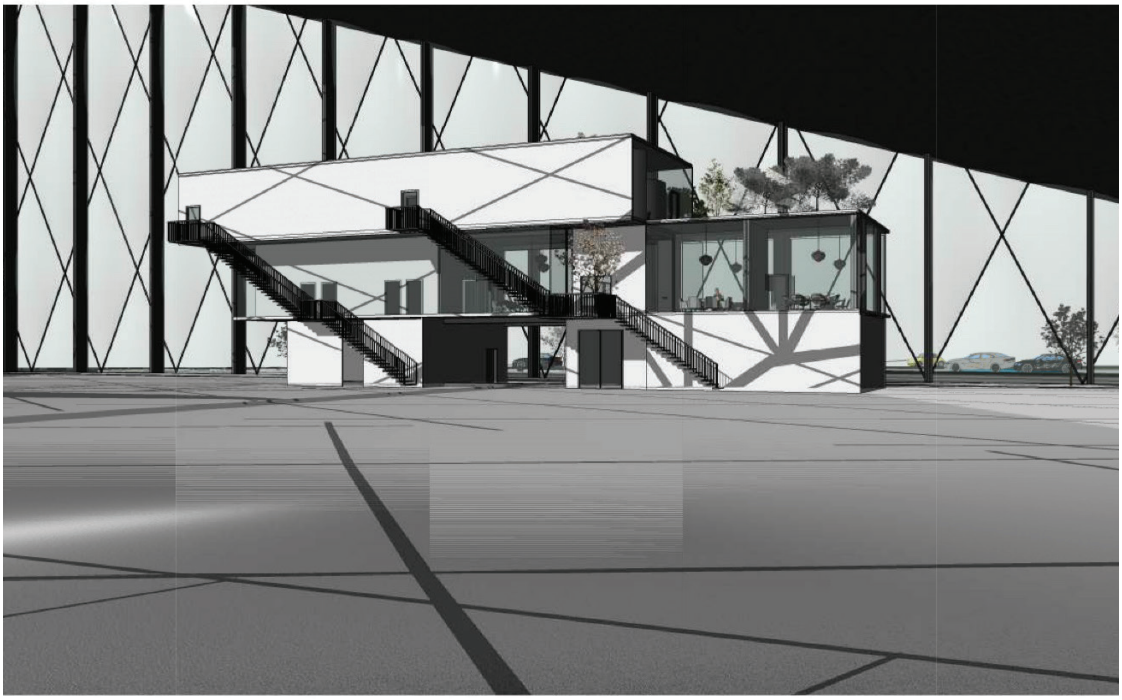

### 3D visualisatie boundaries

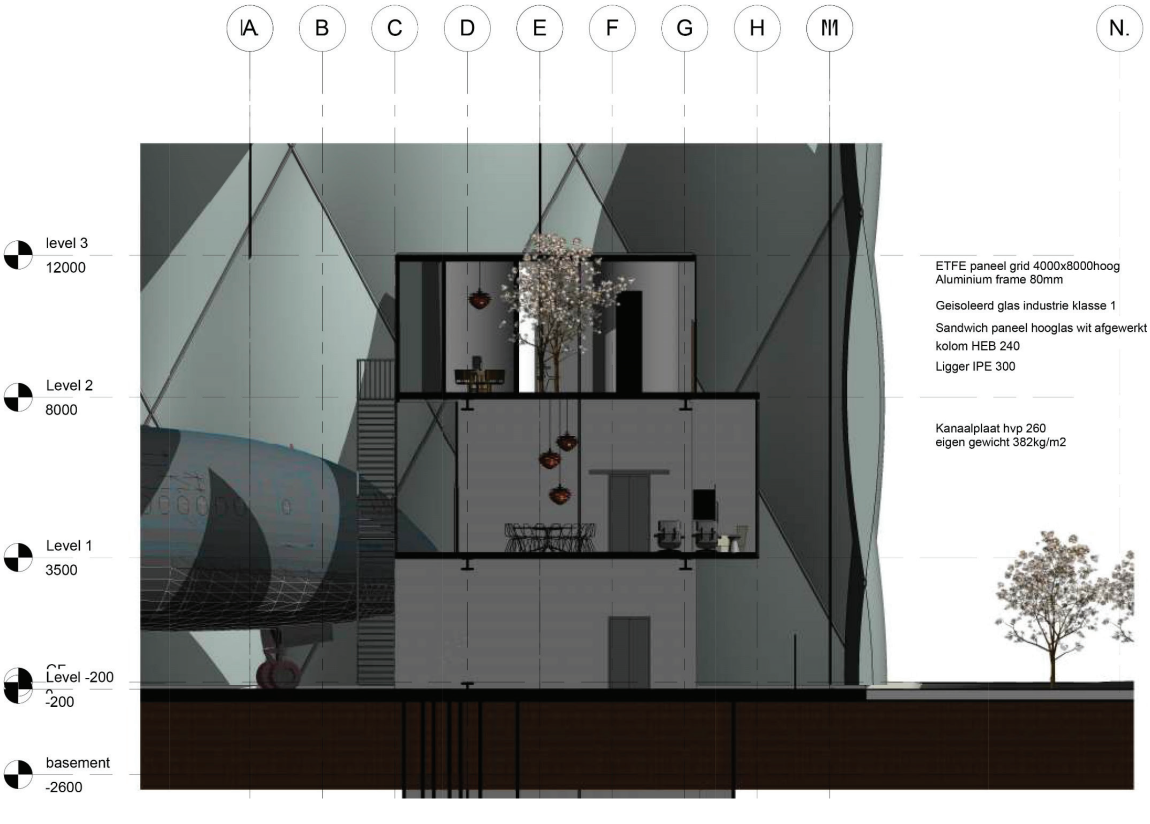


# DESIGN 1.0
## Interior and Climate scheme

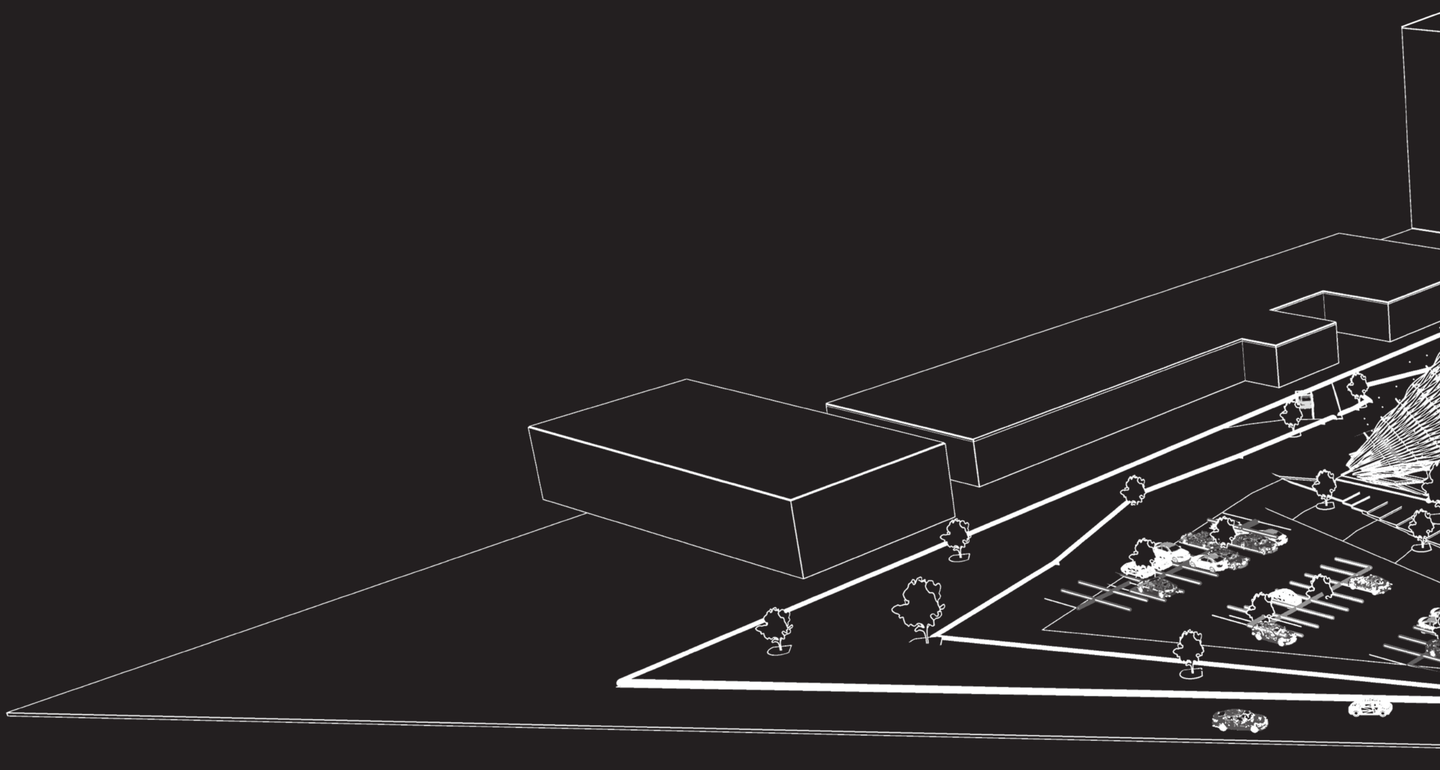


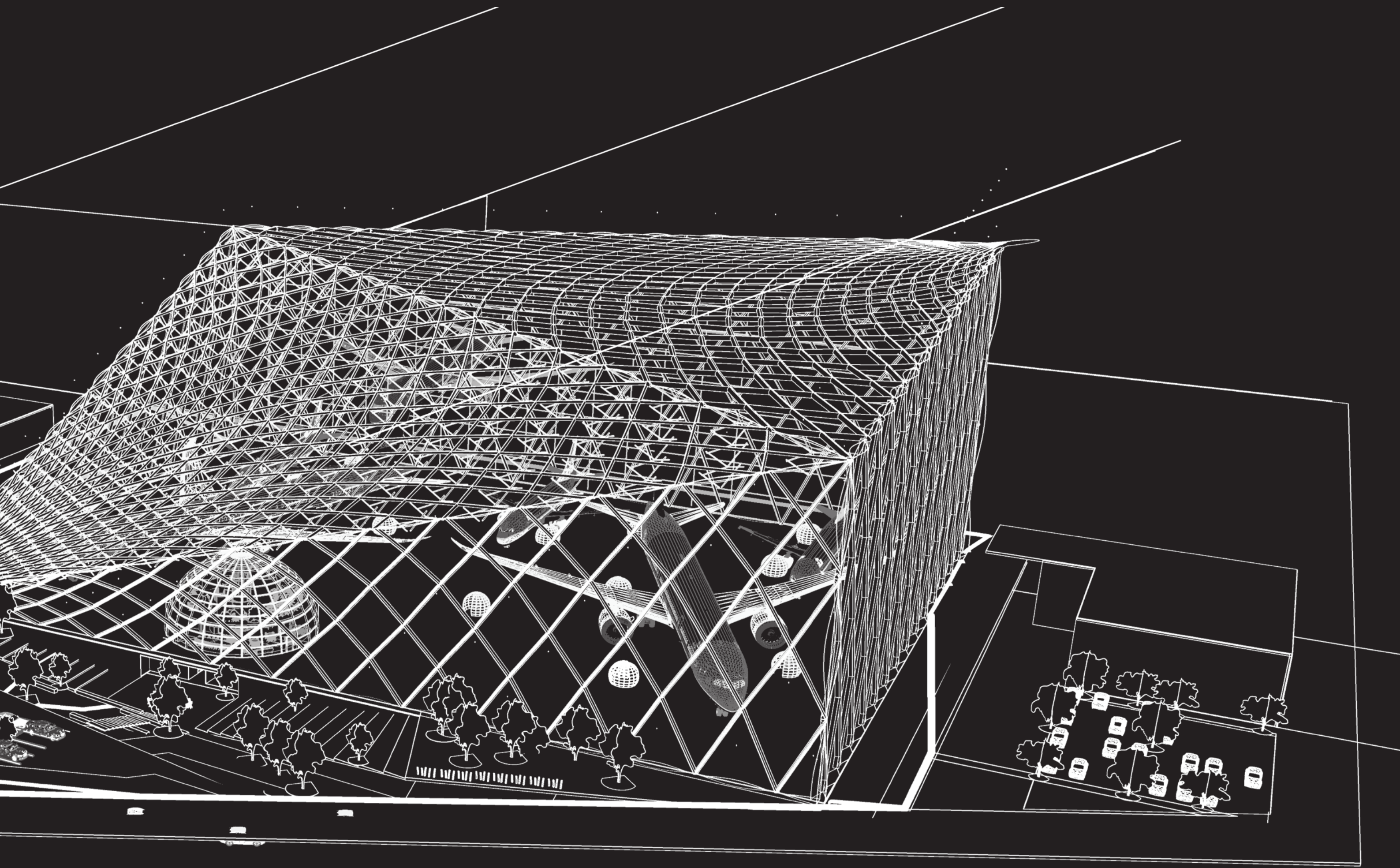


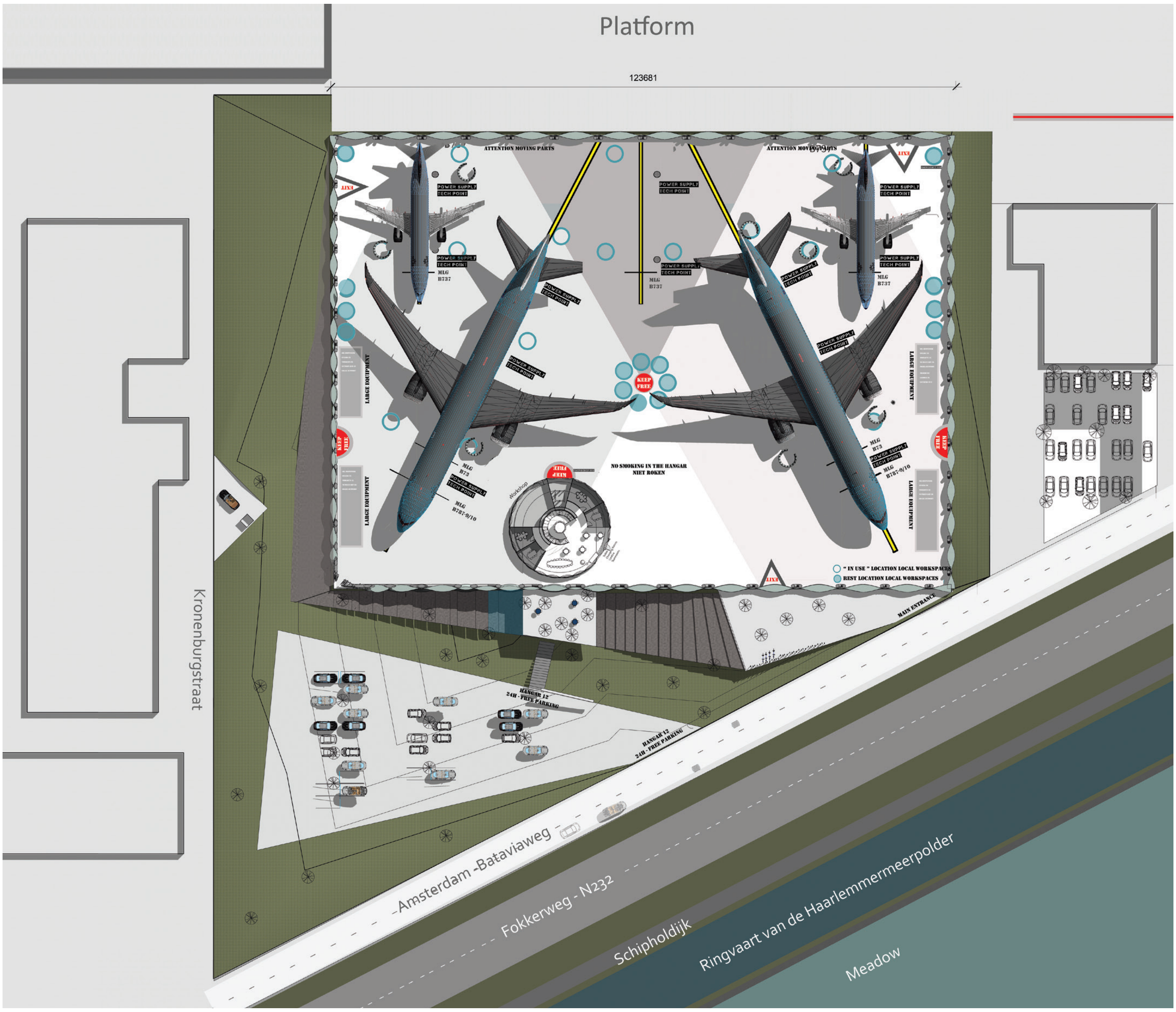



A
B
C
D
E
F
G
H
M
N.
level 3
12000
Level 2
8000
Level 1
3500
Level -200
-200
basement
-2600
ETFE paneel grid 4000x8000hoog
Aluminium frame 80mm
Geisoleerd glas industrie klasse 1
Sandwich paneel hooglas wit afgewerkt
kolom HEB 240
Ligger IPE 300
Kanaalplaat hvp 260
eigen gewicht 382kg/m2

