A FUTURE VISION OF EINDHOVEN AIRBASE

GIVING GROWTH A STRATEGIC DIRECTION TOWARDS 2050

TU Delft

Koninklijke Luchtmacht

DEFENSITY COLLEGE

A future vision of Eindhoven Airbase

Giving growth a strategic direction towards 2050

by

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to obtain the degree of Master of Science in Strategic Product Design

at the Delft University of Technology,

to be defended openly on April 4th, 2018

Student number 4213025
Project duration October 2017 - April 2018

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ROYAL NETHERLANDS AIR FORCE

EINDHOVEN AIRBASE

Eindhoven Airbase is a military airbase

334 SQUADRON

Flight operations; KDC-10, Gulfstream IV, Dornier

336 SQUADRON

Flight operations; C130 Hercules

940 SQUADRON

Logistics, storage & manage materiel

942 SQUADRON

Maintenance

941 SQUADRON

Airbase services

EINDHOVEN AIRPORT

Civil part of Eindhoven Airbase

MUTUALLY OPERATING

ADAPTIVE HUB

SEAMLESS AND RESILIENT TRANSPORT

CIRCULAR OPERATIONS

NOMENCLATURE

LIST OF ABBREVIATIONS

AAR	*Air-to-air refuelling*
AE	*Aeromedical evacuation*
ANSP	*Air Navigation Service Provider*
AOCS NM	*Air Operations Control Station Nieuw Milligen*
AOM	*Airport Operation Manager*
AT	*Air transport*
ATC	*Air Traffic Control*
CLSK	*Commando Luchtstrijdkrachten, Staff Command Air Force*
Current Ops	*Current Operations*
DOSCO	*Defensie Ondersteuningscommando, Defense Support Command*
EATC	*European Air Transport Command*
Eindhoven Airbase	*Vliegbasis Eindhoven (military section)*
Eindhoven Airport	*Eindhoven Airport (civil secition)*
HDB	*Hoofd Directie Beleid, Main management policy*
ISA	*Initial Safety Assessment*
LCC	*Low-cost carrier*
NATO	*North Atlantic Treaty Organization*
LVNL	*Luchtverkeersleiding Nederland*
MCCE	*Movement Coordination Centre Europe*
EA	*Eindhoven Airport (civil)*
METEO	*Meteorology*
MLA	*Militaire Luchtvaart Autoriteit*
MRTT	*Multi-Role Tanker Transport*
NLR	*Nederlands Lucht- en Ruimtevaartcentrum, Netherlands Airspace Centre*
OCC	*Onderdeels Coördinatie Centrum*
OMO	*Operationeel Management Overleg, Operational management consultation*
RNLAF	*Royal Netherlands Air Force*
RVB	*Rijksvastgoedbedrijf*
SM	*Safety Manager*
SNEB	*Sectie Natuur en Ecologie Beheer*
UAS	*Unmanned Aircraft Systems*
V/PD	*Vehicle and pedestrian deviation*
ViP	*Vision in Product Design*
VO	*Veiligheidsoverleg, Safety consultation*