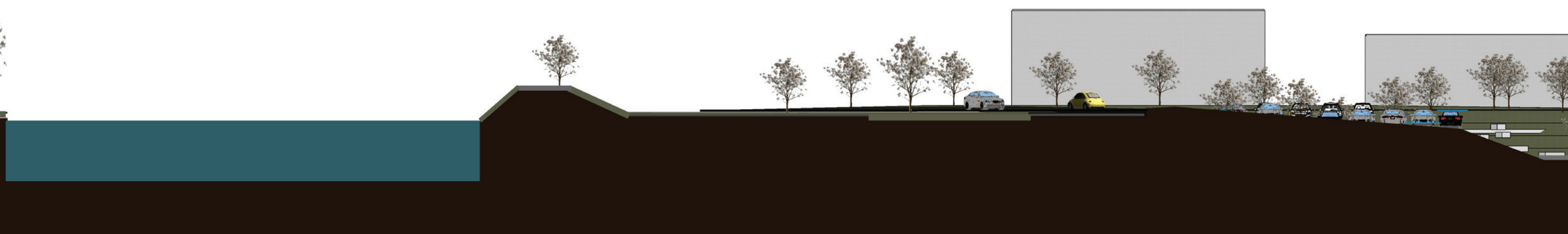
# Design Proposal

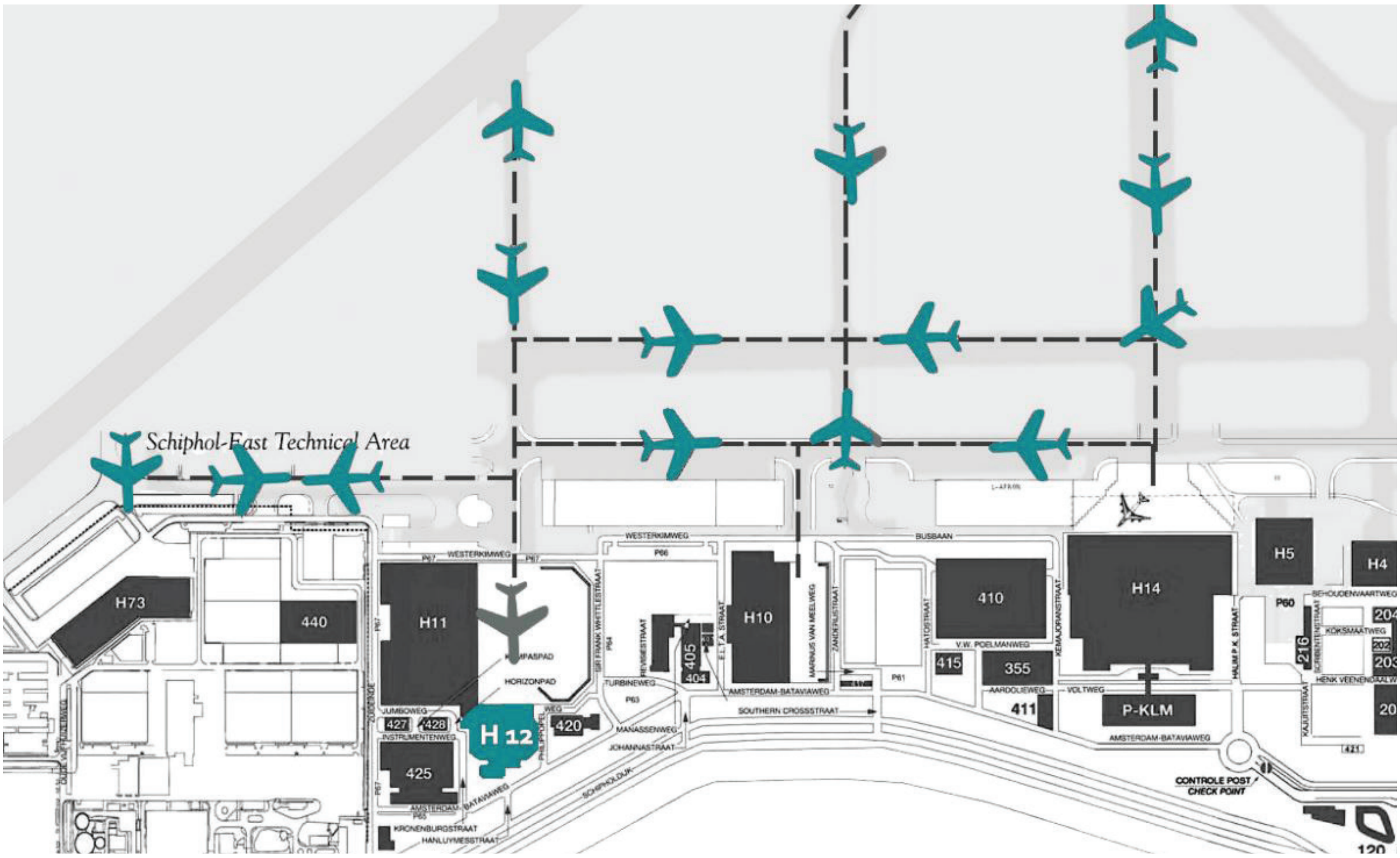




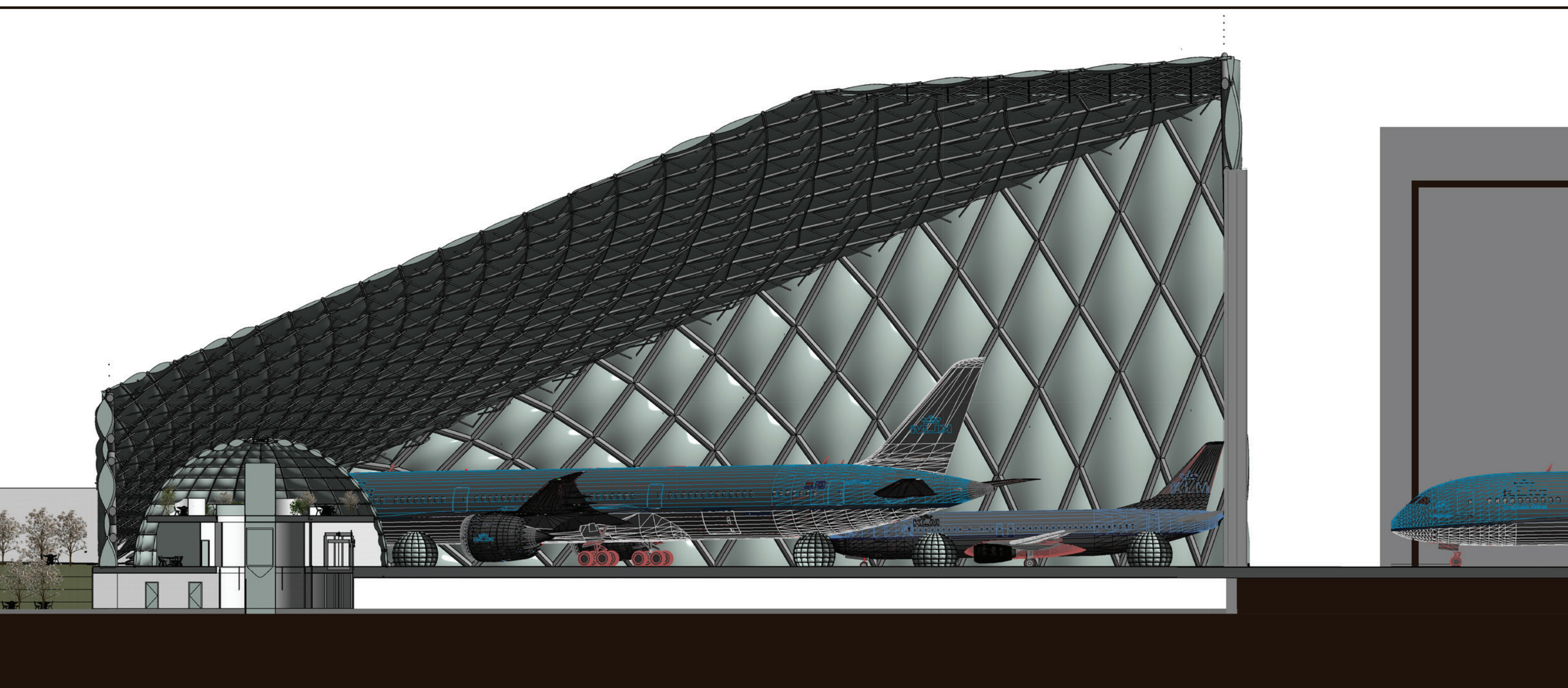



## Floorplan overview

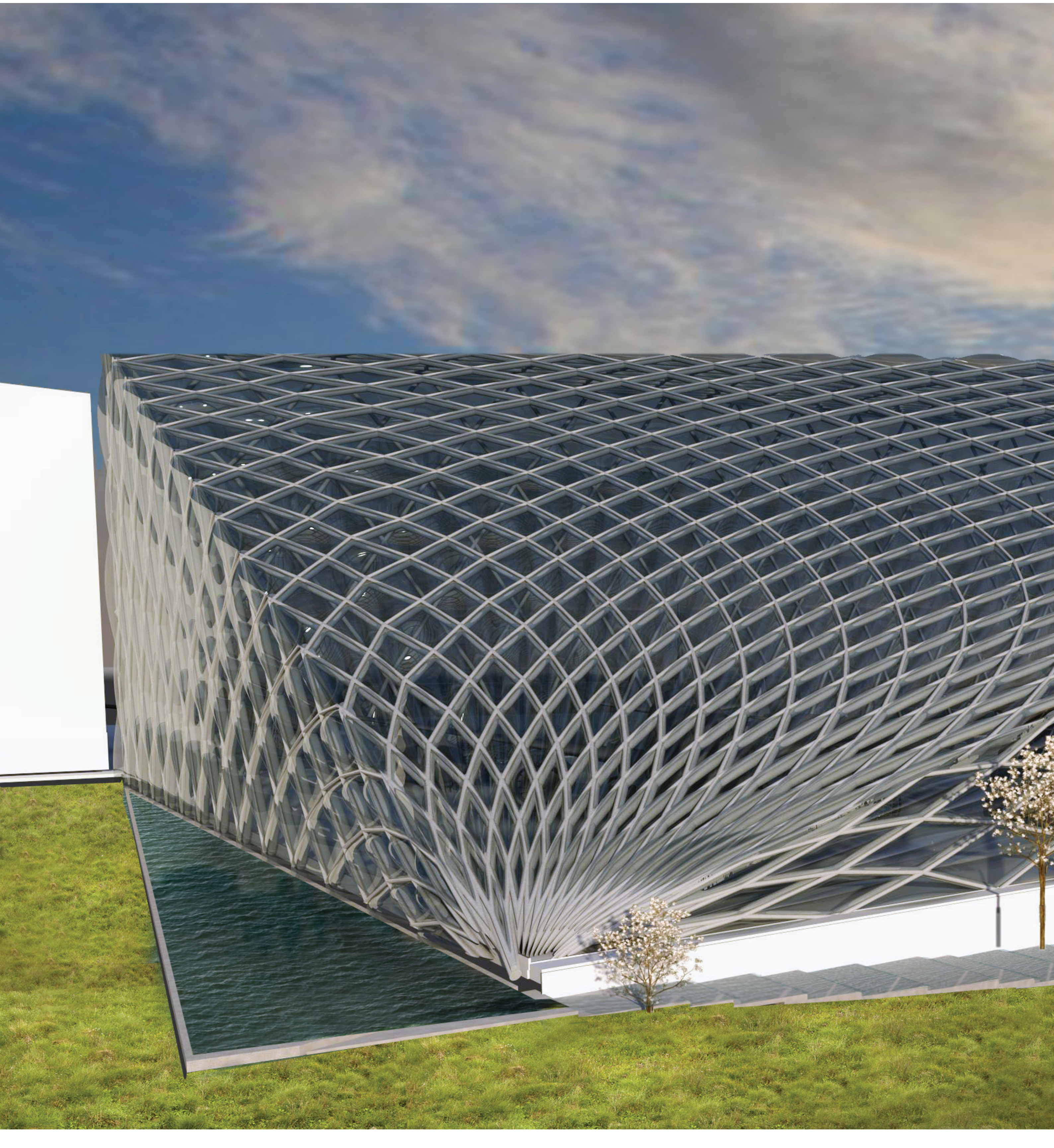


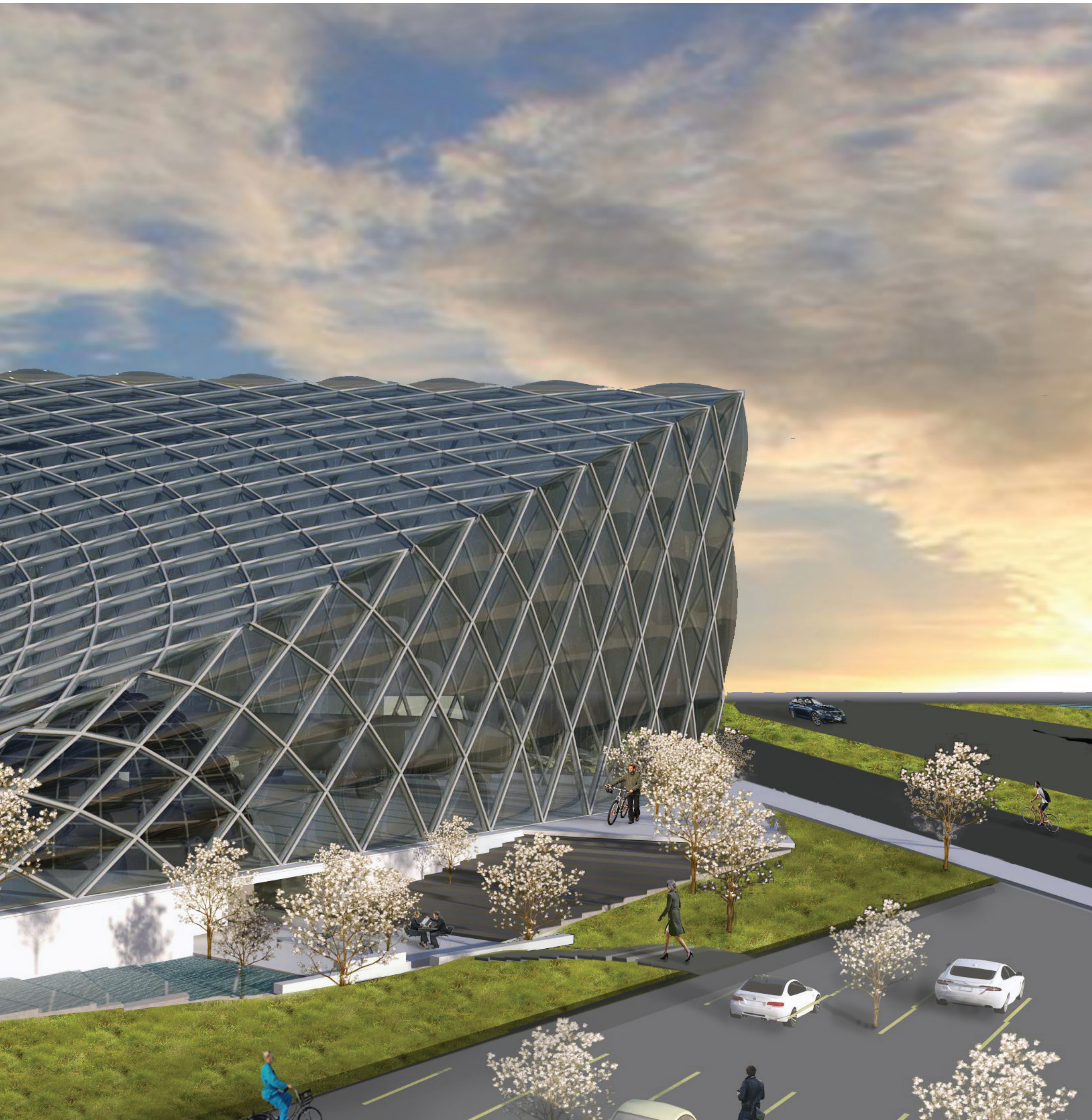


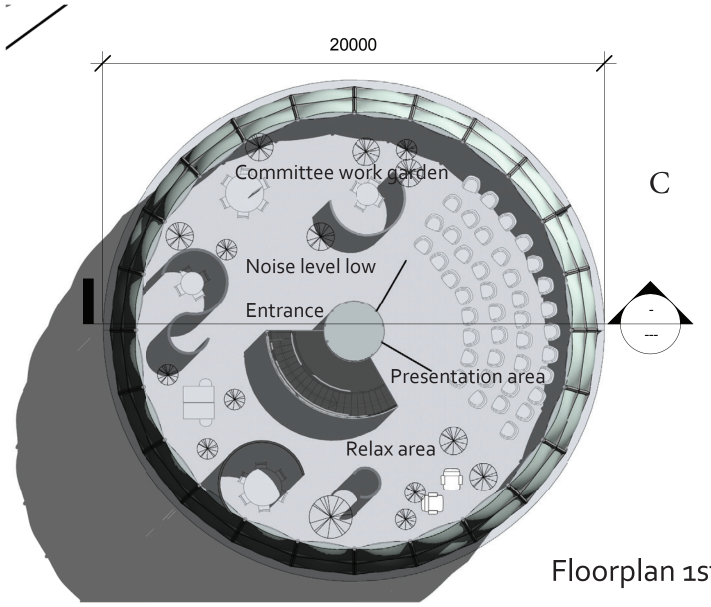

Schiphol Oost situation drawing



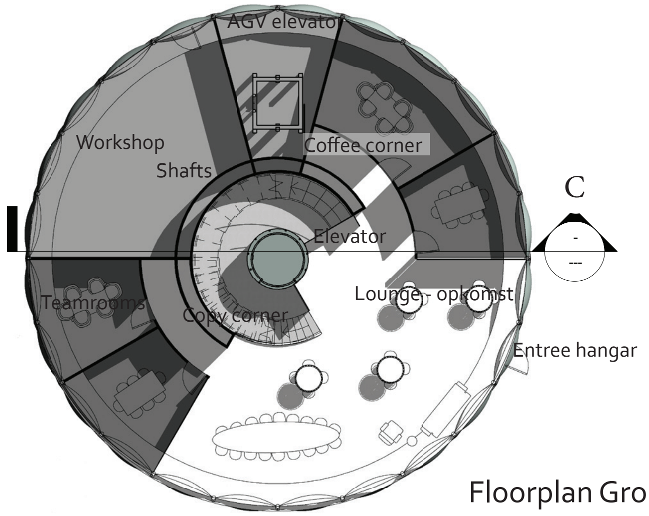
# South West facade



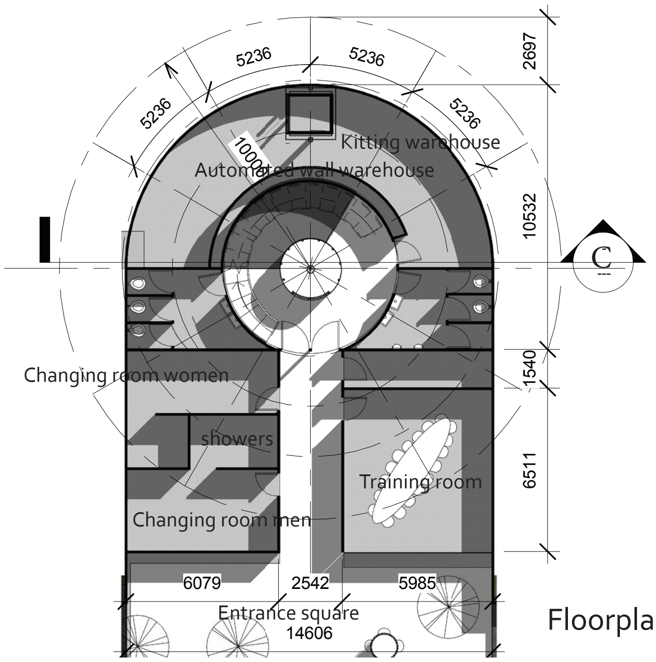




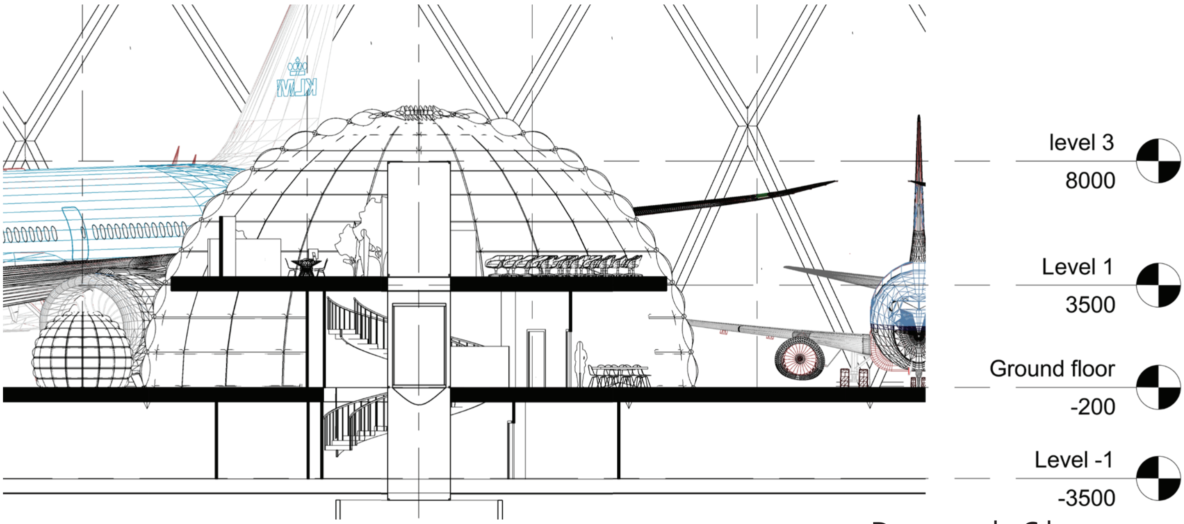

Floorplan 1st floor 1:200



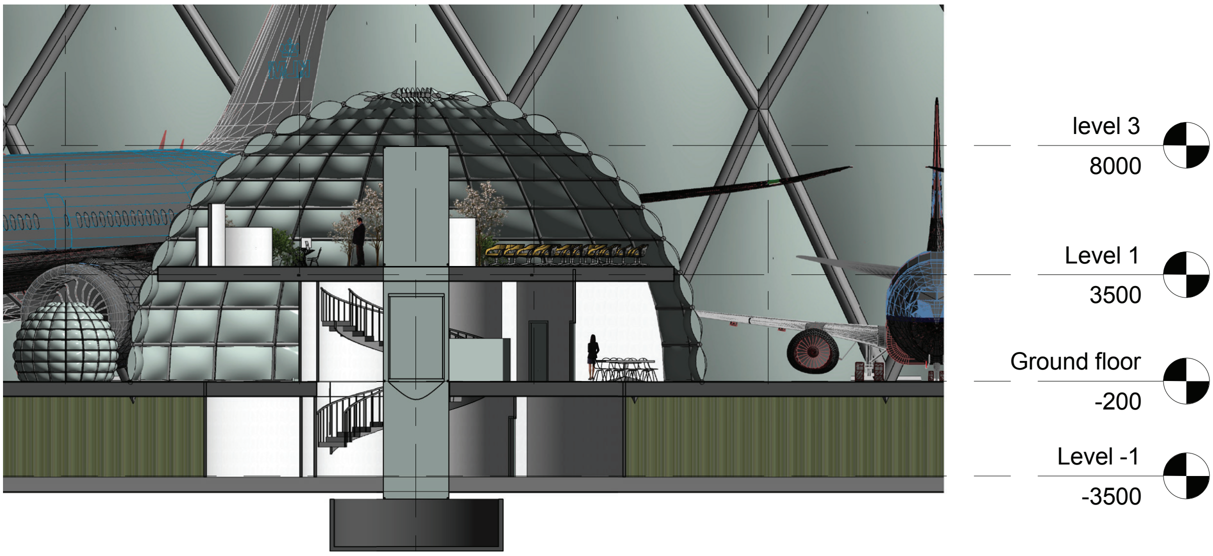

Floorplan Ground Floor 1:200



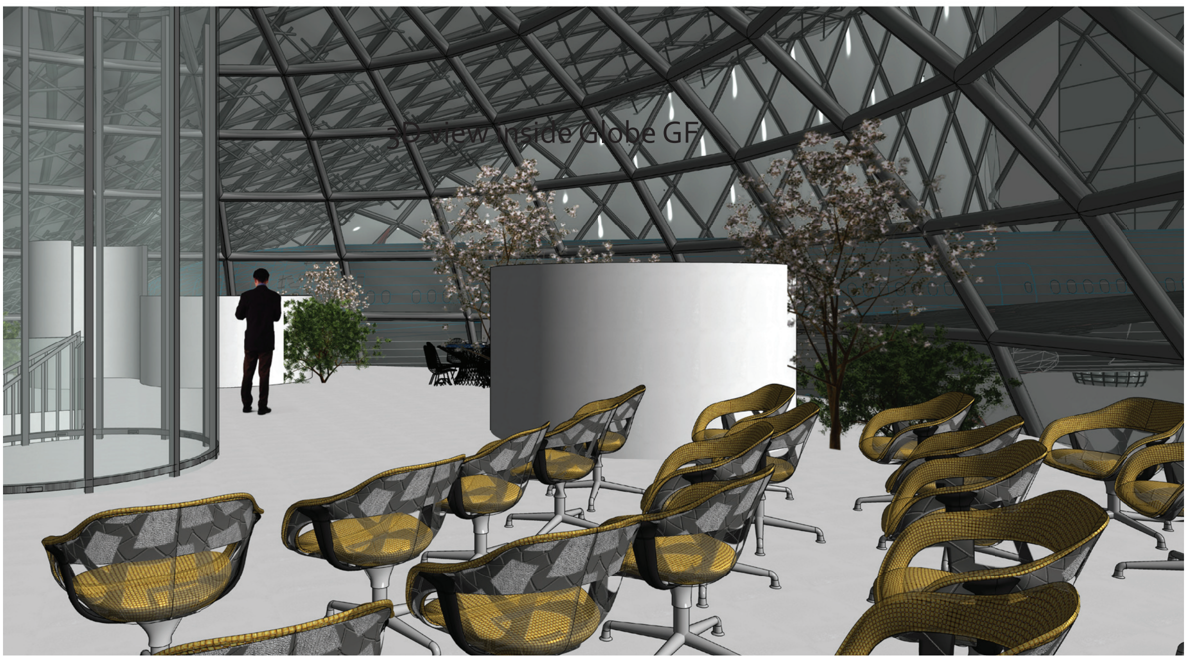

Floorplan -1. 1:200




Doorsnede C kantoren

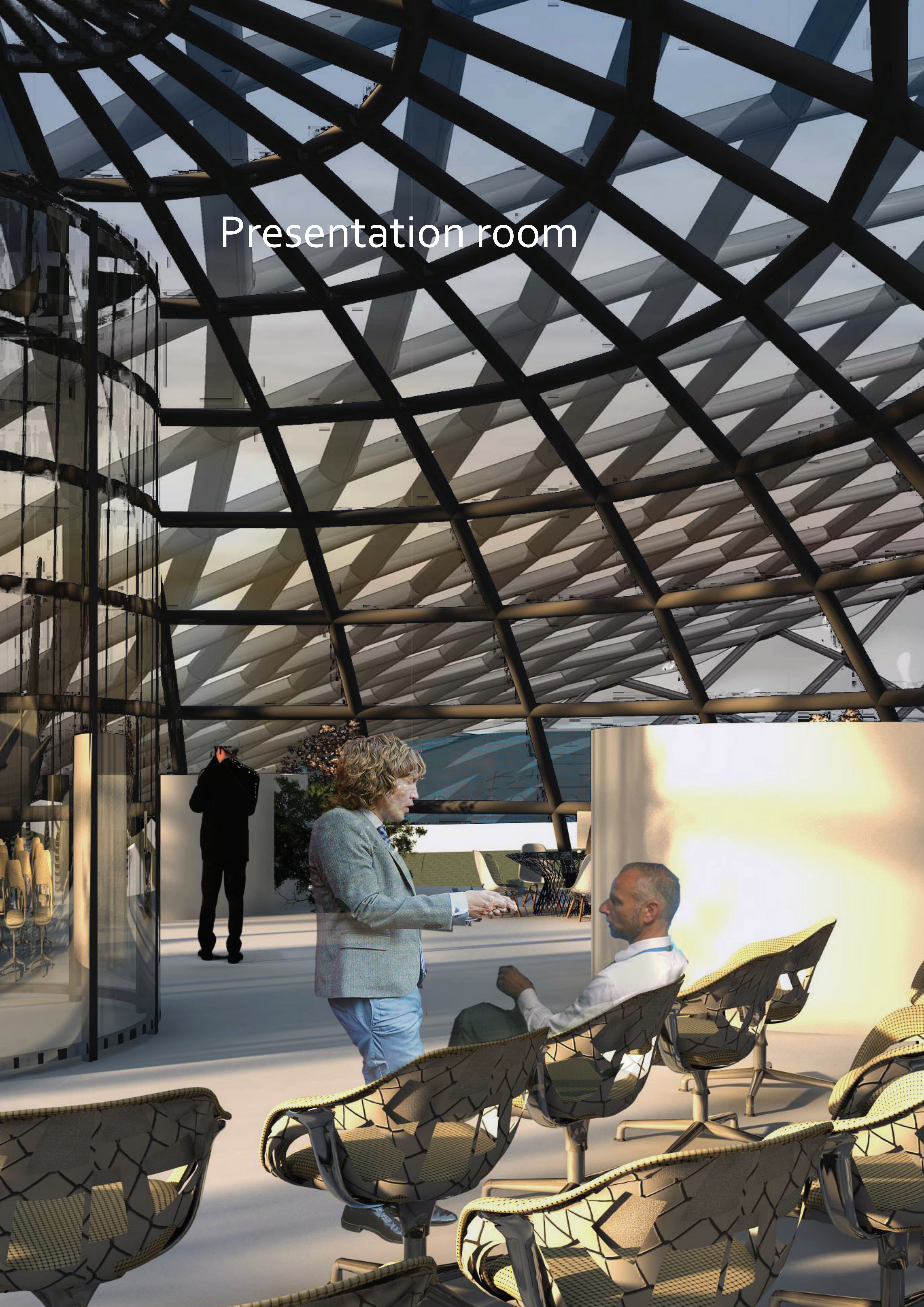