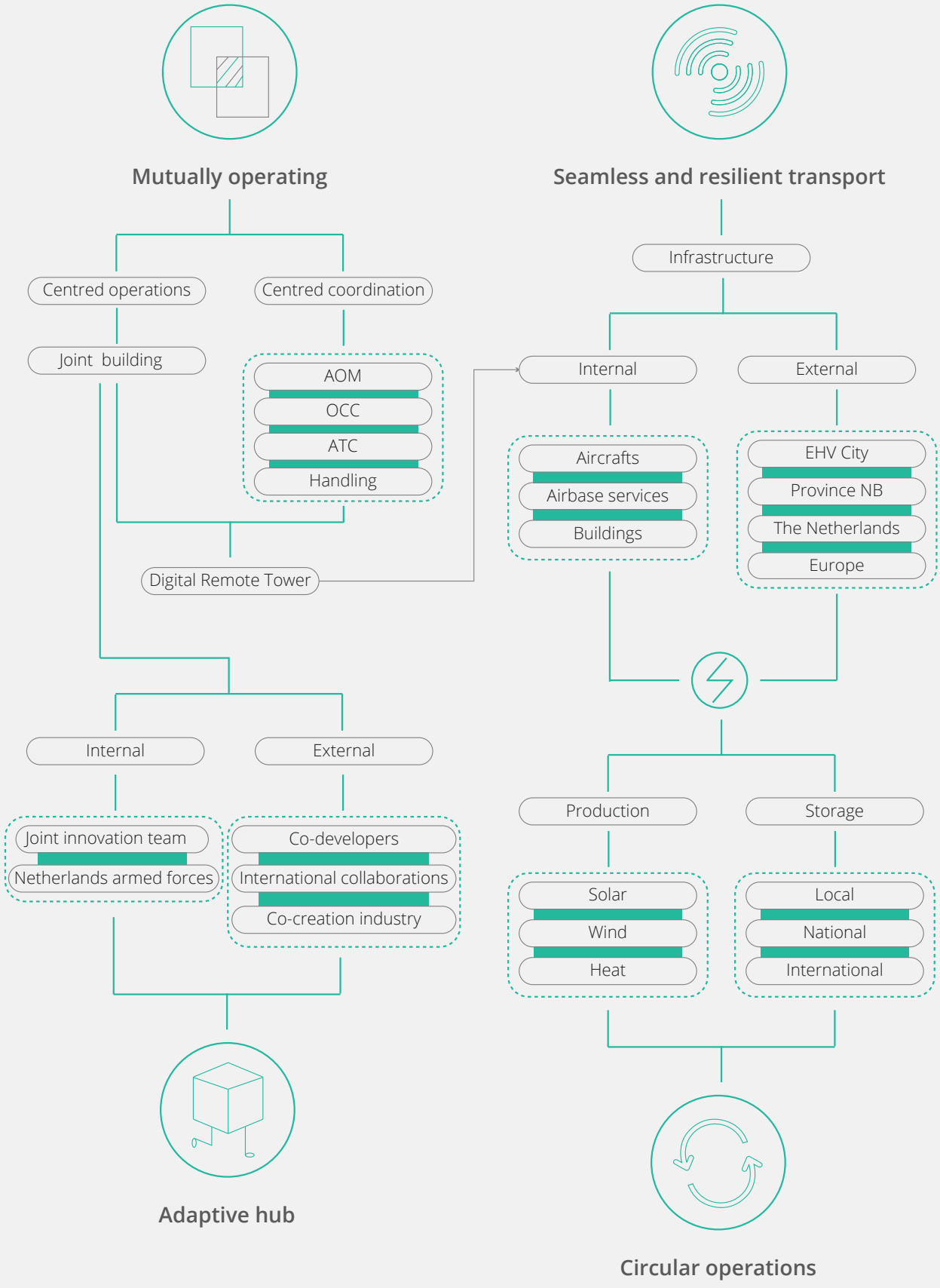


Figure 0. Final concept as a result of the context vision

EXECUTIVE SUMMARY

This project is about Eindhoven Airbase, which is part of the Royal Netherlands Air Force (RNLAF). Eindhoven Airbase is a military airbase, but provides civil flights of Eindhoven Airport at the same airbase. Both organisations are situated at the west side of the field, where they operate on their own, which leads to sub-optimal operations. Moreover, Eindhoven Airport prospects an increase of flight movements towards 2030, which will be tough regarding the current orientation of both companies. In addition to the growth of Eindhoven Airport, Eindhoven Airbase is also growing because of a recently formed international collaboration. This collaboration provides shared forces during operations and transportation of cargo and military personnel. Divided over the years, starting in 2018, five A330s will come to Eindhoven Airbase and replace two KDC-10s. This will result in more flight movements at the side of Eindhoven Airbase, but this growth will not have the same impact on the airside operations as the growth of Eindhoven Airport. As a result of both growth and sub-optimal operations, the safety of operations at the airside is at risk and developements are inhibited.