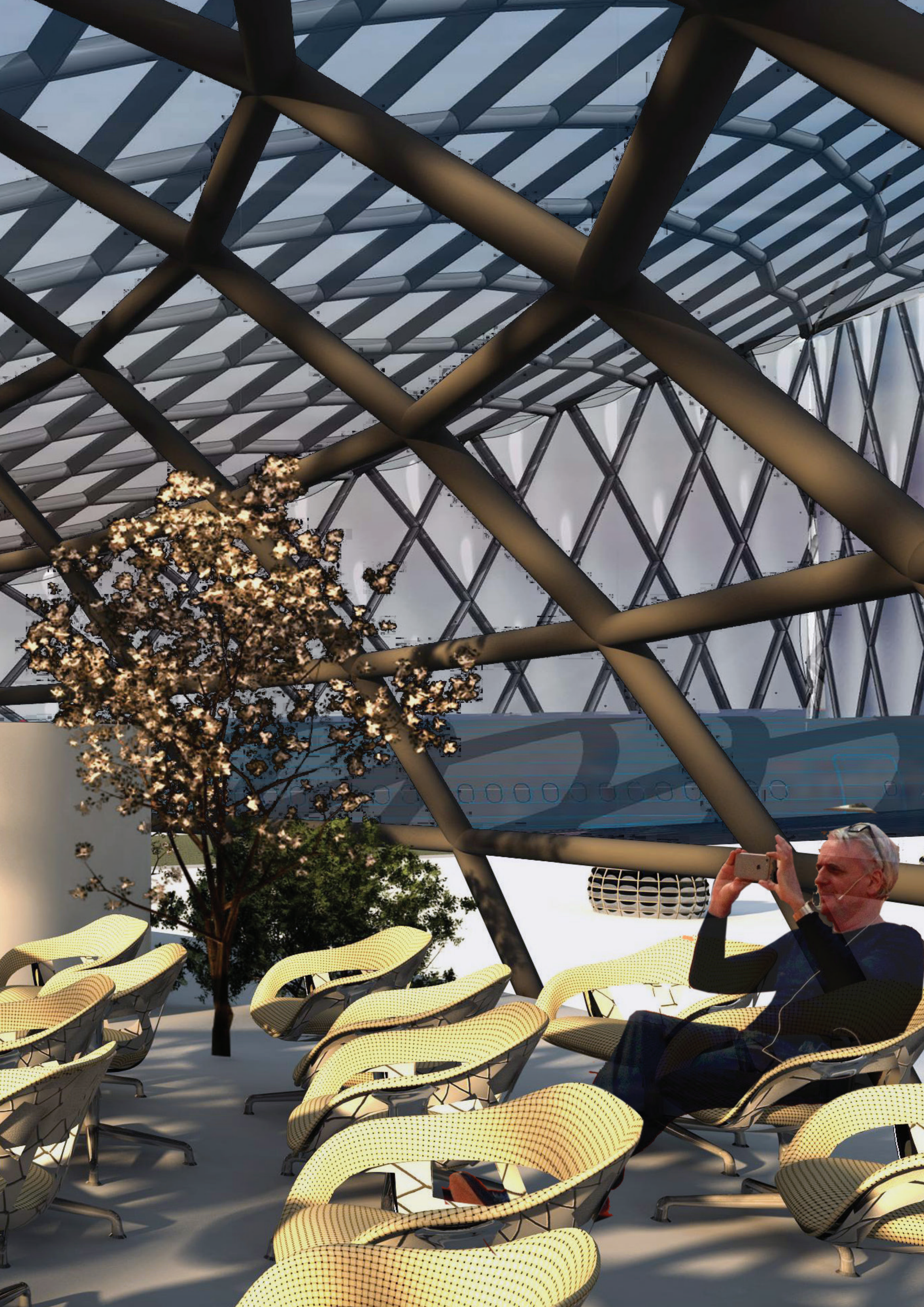

Doorsnede C kantoren

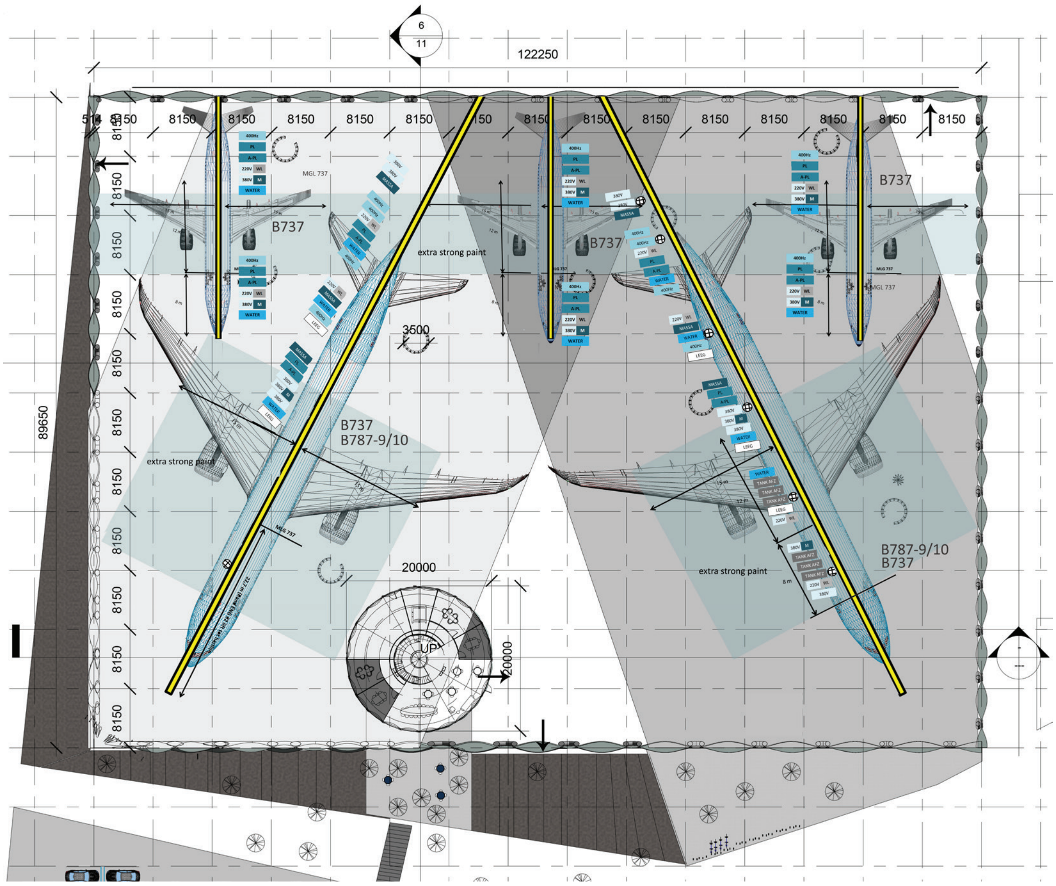



3D view inside Globe GF

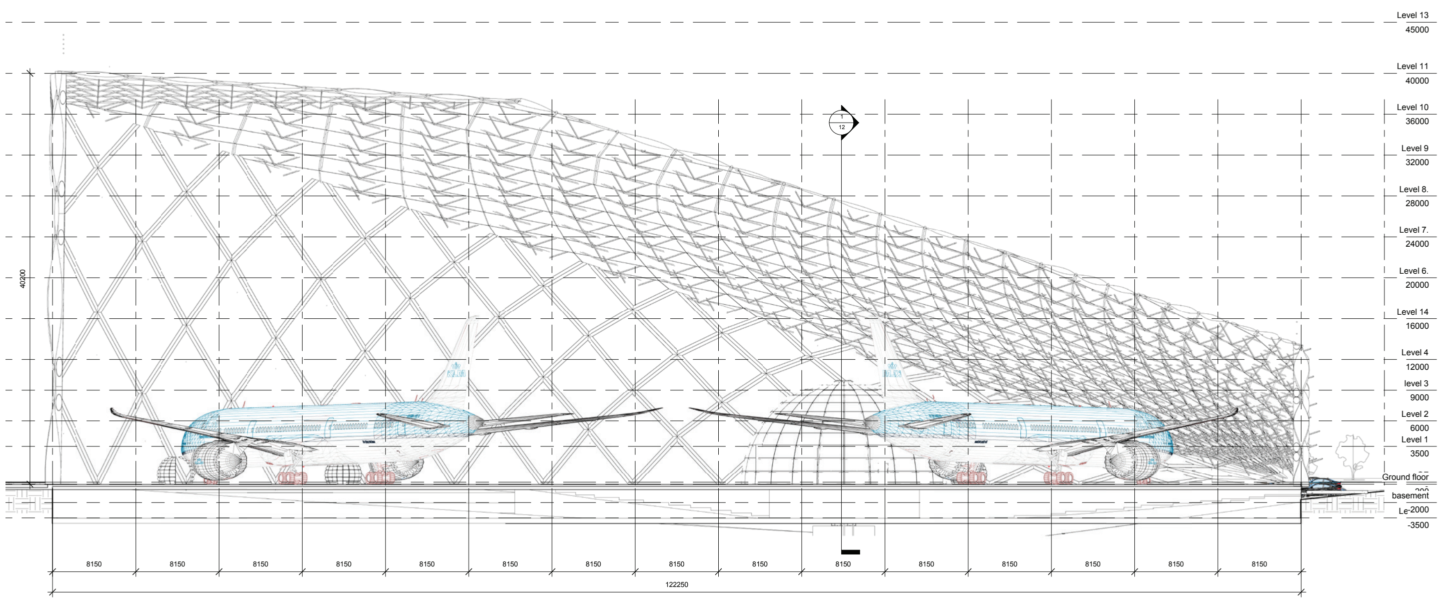
# Presentation room



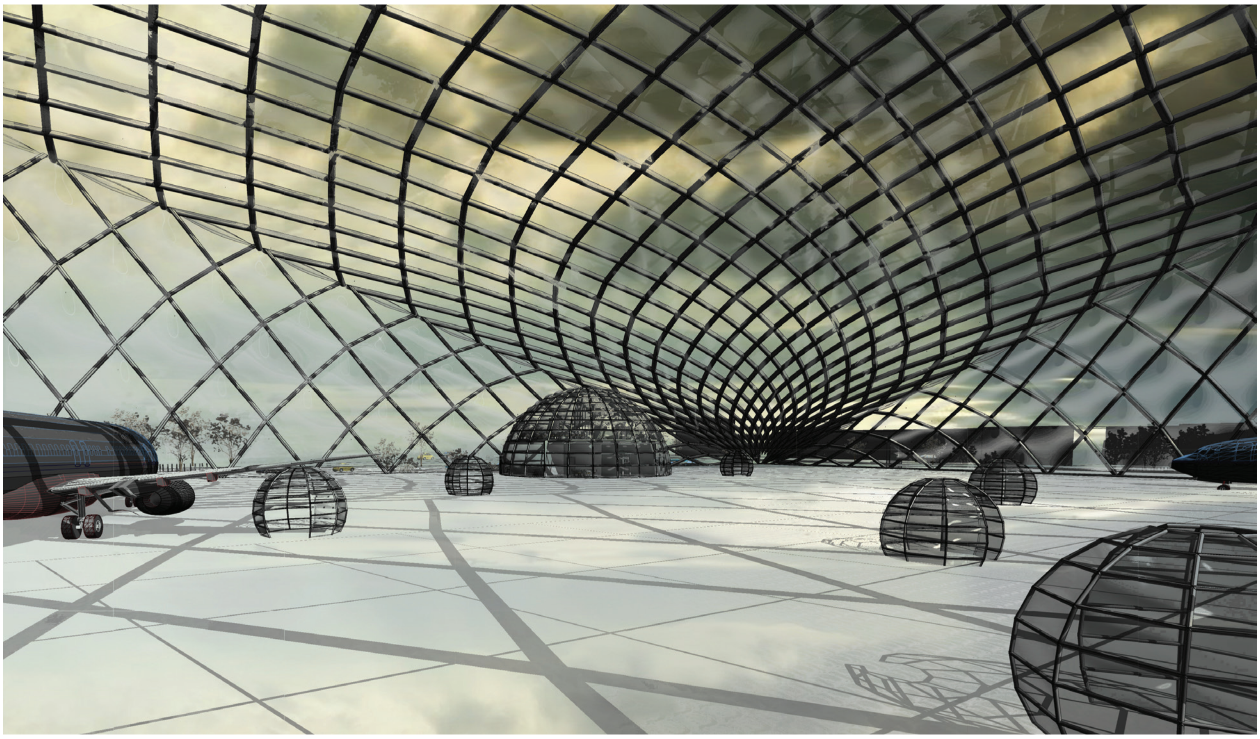




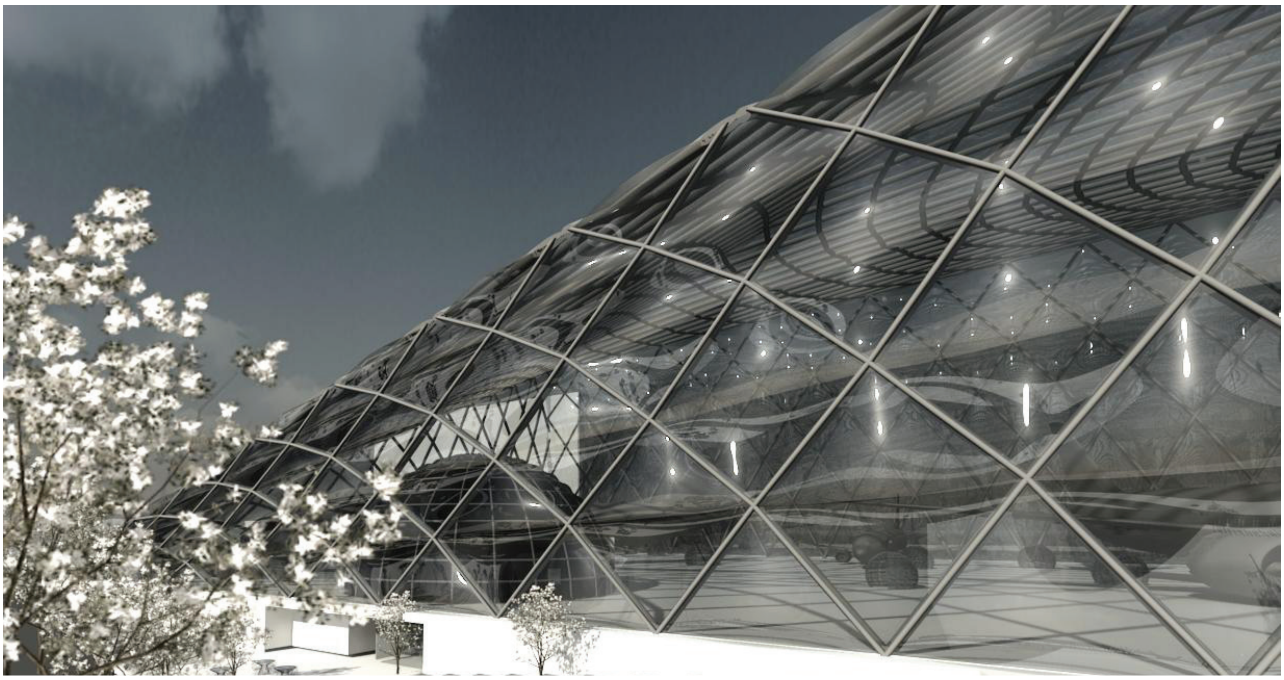

Technical facilities



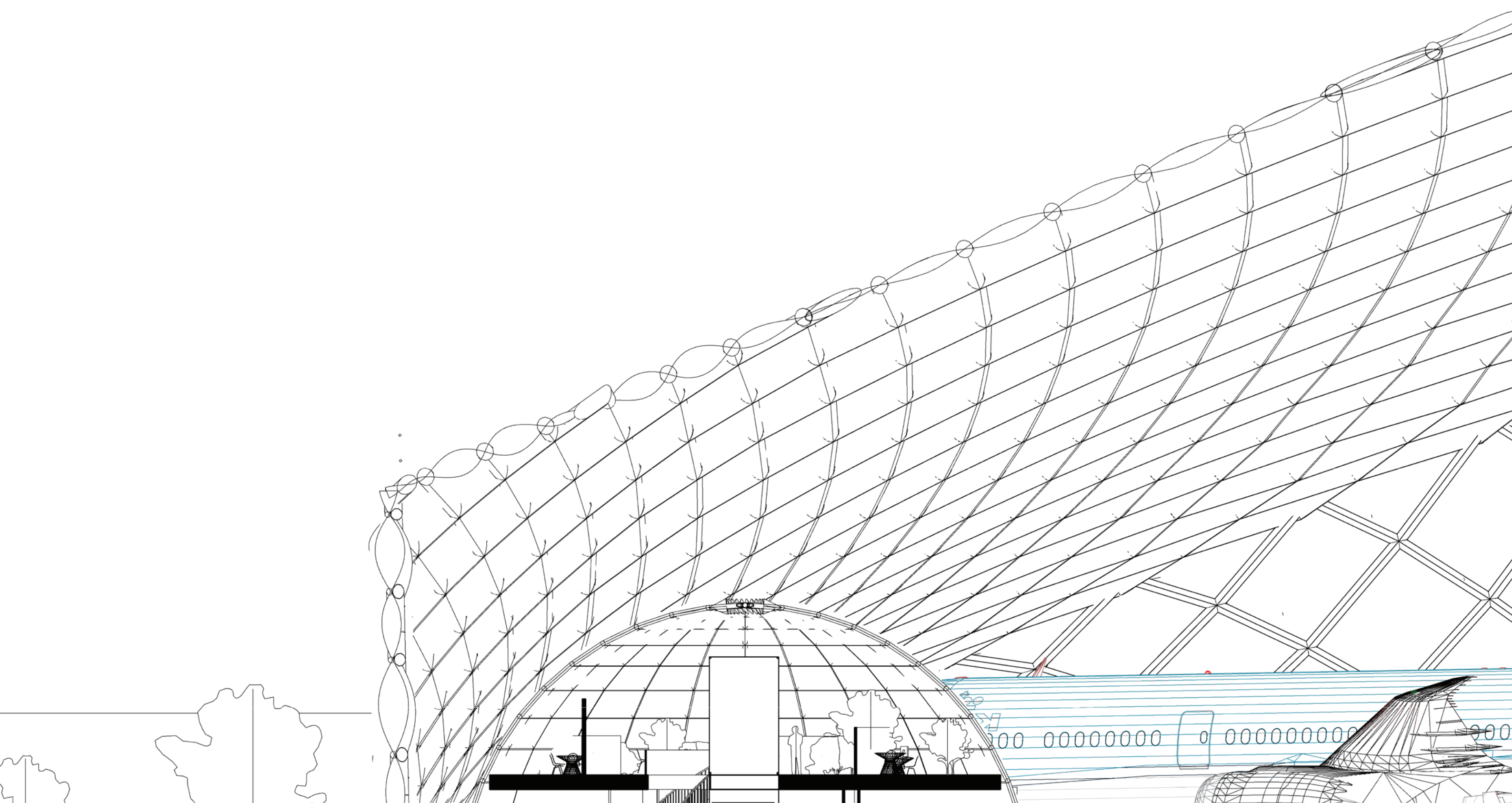

Section A

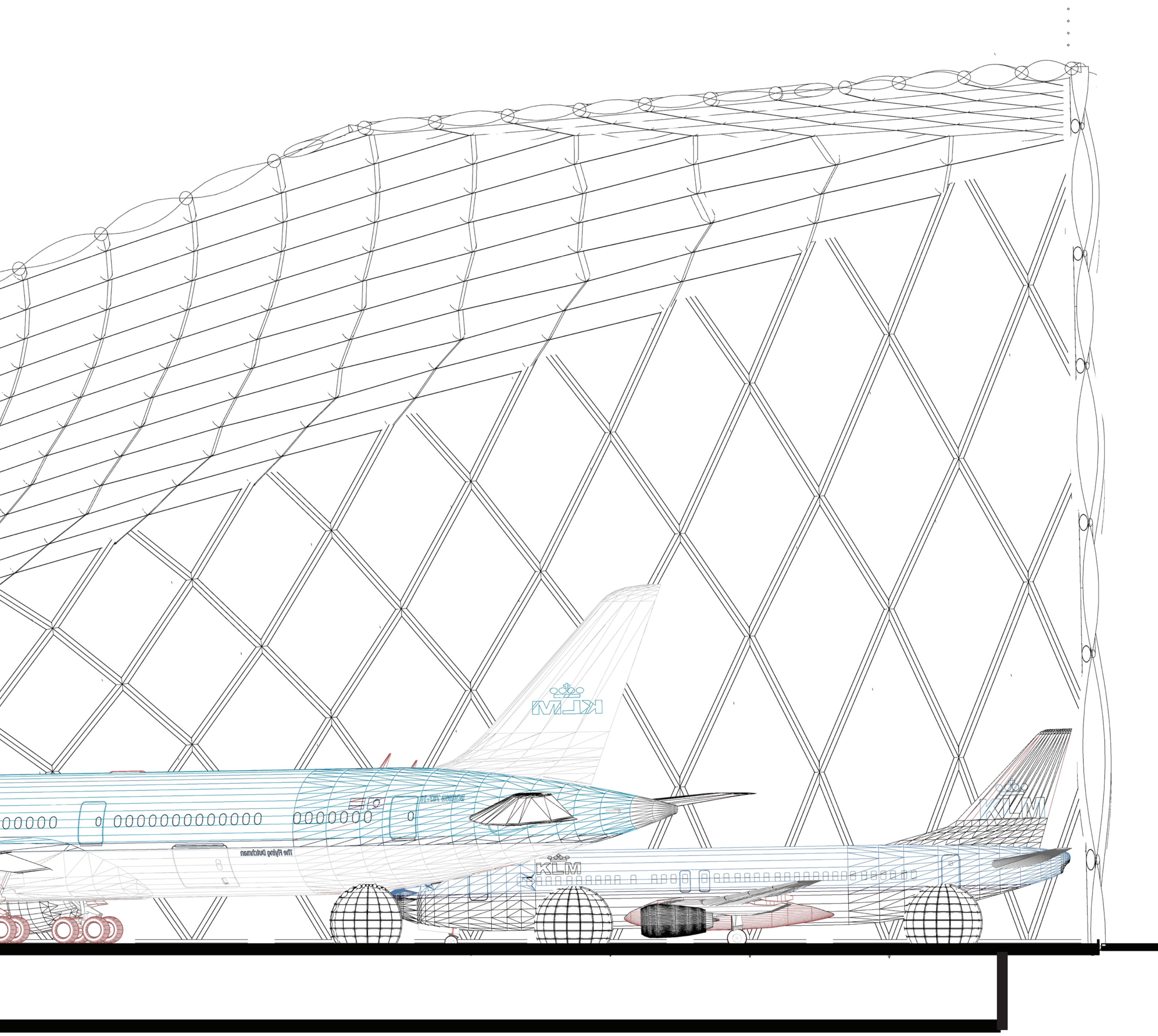


Interior drawing of the hangar

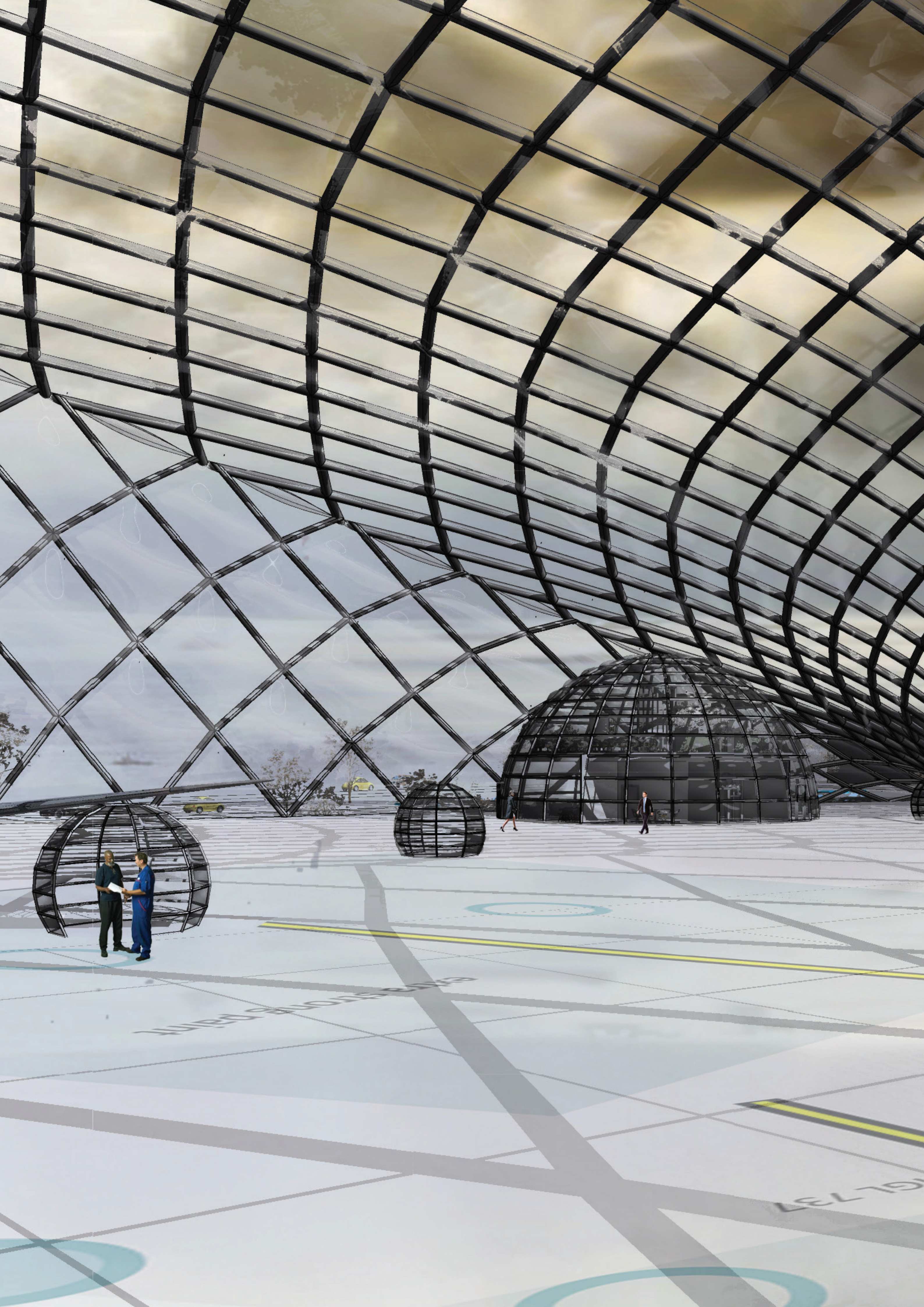


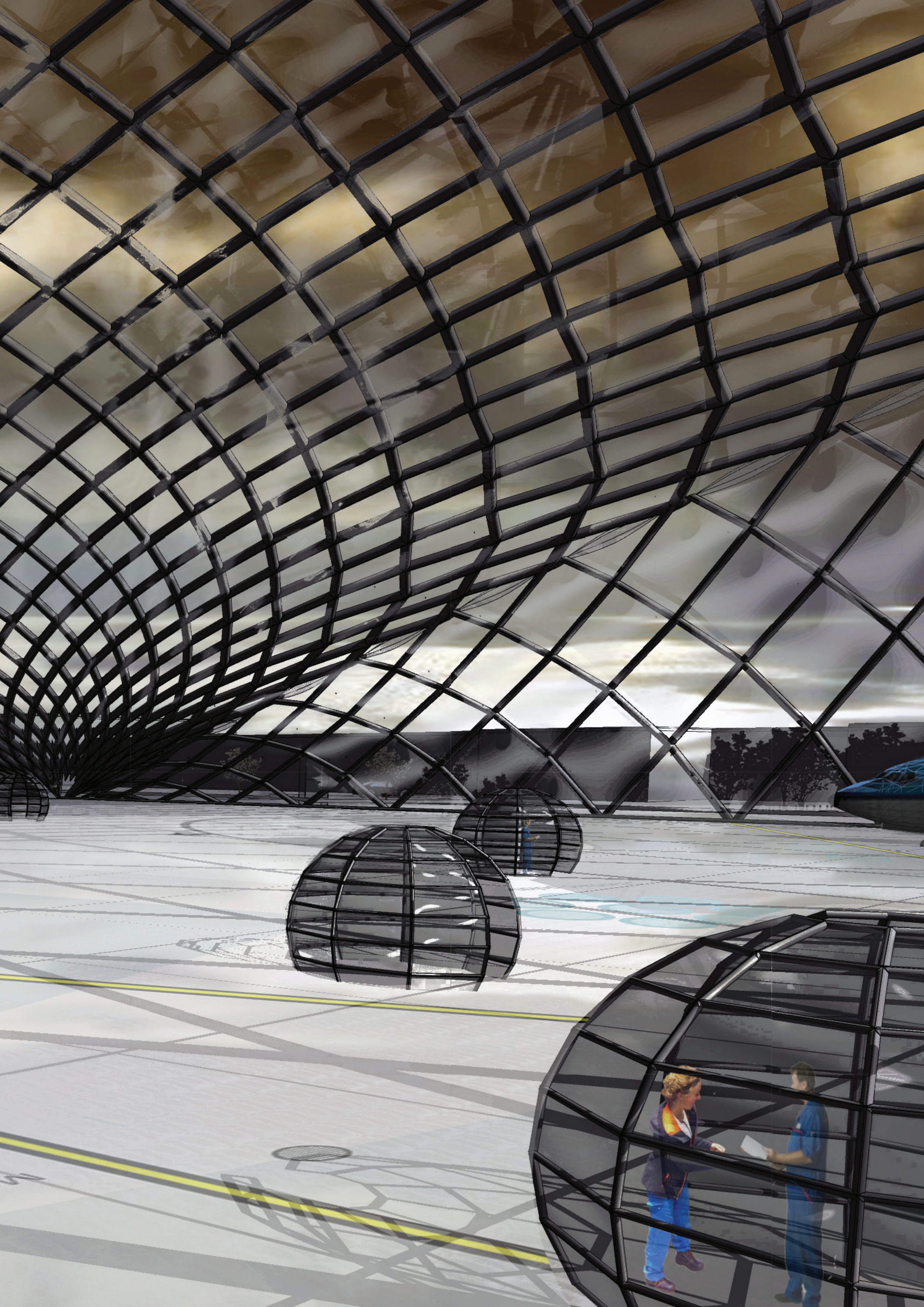
Entrance south facade

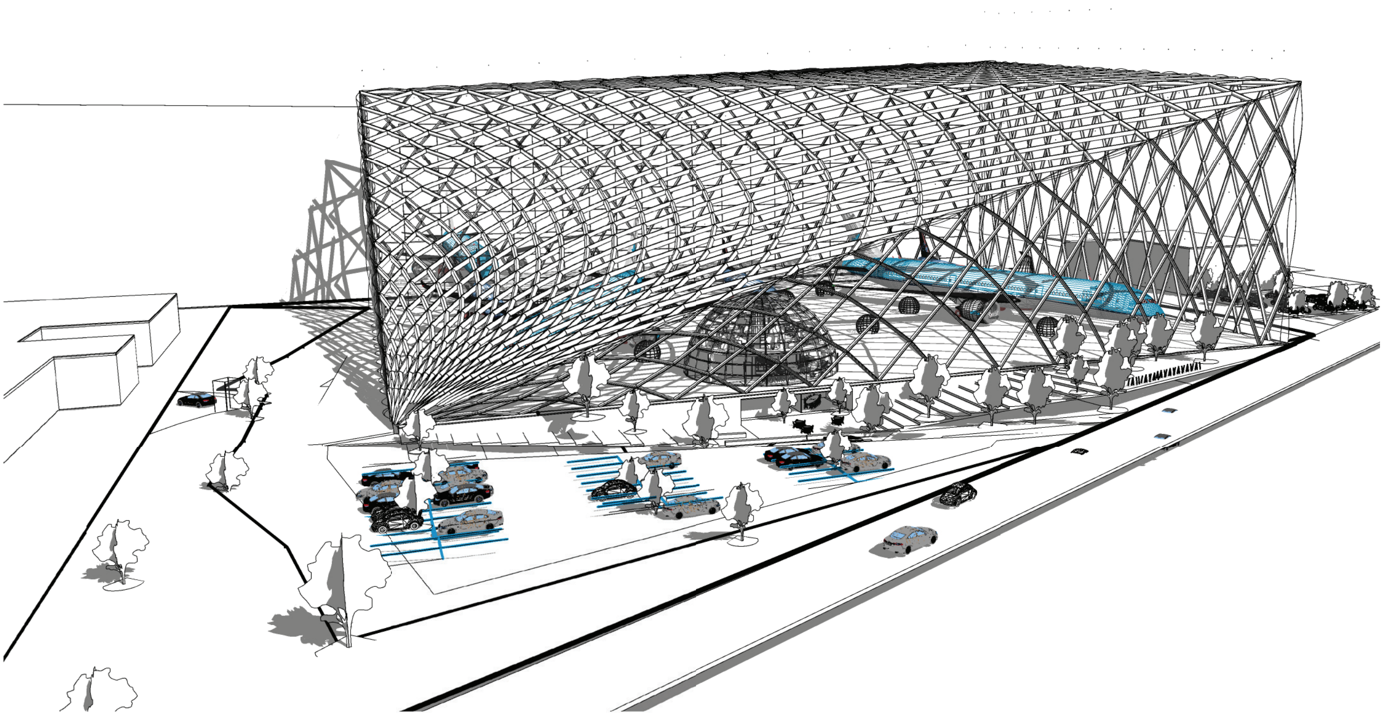




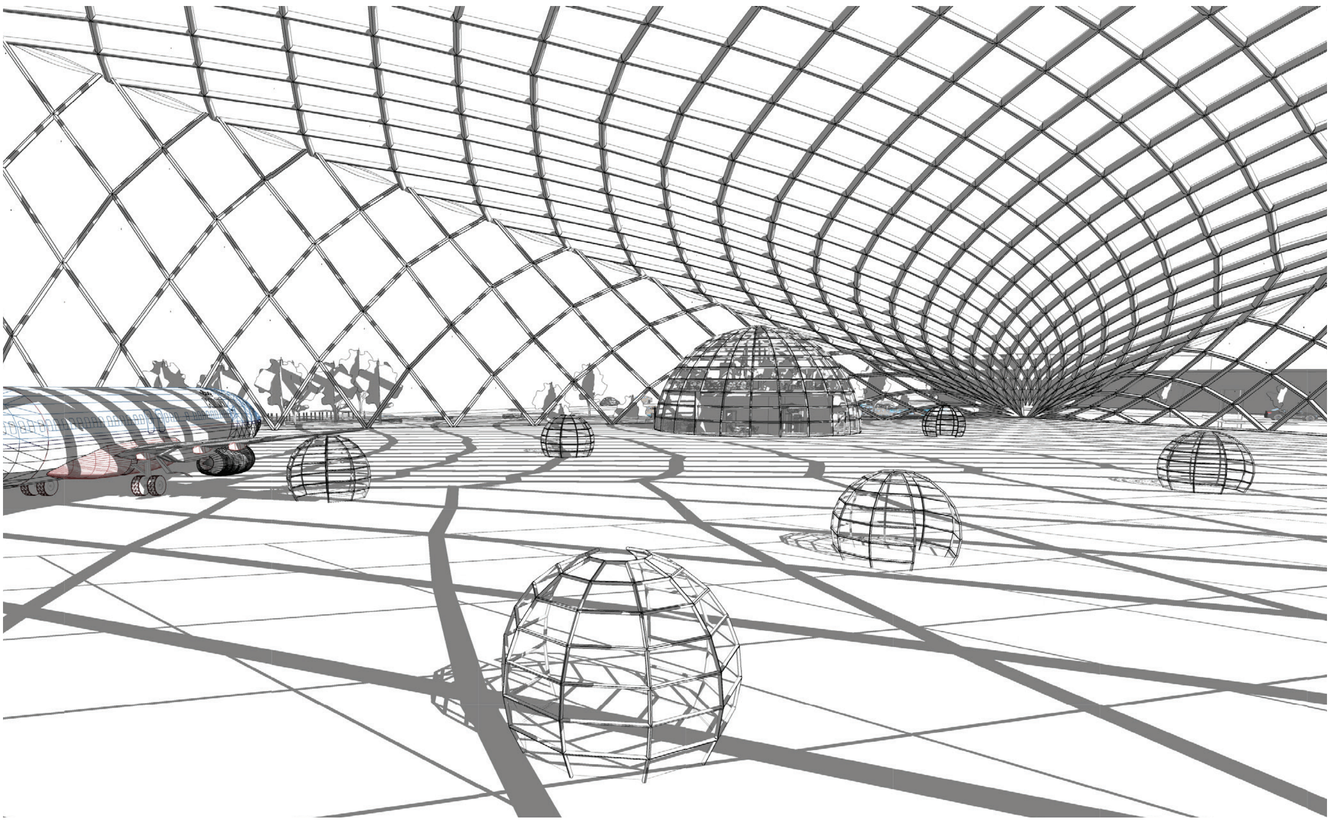

Section A



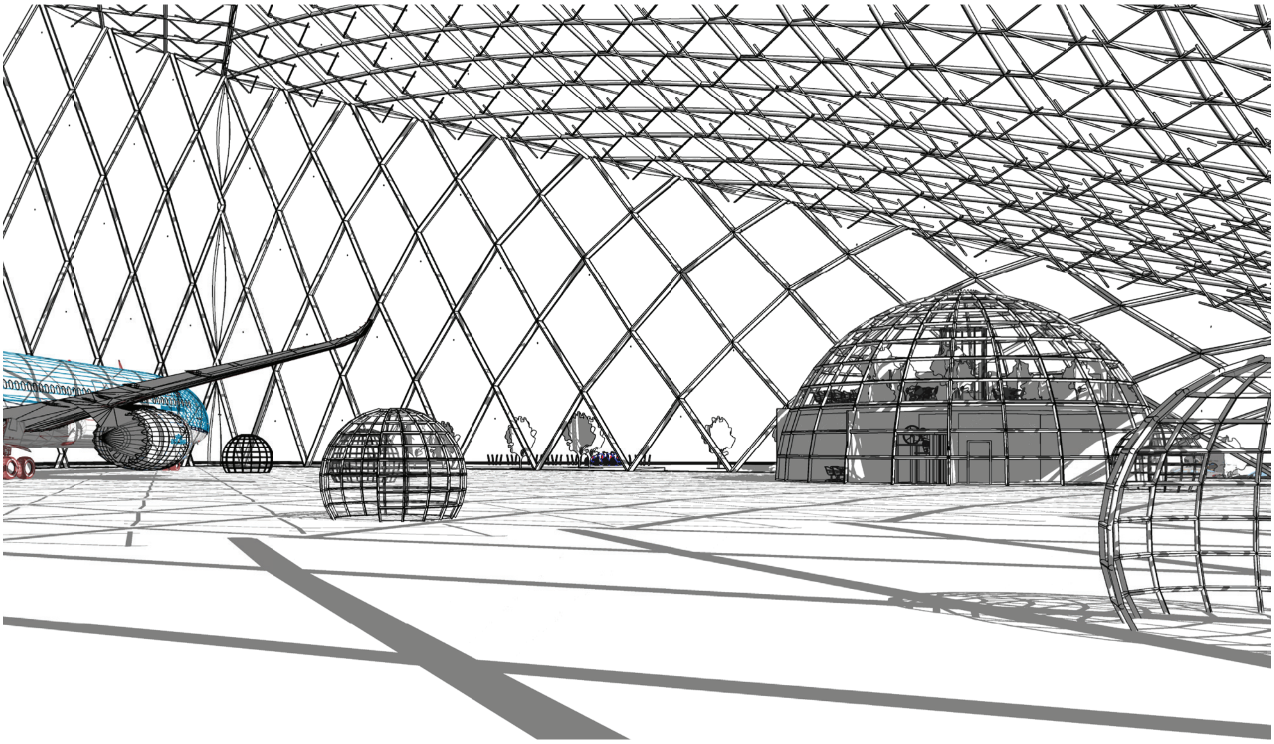




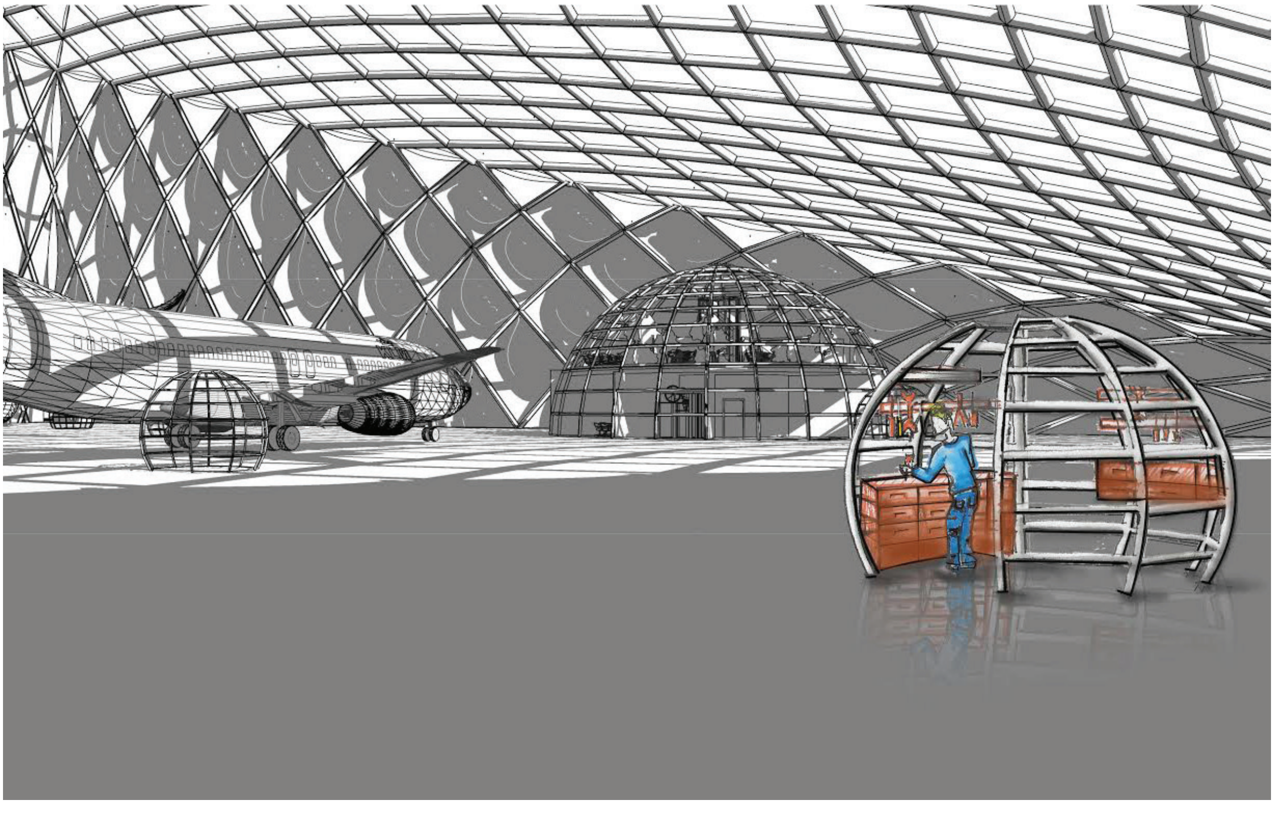