DESIGN CHALLENGE

Airport operations and business models are rapidly changing, driven by competitive forces and capacity constraints. The potential of the airbase in combination with the growth of Eindhoven Airport as well as Eindhoven Airbase offers interesting opportunities in the field of infrastructure and shared services. Adaptation of next-generation equipment at the airbase is necessary for maintaining the relevance and safety of the airbase. The design challenge can be formulated in the following research question:

"How can Eindhoven Airbase create sustainable operations towards 2050?"

The design challenge is tackled by the Vision in Product approach (Hekkert & van Dijk, 2011). The approach is about searching for possible future scenarios, instead of solving present-day problems and will contain disruptive design by creating a vision for a new business model supported by technology, which must fit the strategic goal and mission of the clients (Hekkert & van Dijk, 2009). The clients in this case will be Royal Netherlands Air Force, Eindhoven Airbase and Eindhoven Airport, but mainly focusing on Eindhoven Airbase.

To create the future context a research has been done within the domain:

"Sustainably operating at Eindhoven Airbase in 2050"

With emphasis on sustainable operations, because the prospective growth considers the coming ten years, but is no certainty towards 2050. Therefore, Eindhoven Airbase needs to create a durable system, which will support to maintain the relevance of Eindhoven Airbase.

CONTEXT VISION

The analysis brought up four themes, namely connectivity, automation, electrification and liveability, which are explained below. These themes are implemented in the context vision.

Connectivity

Eindhoven Airbase and Eindhoven Airport are open for a strong collaboration, which is essential with regard to facilitating the future-proof airport. Where Eindhoven Airbase focuses on strategic and tactical transport, host-nation services and airport – and ground support services. Eindhoven Airport connects the (transport) companies in their direct environment and is therefore connectied to the Brainport (Brainport Development NV, 2017).

Automation

With the development of technologies and an increase of flight movements the coming years, all stakeholders need to adapt to these changes. With the increase of flight movements, the communication between all stakeholders needs to be smoothened to lead the airport operations as efficient and safe as possible, because "human

error" is one of the most frequent causes of aviation accidents (Boeing Commercial Airplanes, 2006).

With the technology developments regarding Unmanned Aircraft Systems (UAS), aviation regulations around the world also need to be updated to prepare for the era in which skies are increasingly shared by both manned and unmanned aircraft. The task becomes even more complicated if the UAS is autonomous, i.e., flying without a human at the controls. (Villasenor, 2014).

Electrification
The increase of natural disasters will give the Royal Netherlands Air Force, and therefore Eindhoven Airbase, more work in the future. Concerning this trend, electrification of operations of Eindhoven Airbase is required, because of the prospective lack of resources in the near future. Adaptation to this bridging period is key (Hoeppe, 2015; The Economist, 2017).

Liveability
Furthermore, the new developments will need adequate transitions towards 2050. The military transport will depend more on drones and conventional civil air transportation will change to an on demand service. New ways of transportation such as hyperloop will save time, costs, noise and emission concerning the European destinations. Smaller electric (unmanned) aircraft systems could provide intercontinental flights. This future context results in an infrastructural change towards and within Eindhoven Airbase, where Eindhoven Airbase will be a major junction, and therefore an important connection of international and national transport through the air and via land. As a result Eindhoven Airbase needs to take into account the liveability of the environment, because during the transition external stakeholders have to support the changes that will be made.

As a result, the context vision with associated interaction and qualities of the product-service system are:

Vision

"Eindhoven Airbase needs to mutually operate as the first self-sustaining transport city in the world in 2050."

Interaction

"The interaction with the product-service system is like operating in an infinite loop."

Qualities

"The product-service system is seamless and resilient."

How

"By mutually operating with Eindhoven Airport and connecting Eindhoven city and co-developers with the airbase"

ROADMAP

The context vision consists of four principles, namely mutually operating, adaptive hub, circular operations and seamless and resilient transport. These principles are the base of the concept showed in figure 0.

The concept is implemented in a strategic innovation roadmap towards 2050 within the system of Eindhoven Airbase, -Airport and -city. This roadmap is attached to this report. The three boundaries within the system; knowledge, transport and sustainability, are translated to strategic directions.