South - West view



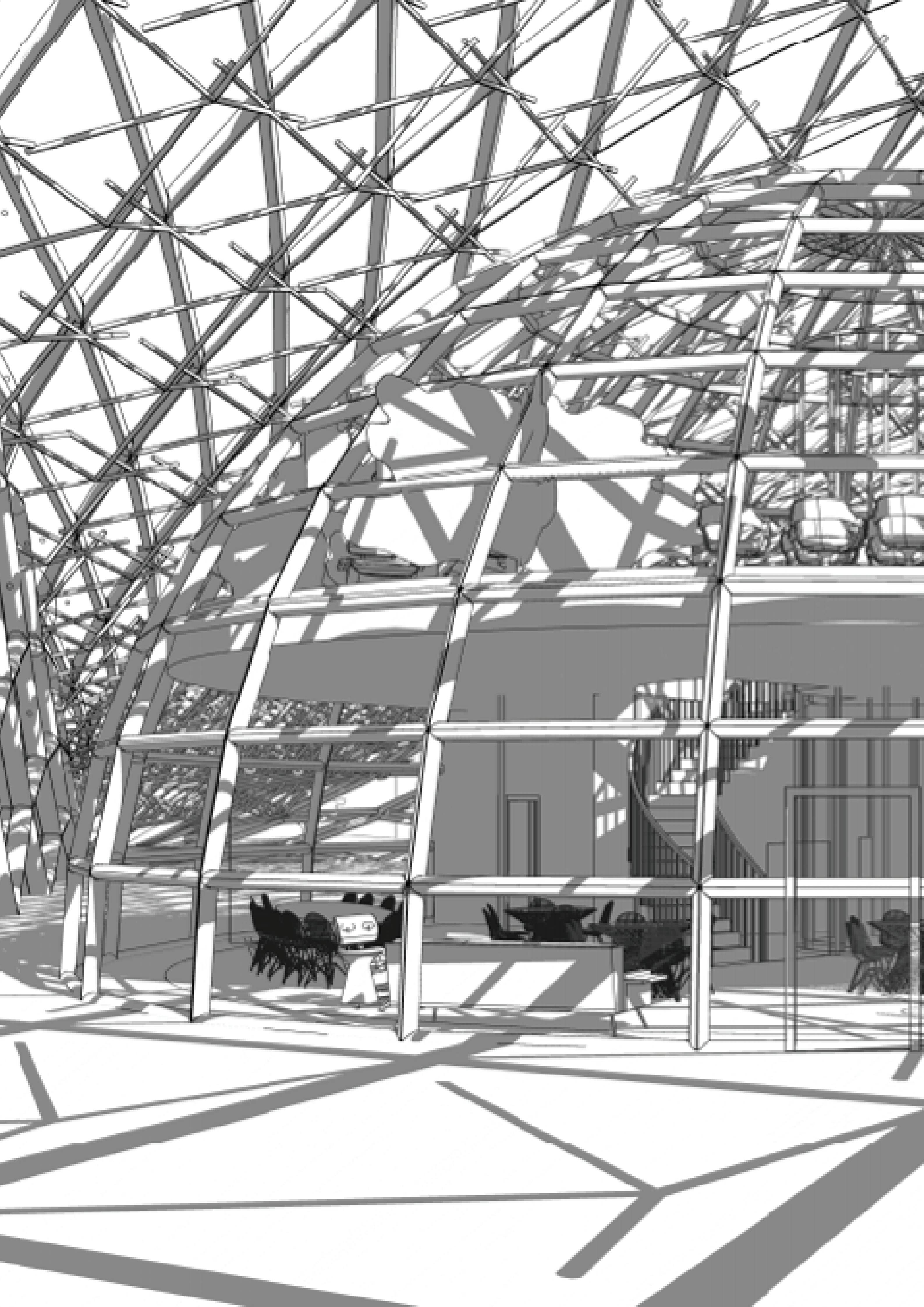
Line drawing interior

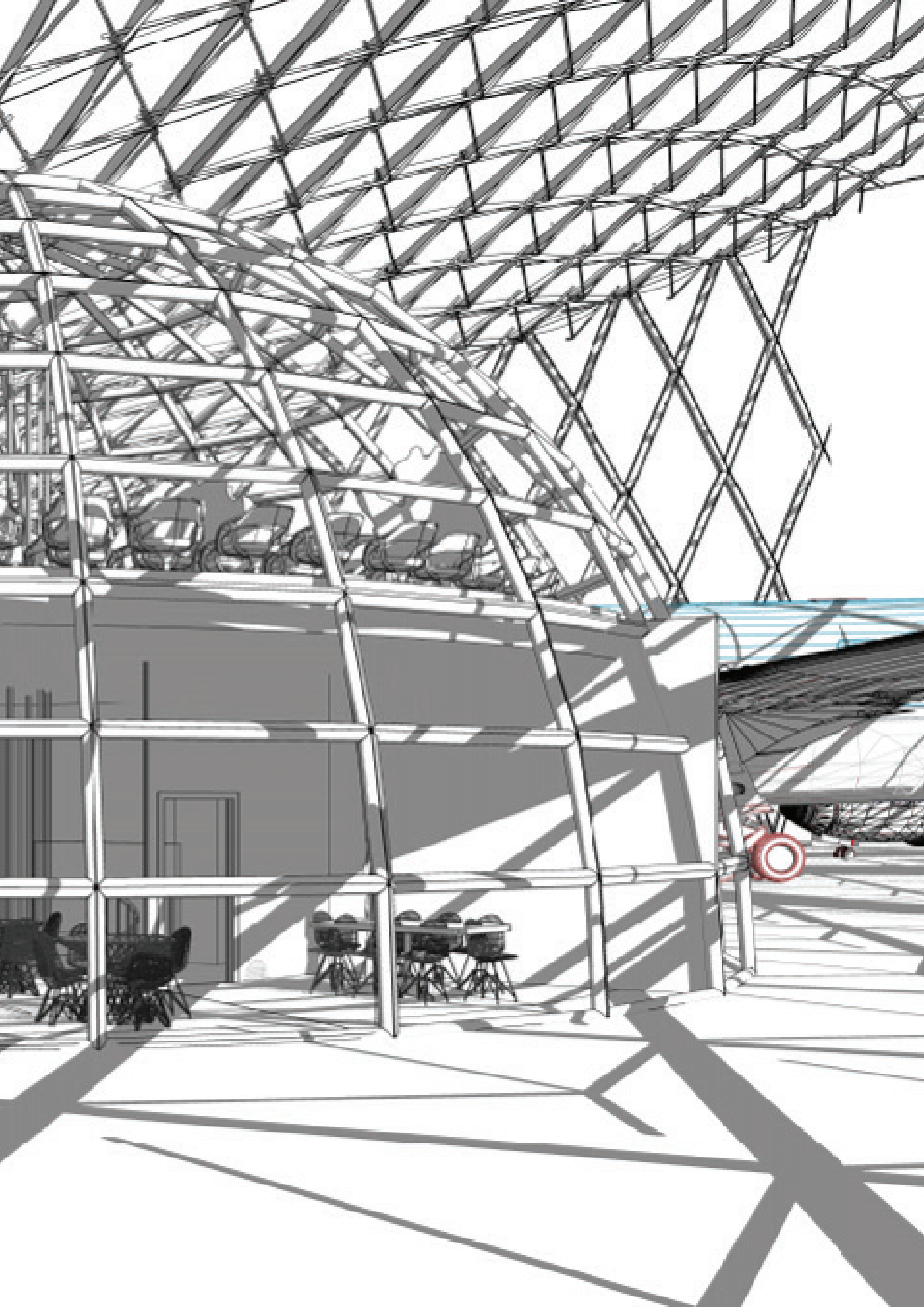


Interior line drawing



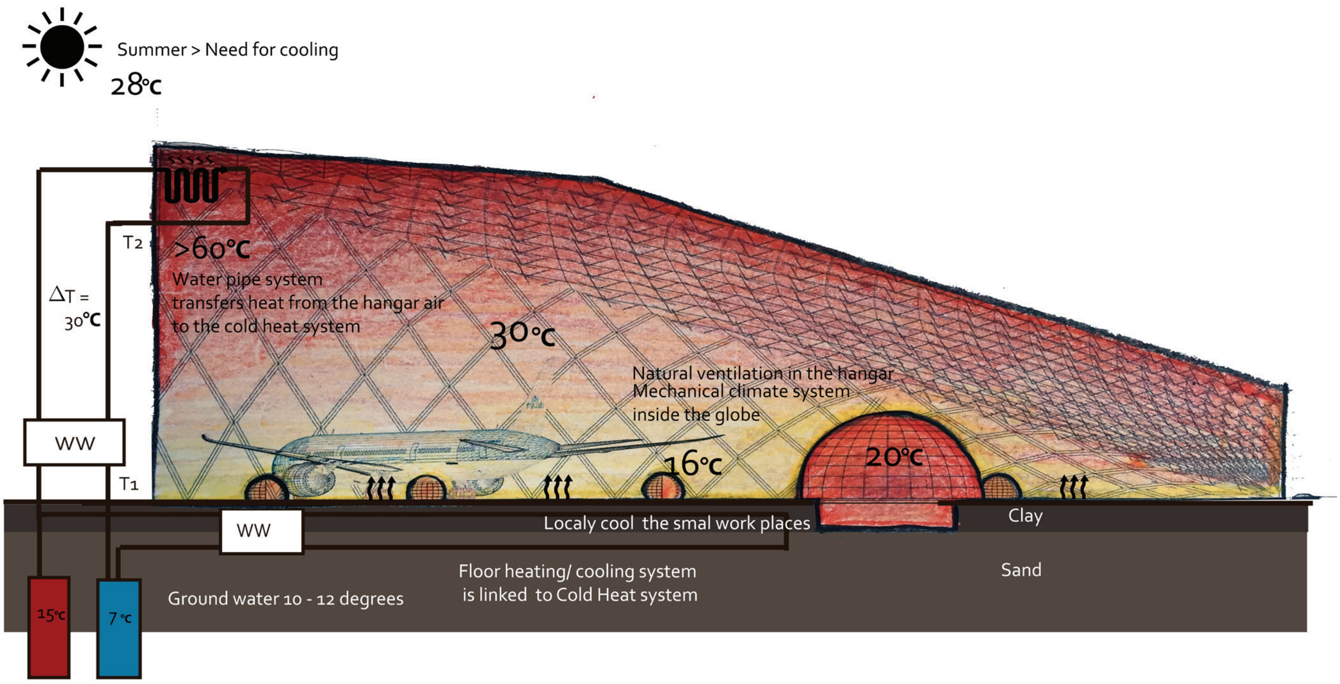
Local workspaces



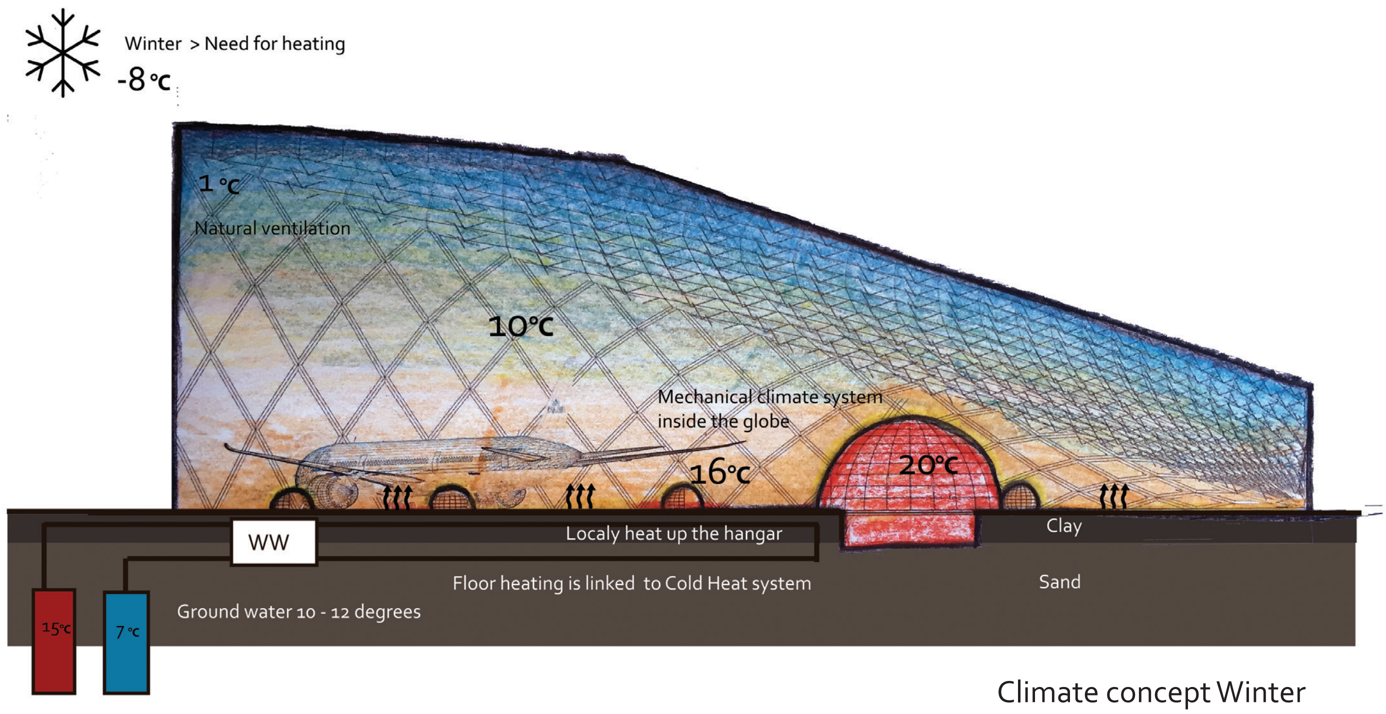


# Opkomstruimte

# Climate concept



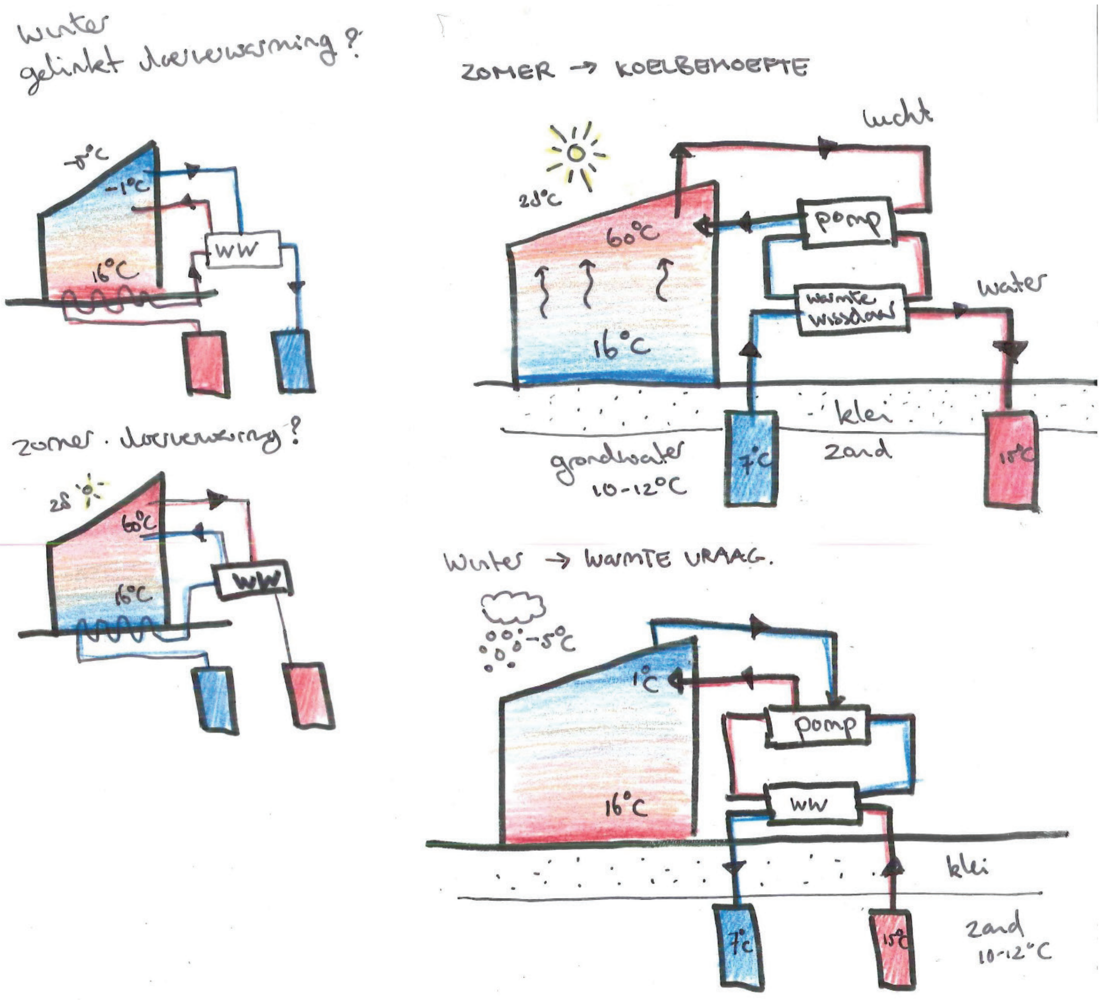

Climate concept Summer



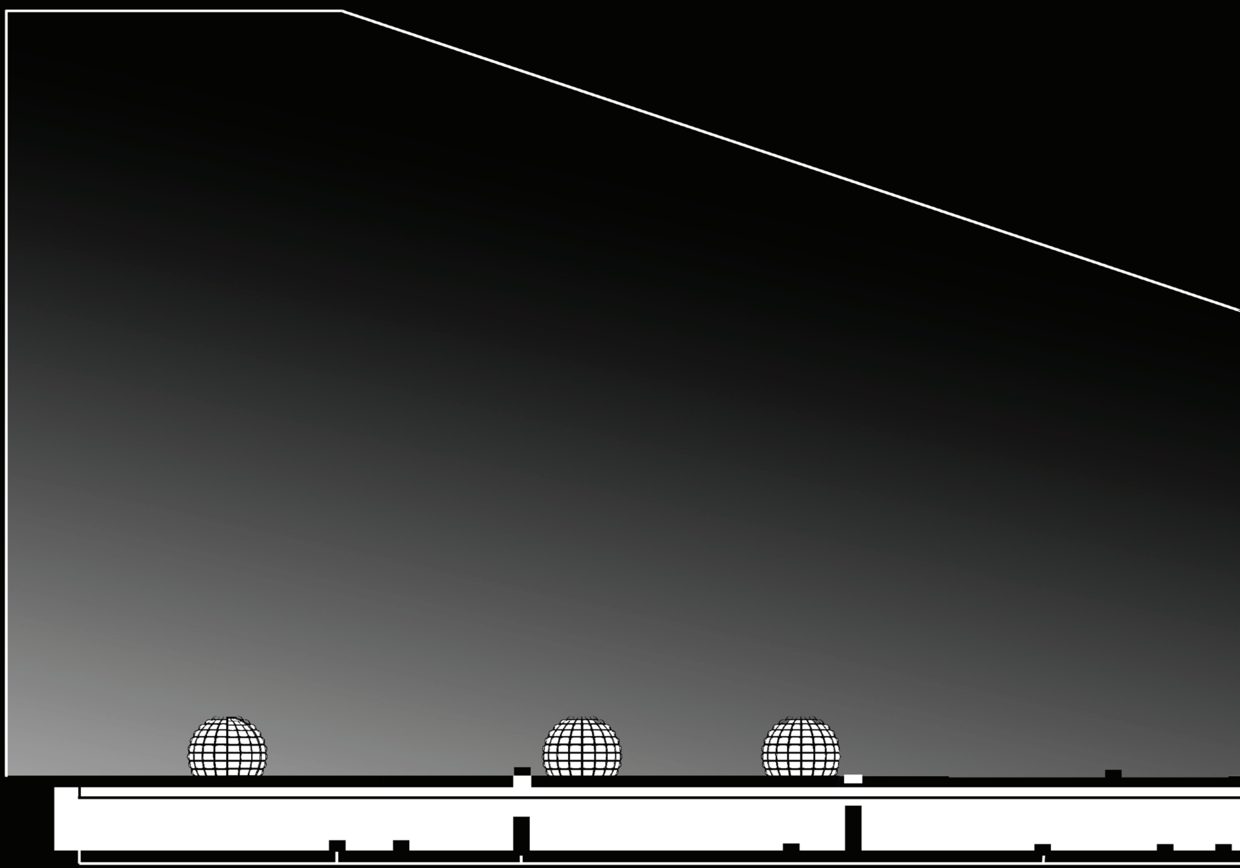

Climate concept Winter

The design of the hangar of the future is based on a low energy consuming principle. Only the areas where people work are heated. The office globe and the local workspaces are linked to a floor heating and cooling system that provides a comfortable work climate. This system is also linked to a heat regain system. The hangar is ventilated naturally as the amount of air in the hangar is relatively large-combared with the required fresh air for the users. Natural ventilation provided by vantilation openings on the south-west side of the hangar (because of wind direction) will be enough.

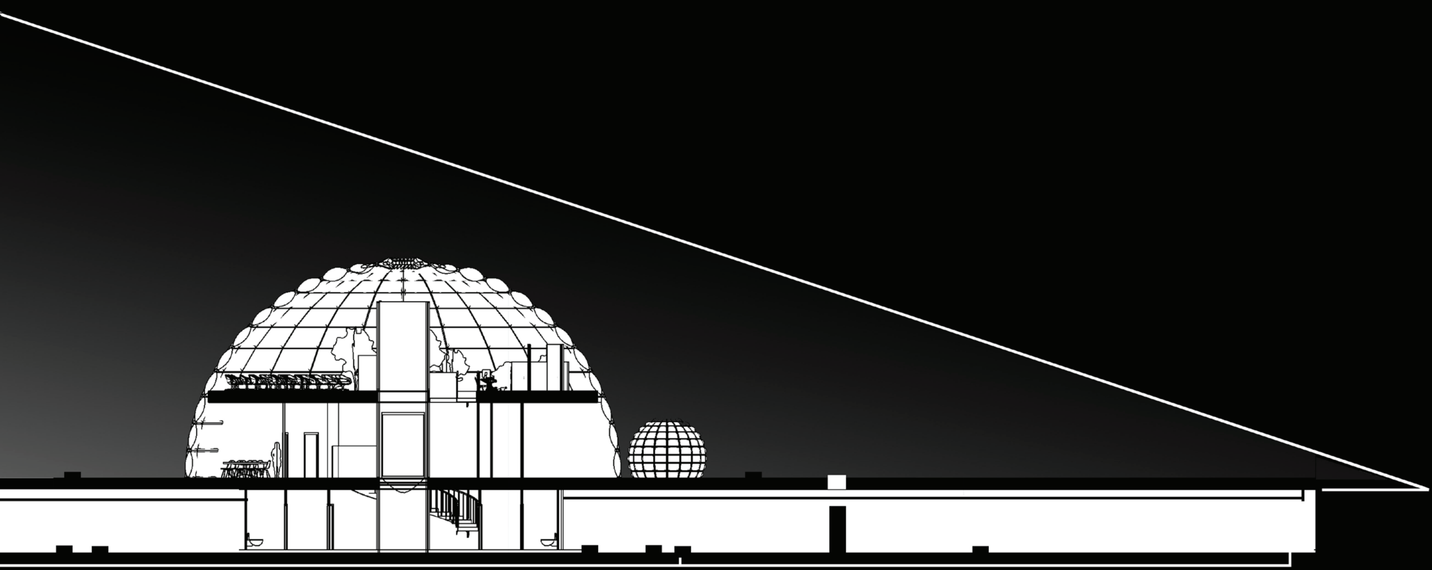
The design makes use of the height of the hangar building that is required for the hight tail of aircraft to be sustainable in it's energy use.

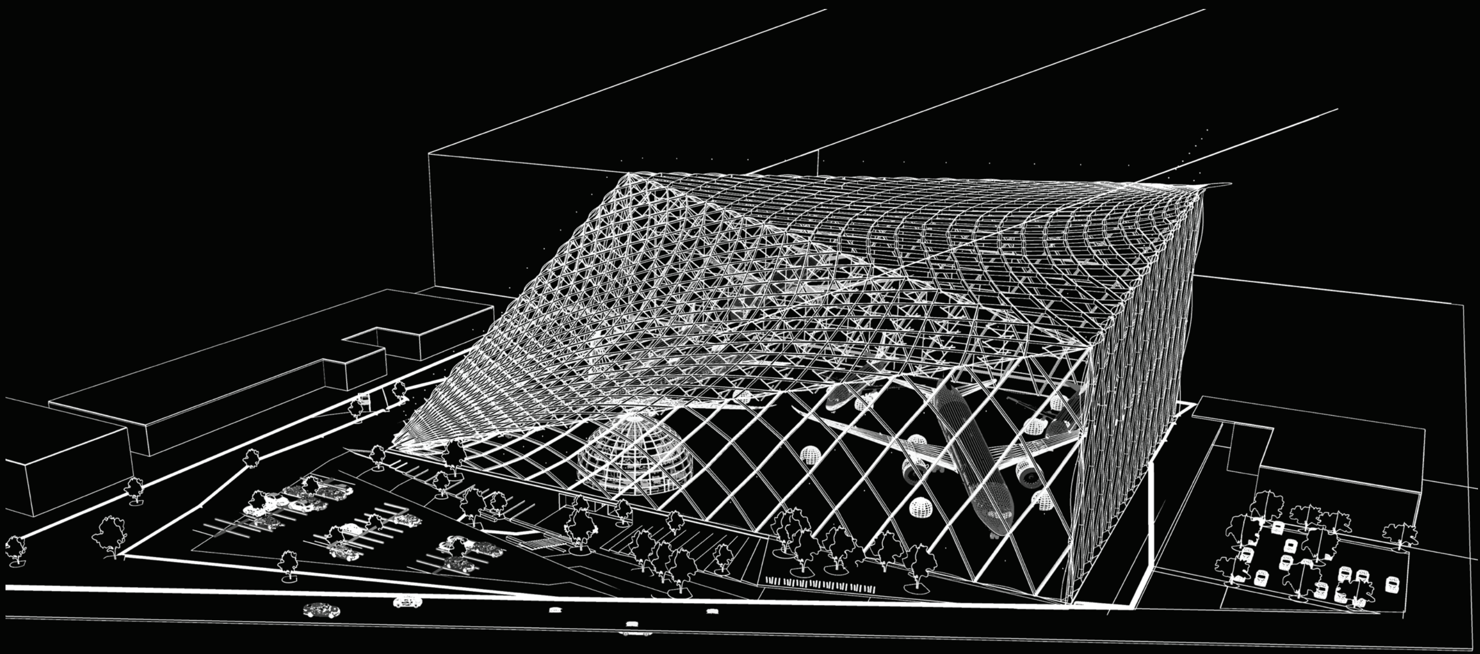



Heating and cooling principle



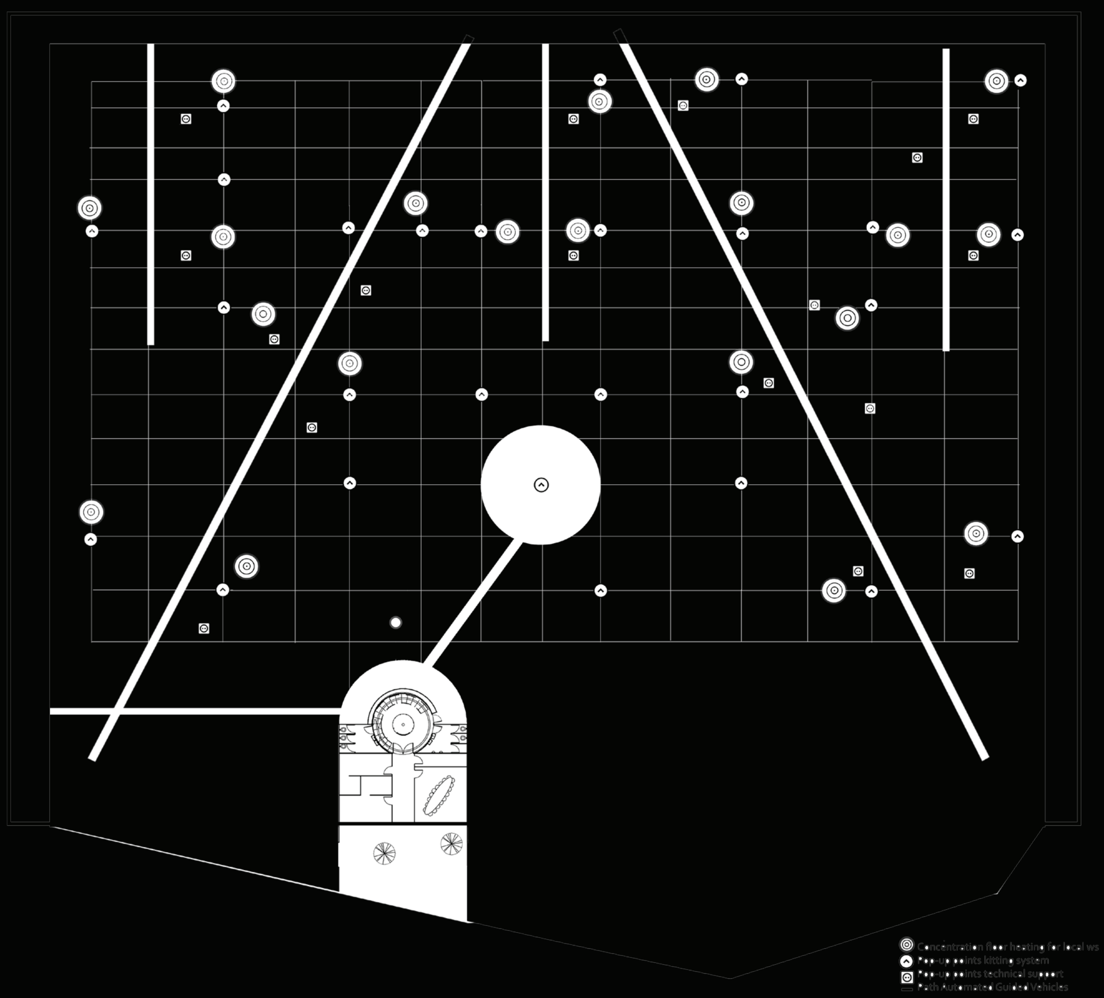
Section of the hangar showing the contrast between the livable pleasant area and the area where harsh wheather is in control. The