Creating a strong position within a co-creation industry

Within this strategic direction, Eindhoven Airbase has to build long-term strategic relationships with the external environment, which will result in environmental, social and economic agreements.
To meet these needs different actions have to be taken by Eindhoven Airbase. Firstly they have to connect with Eindhoven Airport. Secondly Eindhoven Airbase needs to attract co-developers to the airbase, which can provide the transition of electrification, automation and connectivity. These actions also need to focus on the internal employees to facilitate adaptivity in internal processes.

Strengthening the transport infrastructure within the system

Strengthening of the transport infrastructure within the system is needed to align strategic infrastructure developments with future needs,

to be innovative, adaptable and ready for future changes. Eindhoven Airbase has to improve and connect their infrastructure around the airbase with Eindhoven city. As a result the connection with a European network can be created. Due to this, Eindhoven Airbase will establish a connected and combined air- and land transport system. This connected transport system will facilitate the attraction of relevant stakeholders, which can be connected to the network of co-developers around the airbase, resulting in a loop of aircraft and materials with suppliers and co-developers around the airbase.

Establishing a sustainable system

The last strategic direction, establishing a sustainable system, will align strategic goals and aspirations with sustainable business practice and support of the local community by engaging them in the process for maintaining a liveable environment.

Eindhoven Airbase will achieve this by improving the electric infrastructure in current operations at the airbase. After improving this infrastructure it has to connect with Eindhoven city, so a shared electric network can be created. Collaterally improving the electric infrastructure, the development of energy generation at the airbase needs to expand and implement usage in current operations. Furthermore, the airbase has to keep upgrading the system with renewables, this includes creating an automated and connected electrical system. As a result the system at the airbase will be self-sustaining, this can be connected to the loop of materials connected with the co-developers. Considering the mutual operations, this creates a self-sustaining circular economy connected to the external environment, which can fulfil the vision of Eindhoven Airbase in 2050.

CONCLUSION

The concept fulfils the desirability of the company and its employees, the viability within the business approach and feasibility regarding technological innovations. In this case the employees desire the increase of adaptivity and optimisation of the operations at the airside. The concept is supporting the business case of the Royal Netherlands Air Force of striving to be an adaptive organisation by connecting the airbase with Eindhoven Airport and -city, but it also facilitates the possibilities for strong international collaborations. Adapting to technology developments will support the concept towards 2050. As a result, this will also support the strategies of both Eindhoven Airbase and the Royal Netherlands Air Force. Eindhoven Airbase will therefore be able to continue contributing by means of air transport and –operations with military transport airplanes to support the Royal Netherlands Air Force and providing the restoration of the broad employability (i.e. restore material readiness and restore practical readiness), focus on innovation and the transition towards a Fifth Generation Air Force.


SE-MKG

01 INTRODUCTION 12

01.1 Current context
01.2 Design challenge
01.3 Approach

02 CREATING THE CONTEXT 20

02.1 Companies
02.2 Core processes
02.3 Masterplan
02.4 Stakeholders
02.5 Trends and developments

03 VISION 38

03.1 Context vision 2050
03.2 Conceptualisation

04 STRATEGIC INNOVATION ROADMAP 50

04.1 Roadmap
04.2 Conclusion
04.3 Recommendations
04.4 Discussion

05 REFLECTION 56

06 REFERENCES 60

07 APPENDIX 66

A. Deepening research approach
B. Creative sessions and brainstorms
C. The Fifth Generation Air Force
D. Digital Remote Tower
E. Interviews
F. Sustainable aviation
G. Context factors
H. Clustering insights
I. Analogies
J. Concept fundamentals
K. Ideation
L. Evaluation of the concept