Globe and the area under the floor with floor heating are kept at pleasant temperatures. Human beings stay close to the floor, up in the air it is too hot or too cold to live. This climate concept creates an energy efficient hangar.

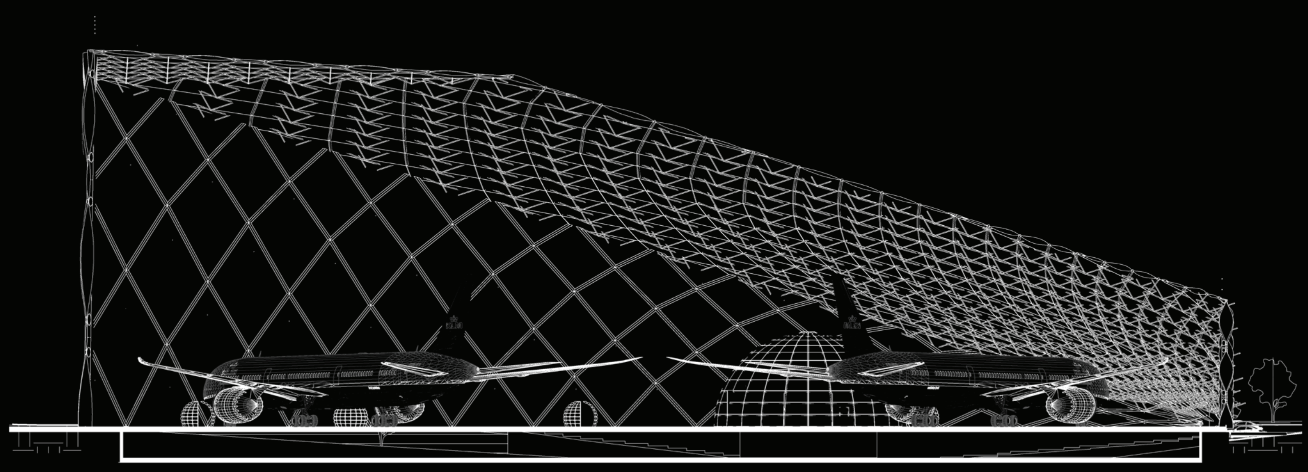




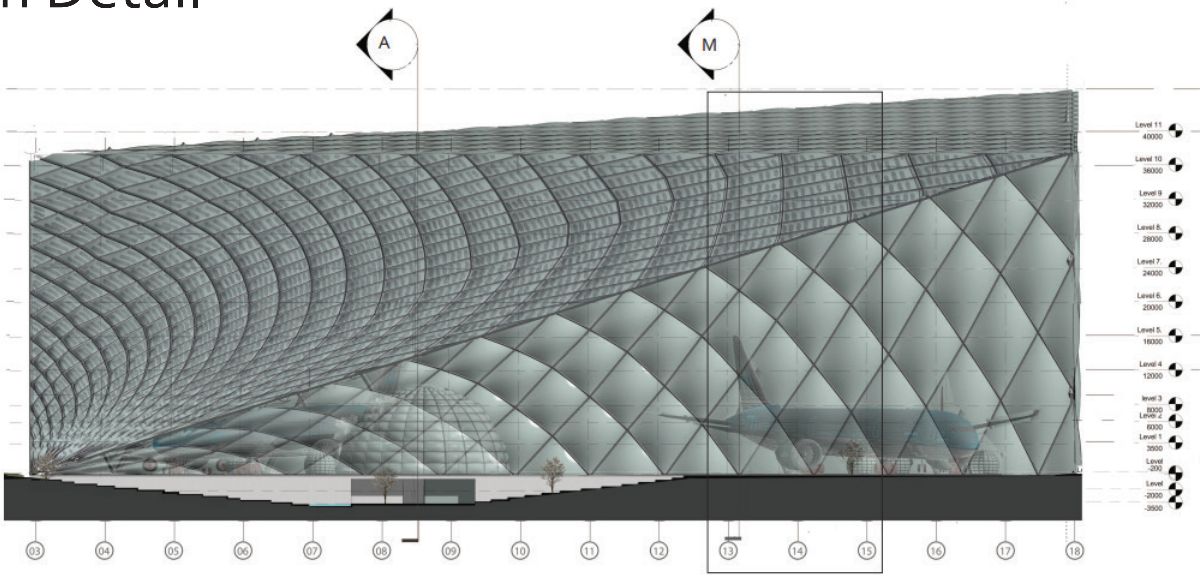
The area underneath the floor is purely used as infrastructural area. This is the domain of the AGV´s, the automated guided vehicles. These self driving machines carry the pre-ordered and prepared kits wit tools and material to the mechanics. The raster on the floorplan shows the grids the agv's follow and the round shapes indicate where they can pop up to the ground floor where the aircraft are waiting.