figure 1. Evacuation of people at Sint Maarten

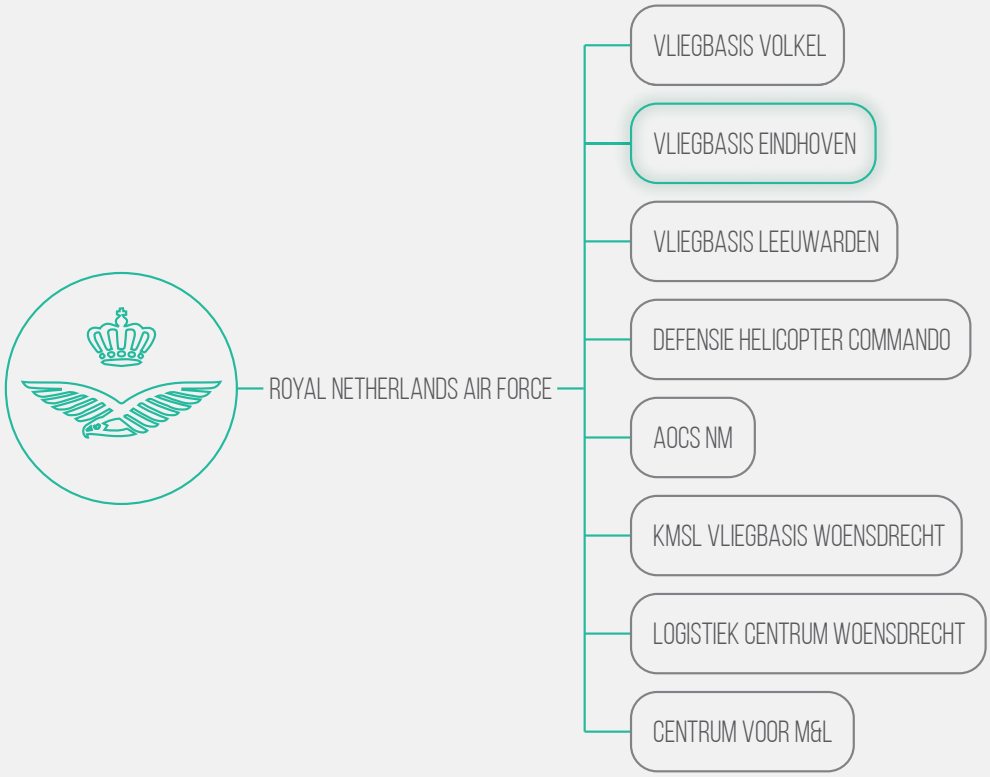


figure 2. Departments of the Royal Netherlands Air Force

01. INTRODUCTION

This project is about Eindhoven Airbase, which is part of the Royal Netherlands Air Force (RNLAF). In times of need, the Royal Netherlands Air Force has the mission to help the afflicted people by sending military personnel to affected areas and by giving emergency aid to the local community (figure 1). The Royal Netherlands Air Force consists of several airbases (figure 2), one of which is Eindhoven Airbase (Vliegbasis Eindhoven). Military personnel and cargo are transported via Eindhoven Airbase to execute the mission of the Royal Netherlands Air Force. Next to being the base of military strategic and tactical transport, the airbase is the second civil airport of the Netherlands due to Eindhoven Airport. Eindhoven Airport is the civil part of the airbase and, in contrast to Eindhoven Airbase, a commercial company. An interesting combination of two different companies with two different strategies working together within the same field.

01.1 CURRENT CONTEXT

Safety and growth

In the coming years the airbase will grow significantly (figure 3). The prospective growth is based on the increase of the number of flight movements and passengers towards 2029. Figure 3 shows that the civil part will increase the strongest, from 33.000 flight movements in 2016 towards 55.000 - 100.000 flight movements in 2029. The prospective growth will ask a lot of the airport organisation. In addition to the growth of Eindhoven Airport, Eindhoven Airbase is also growing because of a recently formed international collaboration. This collaboration will result in more flight movements at the side of Eindhoven Airbase, but this growth will not have the same impact on the airside operations as the growth of Eindhoven Airport.

The operations at the airside, the part of an aerodrome to be used for take-off, landing and taxiing of aircraft, including aprons, require the interaction of five main stakeholders: airport authority (i.e. airport operator), pilot, air traffic control (ATC), ground handling and safety regulator (figure 5). This interaction facilitates the ground movements of aircraft and vehicles, and maintains the surface in working condition. One

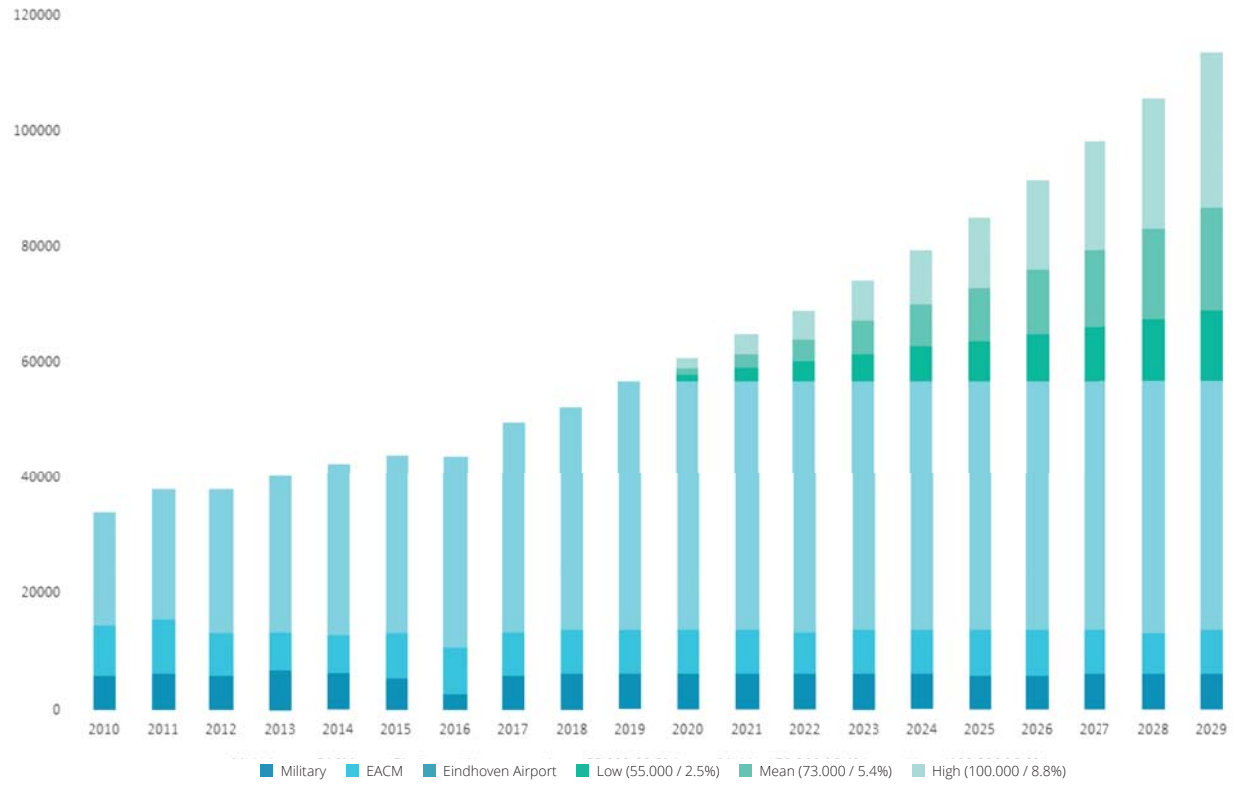


figure 3. Flight movements Eindhoven Airbase and Eindhoven Airport (Eindhoven Airport, 2017)

key performance indicator (KPI) of such operations is safety, which can be defined as 'the state in which the possibility of harm to persons or the property damage is reduced to, and maintained at or below an acceptable level through a continuous process of hazard identification and safety risk management' (ICAO, International Civil Aviation Organization, 2009). The complexity of aircraft and related operations at the airside have proven to be vulnerable and at risk of failure with the consequence that accidents and incidents may occur. The future airside operations need to restrict the risk of failure within the prospective growth.

Layout airside current situation

Figure 4 shows the orientation of both companies at the airside. The airside (runway, taxi track, air control tower and electricity – and communication networks) is part of Eindhoven Airbase. Eindhoven Airport interacts at their civil platform, but makes use of all the other facilities of Eindhoven Airbase. In the current situation both parties are situated at the westside of the field, where both companies are next to each other, but not interacting at the platforms. Within the current layout, Eindhoven Airport is stuck in the corner of the field. It cannot expand their platform and terminal when needed. This is one of the challenges concerning the prospective growth. In the future, the runway will keep the same orientation, the airbase will stay a single runway airbase.