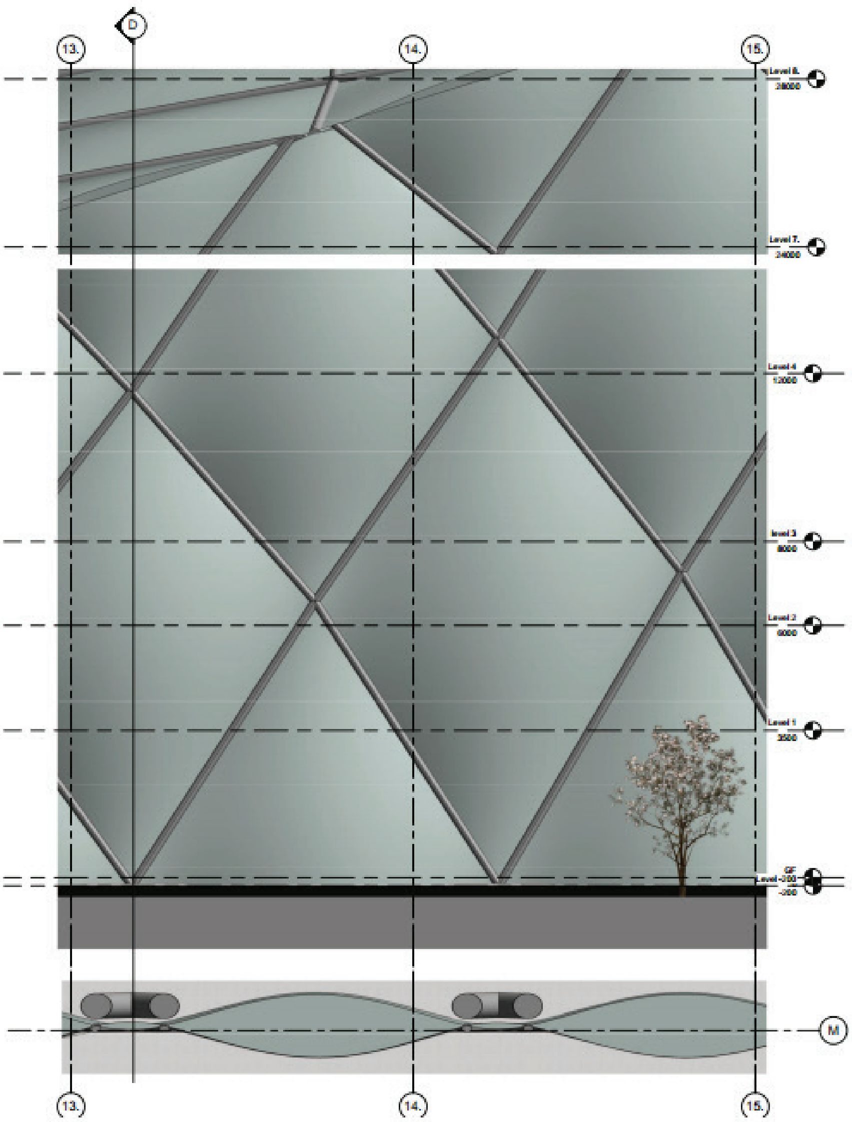
At the heart of the hangar a secured data centre is located at the -1 floor. In this room the databases of KLM are kept and here maintenance and back up data can be safely stored. This is also the place underneath the main check up point for the local workspaces.


Concentration floor heating for local ws
Pop-up points kitting system
Pop-up points technical support
Path Automated Guided Vehicles