Stakeholders

To tackle the design challenge, all stakeholders need to be involved in the project. These stakeholders can be divided into two stakeholder segments:

- Internal stakeholders
- External stakeholders

The internal stakeholders are the stakeholders who are interacting within the airbase, figure 5. Only the interaction on the ground at the airside will be considered. The internal stakeholders that are taken into account are Air Traffic Control, Current Operations, SNEB, Airport Operation Manager, EATC and the Safety Manager. The external stakeholders are the stakeholders outside the airbase interacting with the airbase (figure 6). The external stakeholders which are taken into account are Military Aviation Authority, municipality of Eindhoven, Noord-Brabant Provincial Authority, LVNL, RVB and Teuge- and Twente Airbase. Both internal- and external stakeholders need to be involved while creating a future context for Eindhoven Airbase. Next to that, the new vision for this future context needs to be communicated to all stakeholders, because of the complexity of the decision making system.

01.2 DESIGN CHALLENGE

Airport operations and business models are rapidly changing, driven by competitive forces and capacity constraints. Outside the airport terminal, congested airspace and obsolete air traffic management (ATM) infrastructure will necessitate investment in next-generation equipment and information management systems (Frost & Sullivan 2016). Currently all units at Eindhoven airbase and – airport are working on their own. This is leading towards sub-optimal operations and slows down the innovative developments around the airbase. The potential of the airbase in combination with the growth of Eindhoven Airport as well as Eindhoven Airbase offers interesting opportunities in the field of infrastructure and shared services. Adaptation of next-generation equipment at the airbase is necessary for maintaining the relevance of the airbase. The design challenge can be formulated in the following research question:

"How can Eindhoven Airbase create sustainable operations towards 2050?"

With emphasis on sustainable operations, because the prospective growth considers the coming ten years, but is no certainty towards 2050. Therefore, Eindhoven Airbase needs to create a durable system, which will support to maintain the relevance of Eindhoven Airbase.

The design challenge is tackled by the Vision in Product approach (Hekkert & van Dijk, 2011). This approach will result in a future context vision regarding Eindhoven Airbase in 2050. This vision is the base for a strategic design for Eindhoven Airbase. In the end the vision needs the support of the relevant stakeholders (figure 5 and figure 6), to successfully lead Eindhoven airbase and –airport towards 2050.