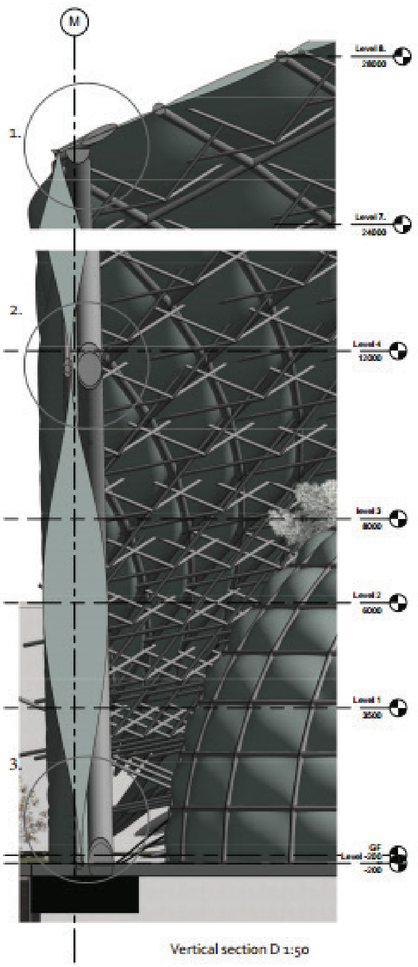


# In Detail

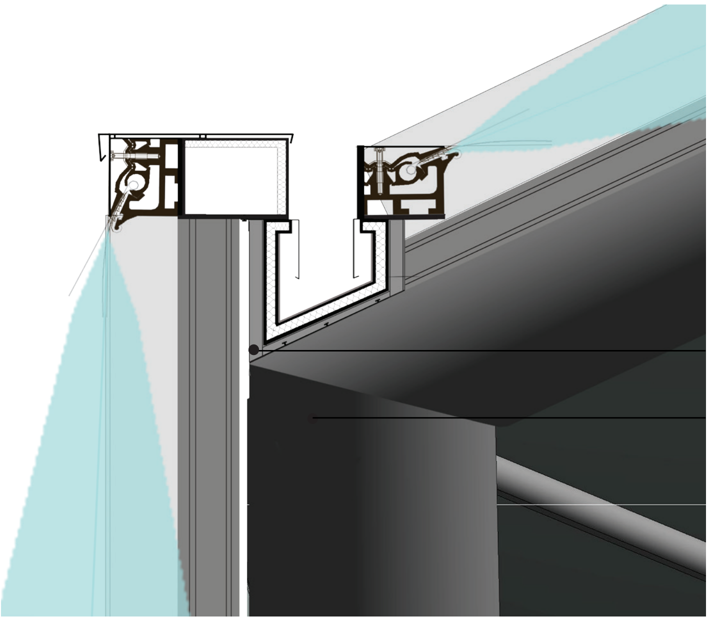


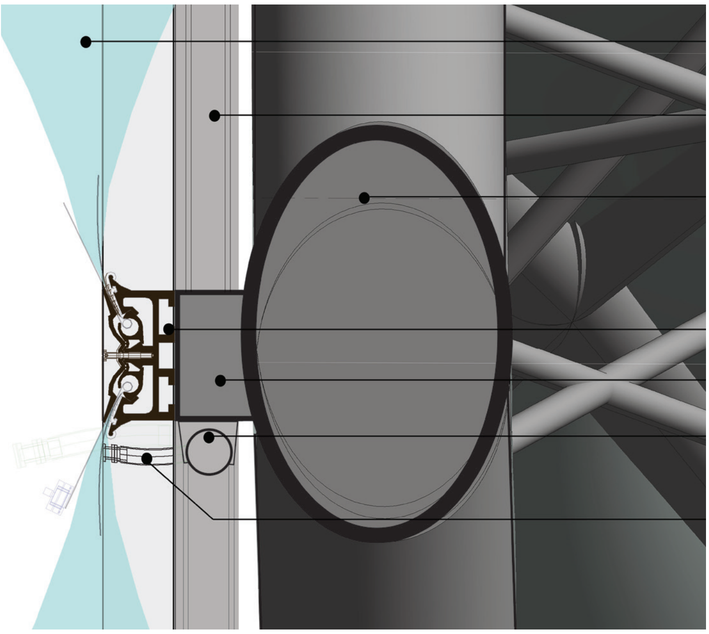

Horizontalsection M 1:50



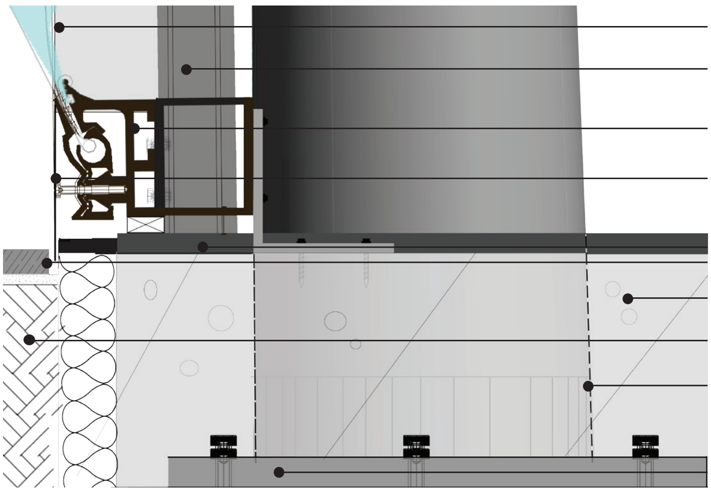

Vertical section D 1:50



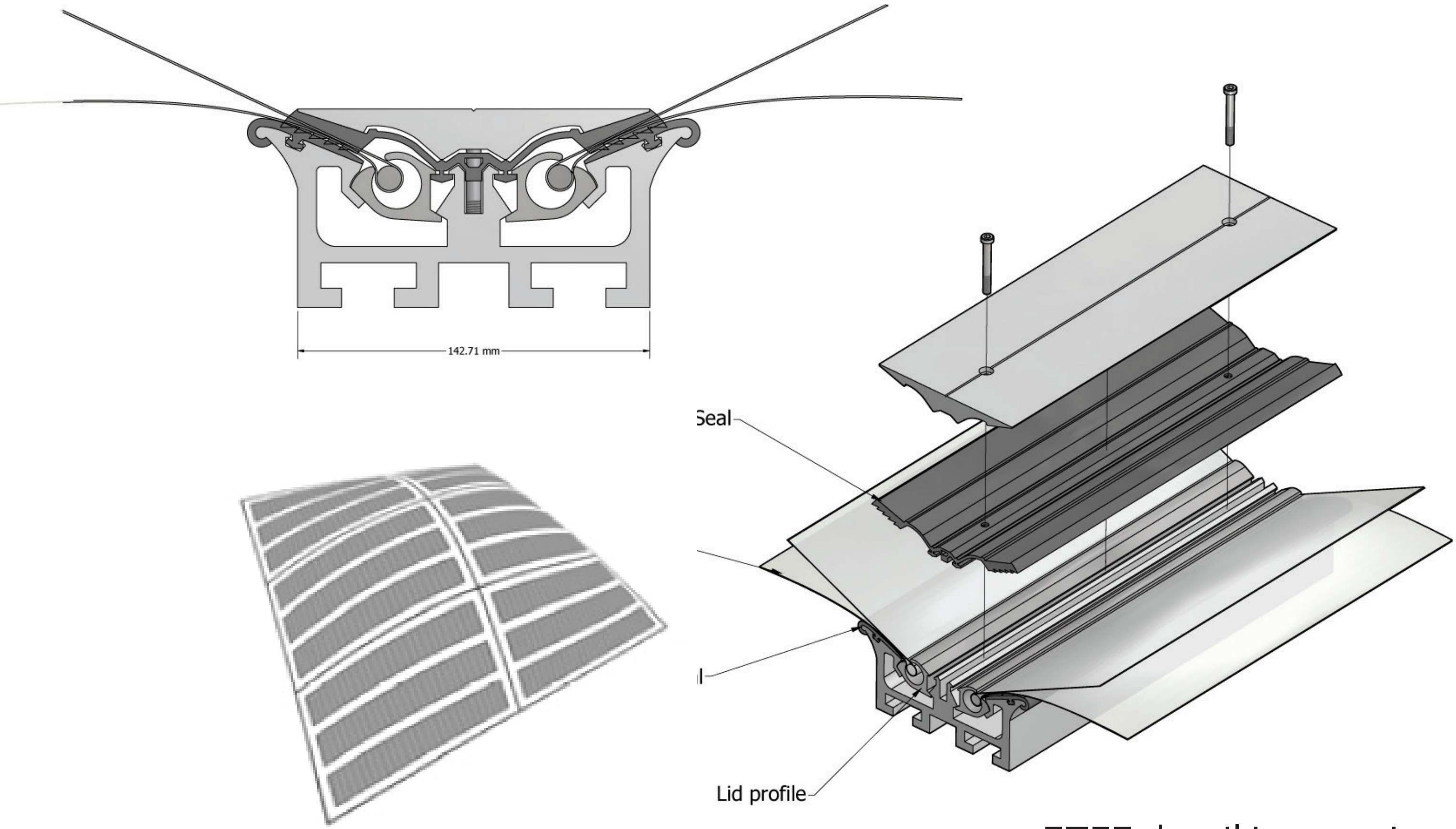

Detail 1. 1:10



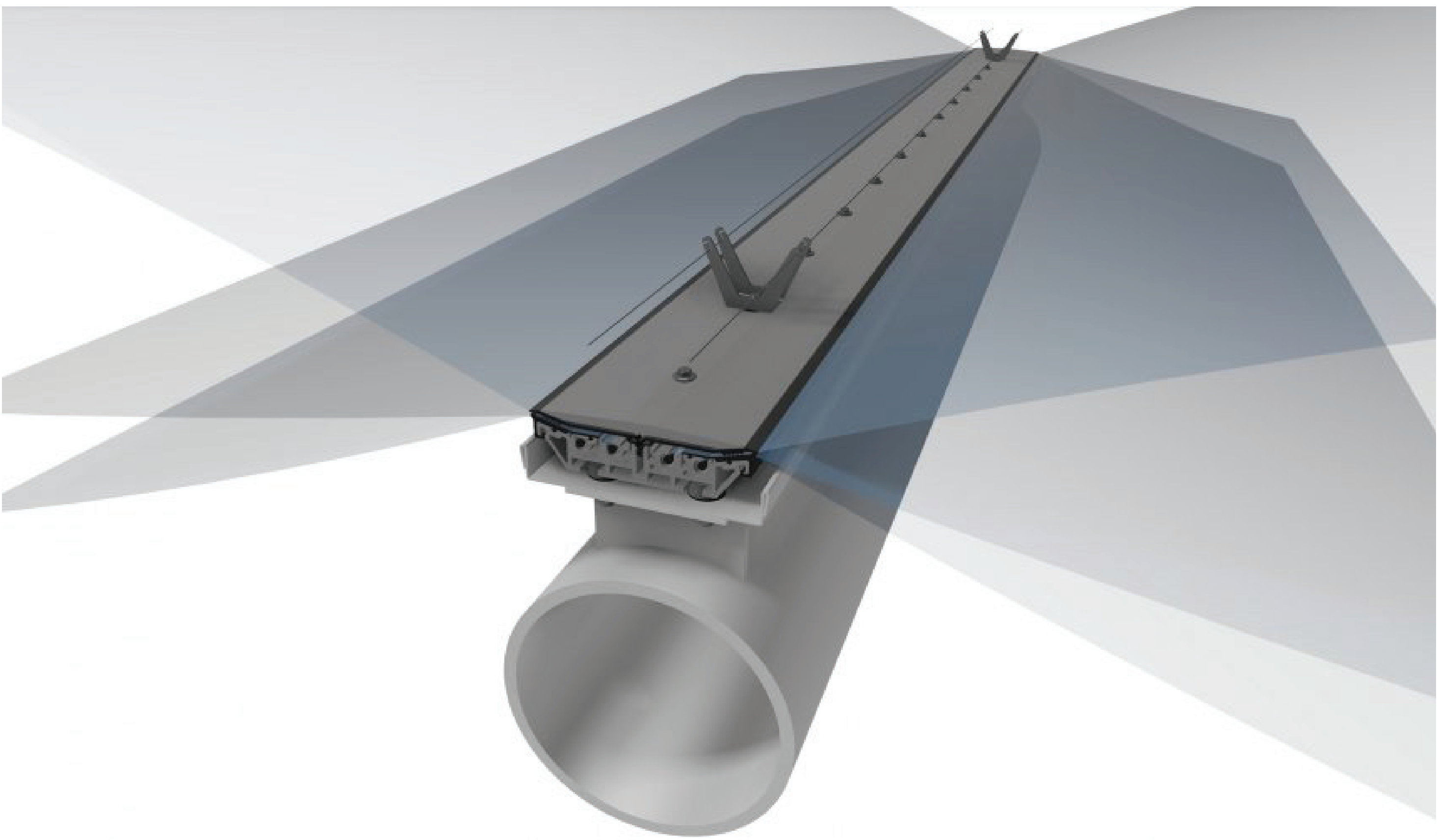

Detail 2. 1:10



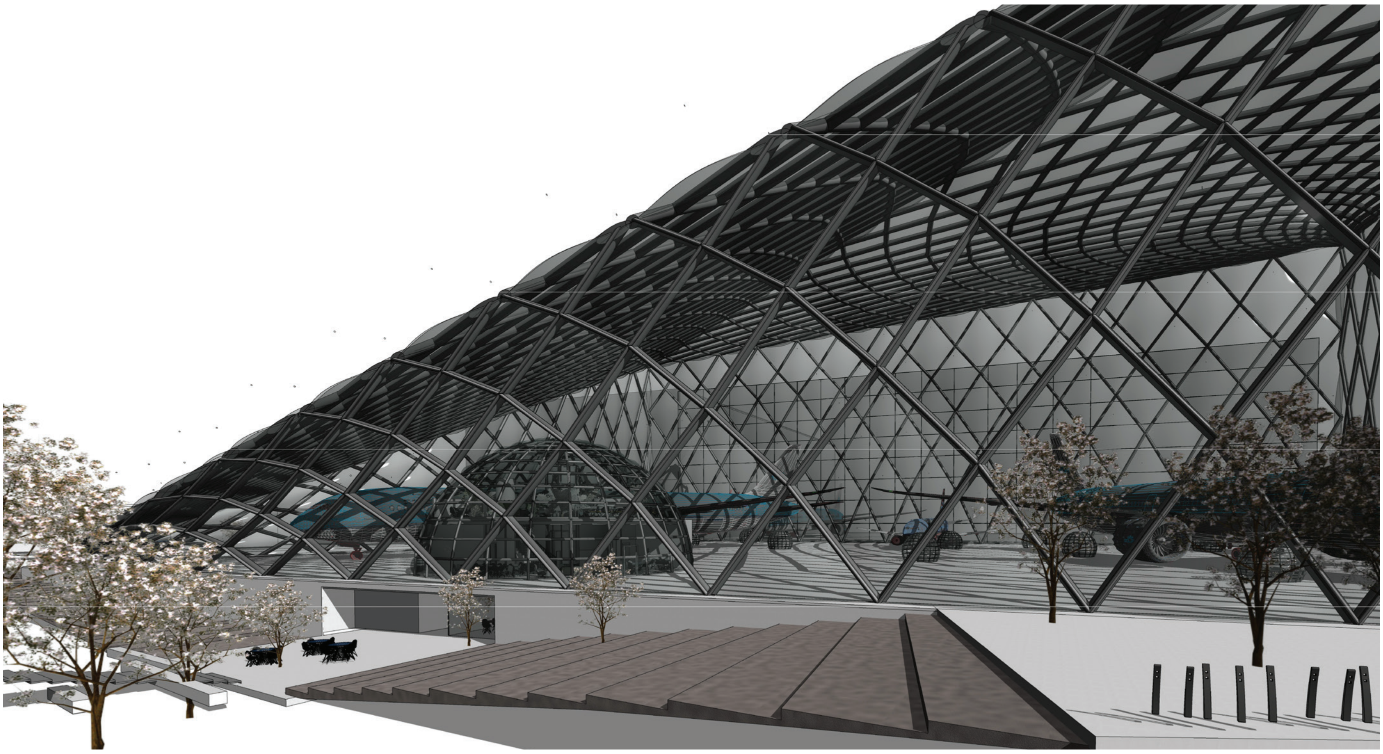

Detail 3. 1:10



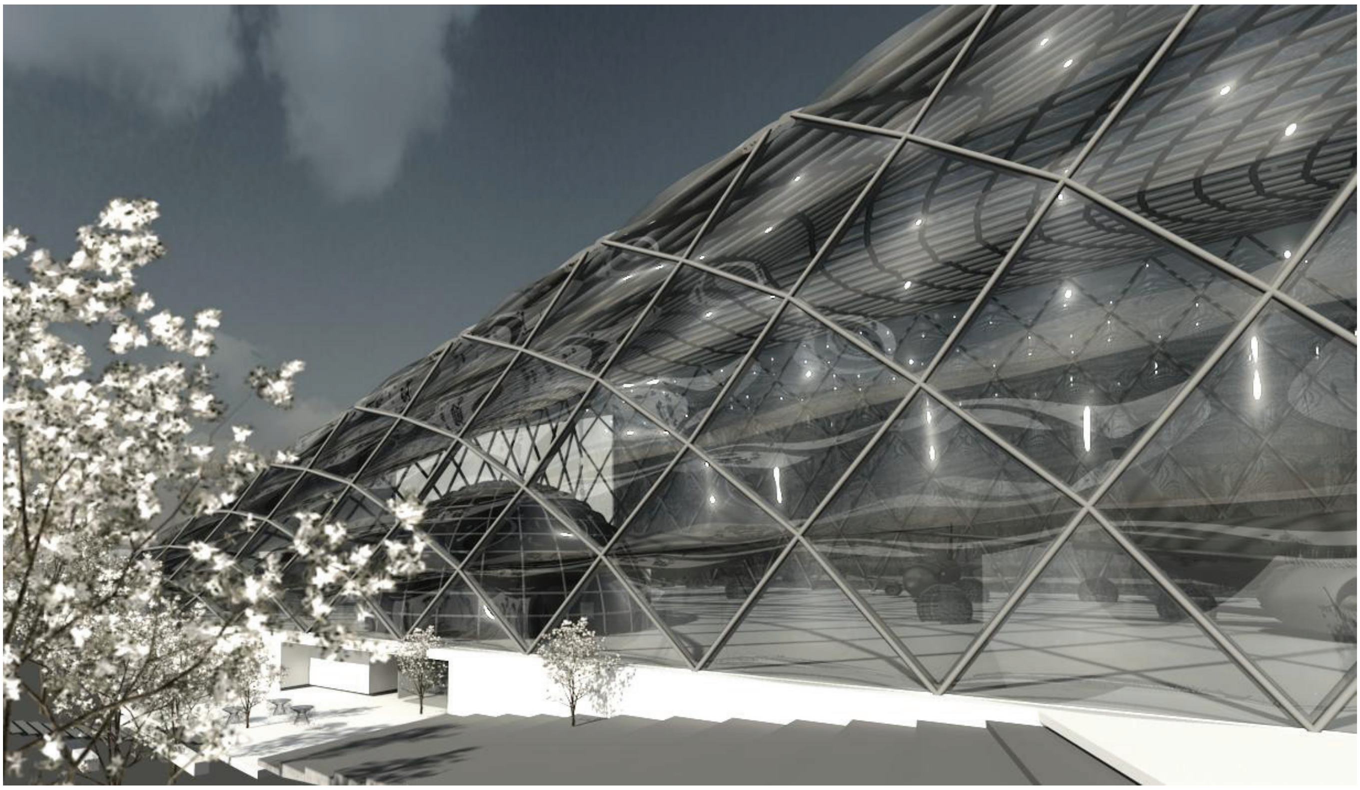

ETFE detail impression



ETFE 3D visualisation



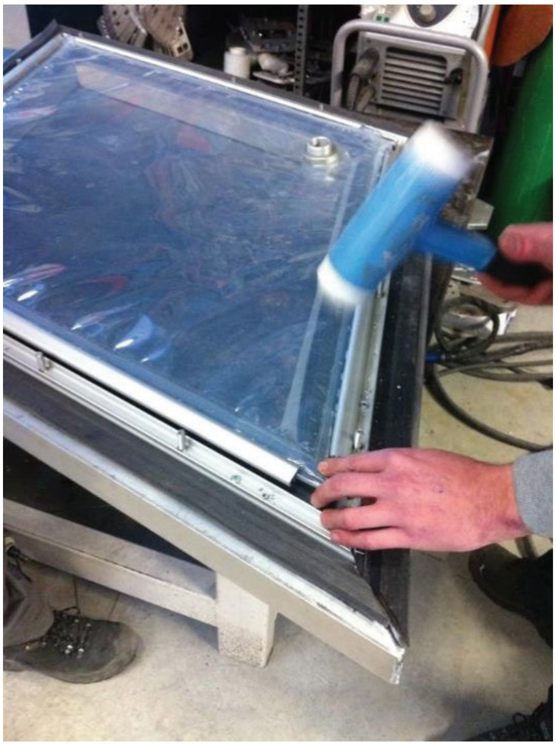
ETFE cushions in Revit model

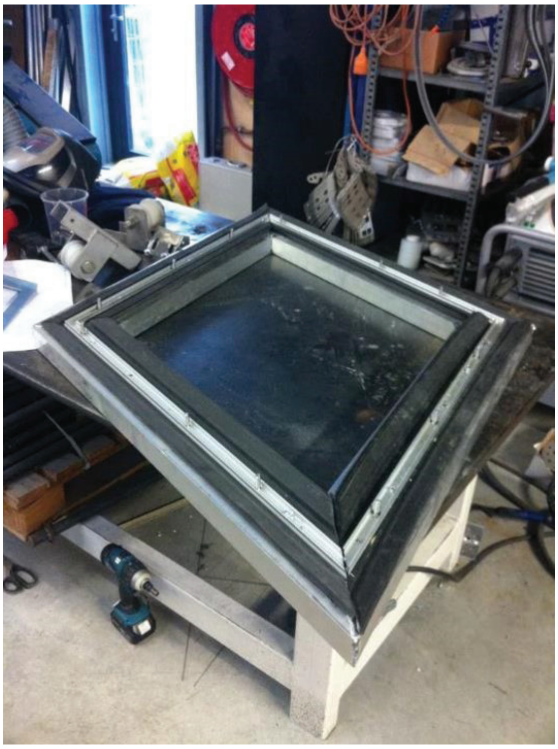


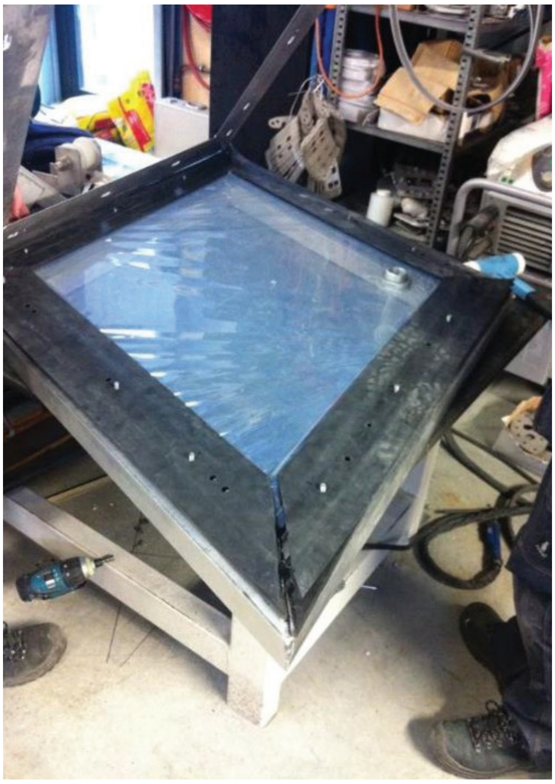
ETFE cushions in render

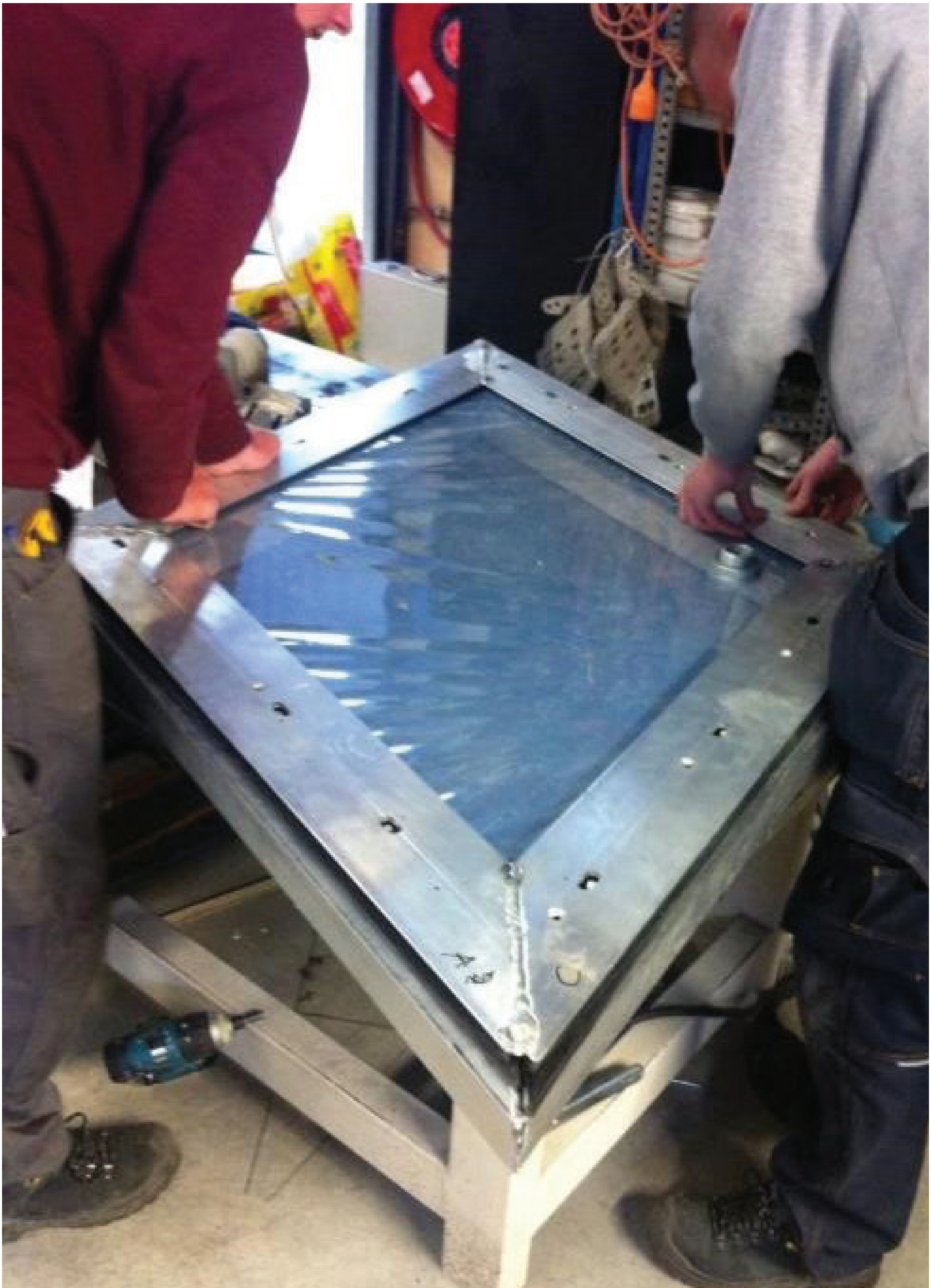
# Facade Prototype
Buitink Technology ETFE Panel

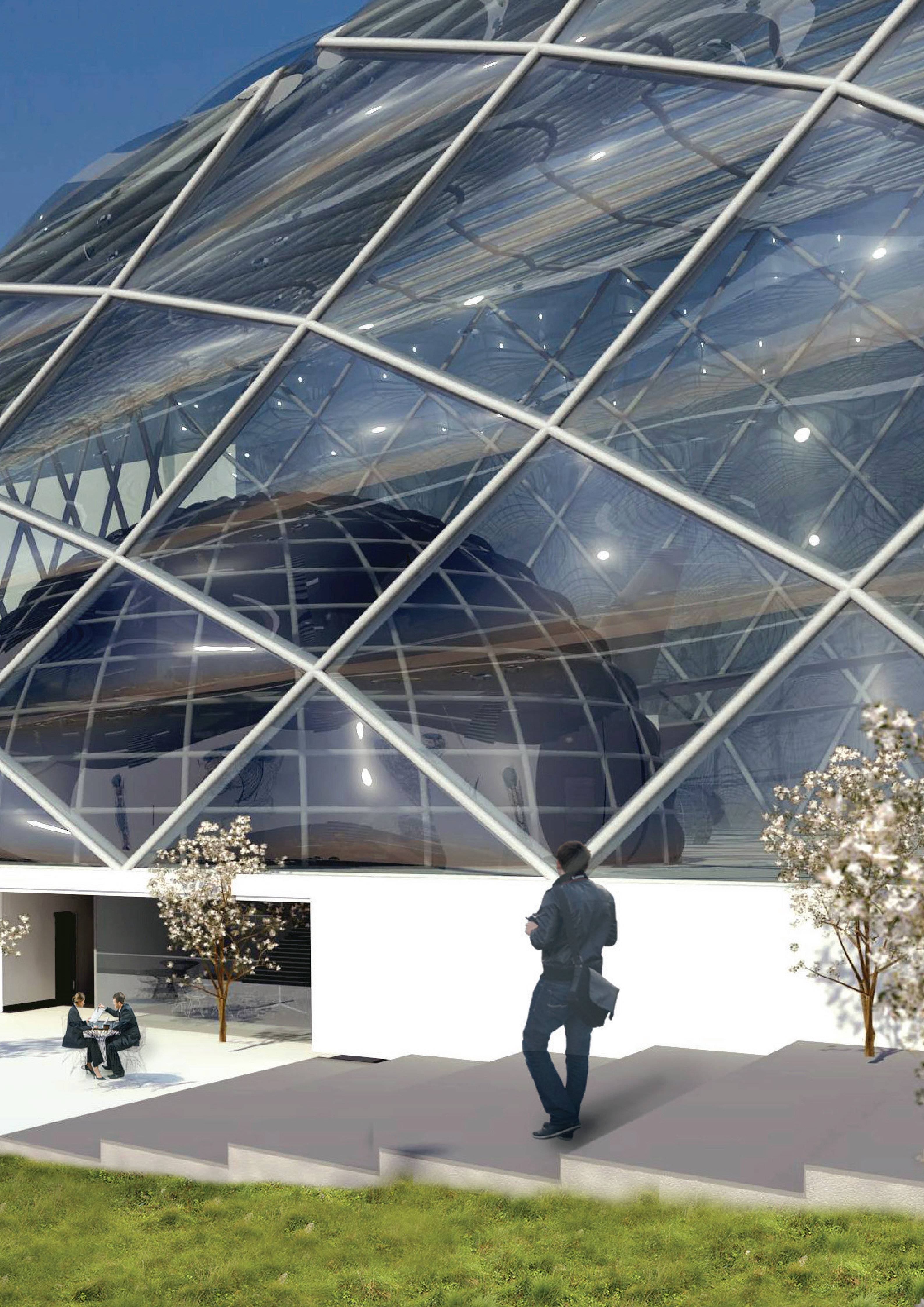
BUITINK TECHNOLOGY
Advanced Lightweight Structures











# Reflection

When I first started this new design challenge as antern and graduate student at the same time I had no knowledge whatsoever about aircraft of hangars. The combination of an internship and a design project that ran parrallel has proven to be a very usefull combination to gather practical knowledge and at the same time design withouth strong contrains and restrictions.

## Internship

As intern at KLM I designed new offices in the existing Hangar 12 as well as a new outdoor area for the mechanics working in Hangar 12. These design assignments were separate from my graduation design, however the combination of an internship and a graduation project did offer the possibility to access information about the aviation industry which has proven to be very useful for the research and graduation design. For my understanding of the functionalities of a hangar and how maintenance processes work, it was very helpful to be able to walk around in real hangars, talk to employees and actually work in a hangar. This has helped me to firstly understand the current architecture in order to then be able to think of a design of " the hangar of the future ". The methodology I used transferred the internship into an addition to the research and in this way contributed to the design. I would advise more students to use this approach, however, when performing a gradation project in combination with an internship one should be aware of the influence the company has on the scientific quality of the graduation work as well as on the freedom in the final design and design process.

After my research I understood "the hangar" and I could start designing the output specifications for the Hangar of the Future. Eye opener of this graduation project was that in my opinion the design does not start after the O.S have been specified, but at the very beginning of specifying them. In my O.S document design ambitions as well as requirements for spaces and technical requirements are defined, but also a new KLM organisation is described. By using the Brief builder programme I was able to structurally write down in detail which requirements the hangar of the future has, from design ideologies to the specification of the epoxy floor coating. This O.S was then linked to the design concept and these two together formed the basis of the design proposal.

# Architectural position

An architect has to take a position in what context he or she is designing. In the specific case of the hangar of the future one of the ambitions defined in the O.S is as follows: " design a hangar that supports the hangar functionalities in an innovative way and offers a pleasant work environment." There are many contexts to do this in, options are for example to connect to the context of the surrounding area at Schiphol Oost. Or one could choose the context of all the hangars in the Netherlands and base the design on the local existing hangar architecture. I have chosen to position the design in the context of the existing hangars in the world and focus on KLM as user of the hangar. It must be mentioned that the context of the surrounding always must be taken into account. In the research report an analysis of ten different types of hangars all over the world can be found. This design positions itself between these hangars.

Most of the hangars at Schiphol Oost are beautiful in their purely efficient, practical architecture and fit into the type of "Functional Hangar architecture". For example the Lufthansa hangar in Frankfurt from the analysis also fits into category. Other examples in my analysis were not even actually built because of their, however beautiful, unrealistic design. The Hangar of the Future positions itself in between these two extremes, more leaning to the functional design category but the architecture is much more influenced by sustainability and ambiance then the other existing functional hangars in the analysis. Shape and materialisation are decided upon by referring to the ambitions of ambiance and concept of the energy machine. The idea behind this is to create beautiful architecture that is pleasant, still affordable, realistic and functional. The beauty of the integration of construction and architecture in combination with a practical transparent materialisation leads to a pleasant work environment. Together with innovative climate system and new organisational model the hangar of the future really does support the maintenance processes in an innovative way.This also leads to happy, and therefore productive employees. After all, the hangar  is an industrial building where profit and efficiency of processes plays an important role.

Wider social context

For the wider social context two main aspects of the hangar are of importance. Firstly that this hangar shows that it is possible to create a new type of sustainable hangar and secondly a hangar with a completely new organisation.
Sustainable, as the shape is designed to save and even produce energy and equipped with the new unproven concept of local workspace. These local work bubbles offer a pleasant work climate without the need to heat up the enormous hangar hall which saves an substantial amount of energy considering one façade opens almost completely several times a day.

New organisation models are required as the current society is used to certain organisational structures that many companies follow. I am however convinced that this is not the organisation structure people are most happy in and therefore also not as efficient as they could be. I propose to provide employees, at KLM but at all companies in general, with more responsibility and freedom and less hierarchy. Intrinsic motivation is the best motivation and no money or punishments can provoke this. When the new organisational method is implemented it will increase efficiency as well as work pleasure. Example of successful implementation of such a model is General Electric. Here the teams that work on engines are responsible for the engines themselves The boss does not decide on the worktimes or shifts but merely sets the deadline. Next week he says, the engine should be finished. If the employees work all night and day during two days or just one week 8 hours per day does not interest him, the employees are free to decide. There are also no secretaries or managers, nor cantine ladies or cleaners. Everybody does everything. The architecture of the workplace has to support this new organisational structures that will require completely different type of spaces. The hangar of the Future is designed based on this principle and if actually built would form a great example of a completely new organisation, as well as new hangar architecture.

# Thank you

I would like to thank my professor Kees Kaan and weekly mentor Henri van Bennekom for their enthousiasm about the project and the inspirational way in wich they have guided me through this graduation project. It has been a pleasure.

Thanks also to Coen Swaanenburg, mentor at the KLM for showing me how KLM works and by being open and always looking for innovations. It was very nice working together and thank you for giving me the freedom that I needed while always being there with knowldge and input when required.

Thank you Mahasti for letting me use your super computer for hours and hours to make my high resolution renders and for all the other things, there are to many to mention. Johan thank you for your critical view and helping me when the model was not working out the way I wanted. And also for providing the perfect workspace with nice tools, materials and most of all strong coffee.

Lyla, it was awesome graduating together and thank you for helping me in hard times with the roof and for being nice when I was slightly grumpy.

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It was a great experience with all of you.

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