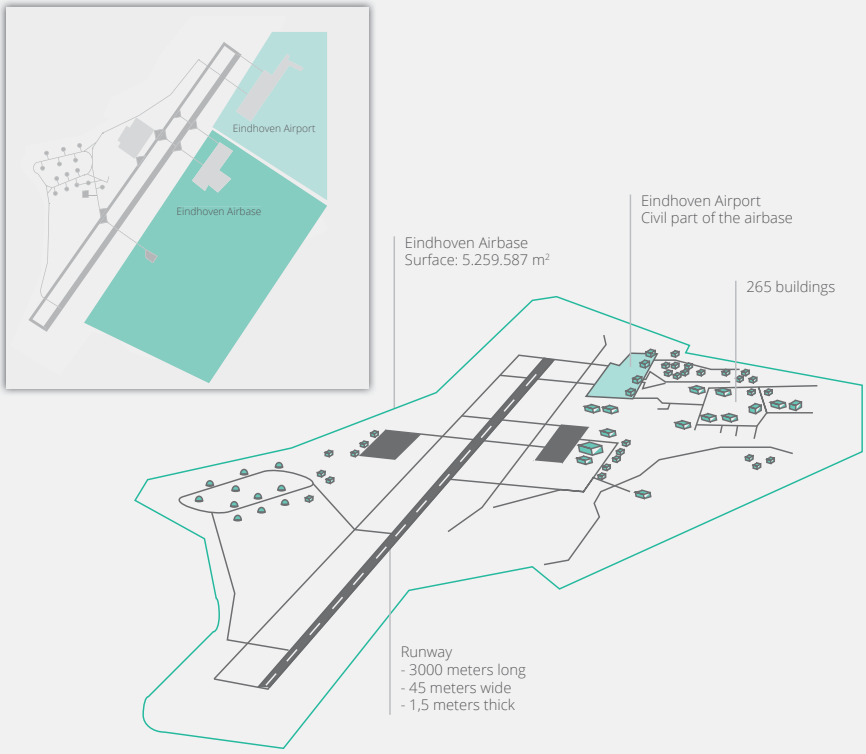


figure 4. Current layout of the airside, top- and front view

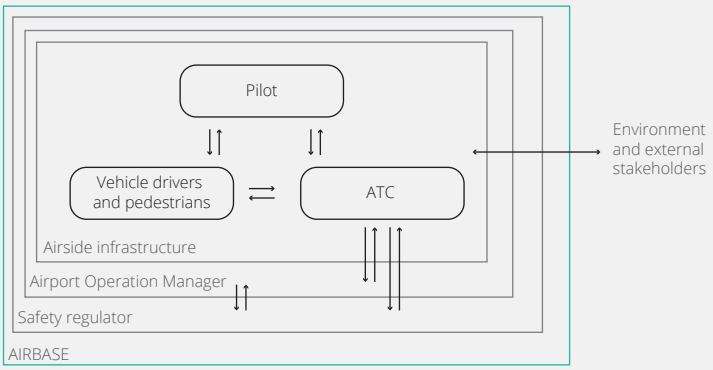


figure 5. Interaction five main stakeholders at airside of Eindhoven Airbase

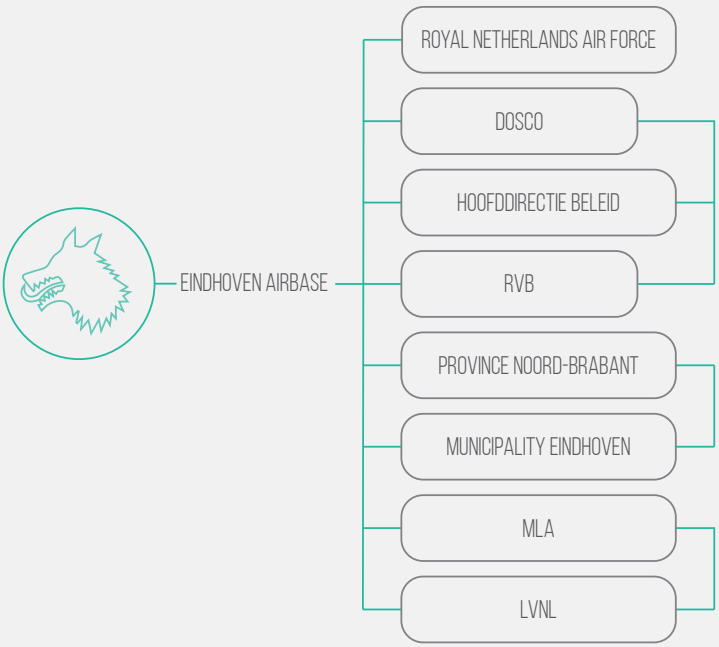


figure 6. Relevant external stakeholders for Eindhoven Airbase

01.3 APPROACH

Strategic design method

The Vision in Product (ViP) approach is based on a framework which designers can interpret as not fixed. The approach is about searching for possible future scenarios, instead of solving present-day problems. Moreover, ViP is interaction-centred because products or product-service systems obtain their meaning when they interact with people. Lastly, ViP is also context-driven because the appropriateness of an interaction is determined by the context for which it is designed. This context can be the world of today, tomorrow, or may lie years ahead. Future contexts demand new and different behaviours (Hekkert & van Dijk, 2011). In addition to this approach, the process will be collaborative and iterative. During the project different co-creation- and validation sessions will be executed (appendix B).

The Vision in Product approach is shown in figure 7. The ViP approach will contain disruptive design by creating a vision for a new business model supported by technology, starting by setting a domain within a timeframe for the project, which must fit the strategic goal and mission of the clients (Hekkert & van Dijk, 2009). The clients in this case will be Royal Netherlands Air Force, Eindhoven Airbase and Eindhoven Airport, but mainly focusing on Eindhoven Airbase.

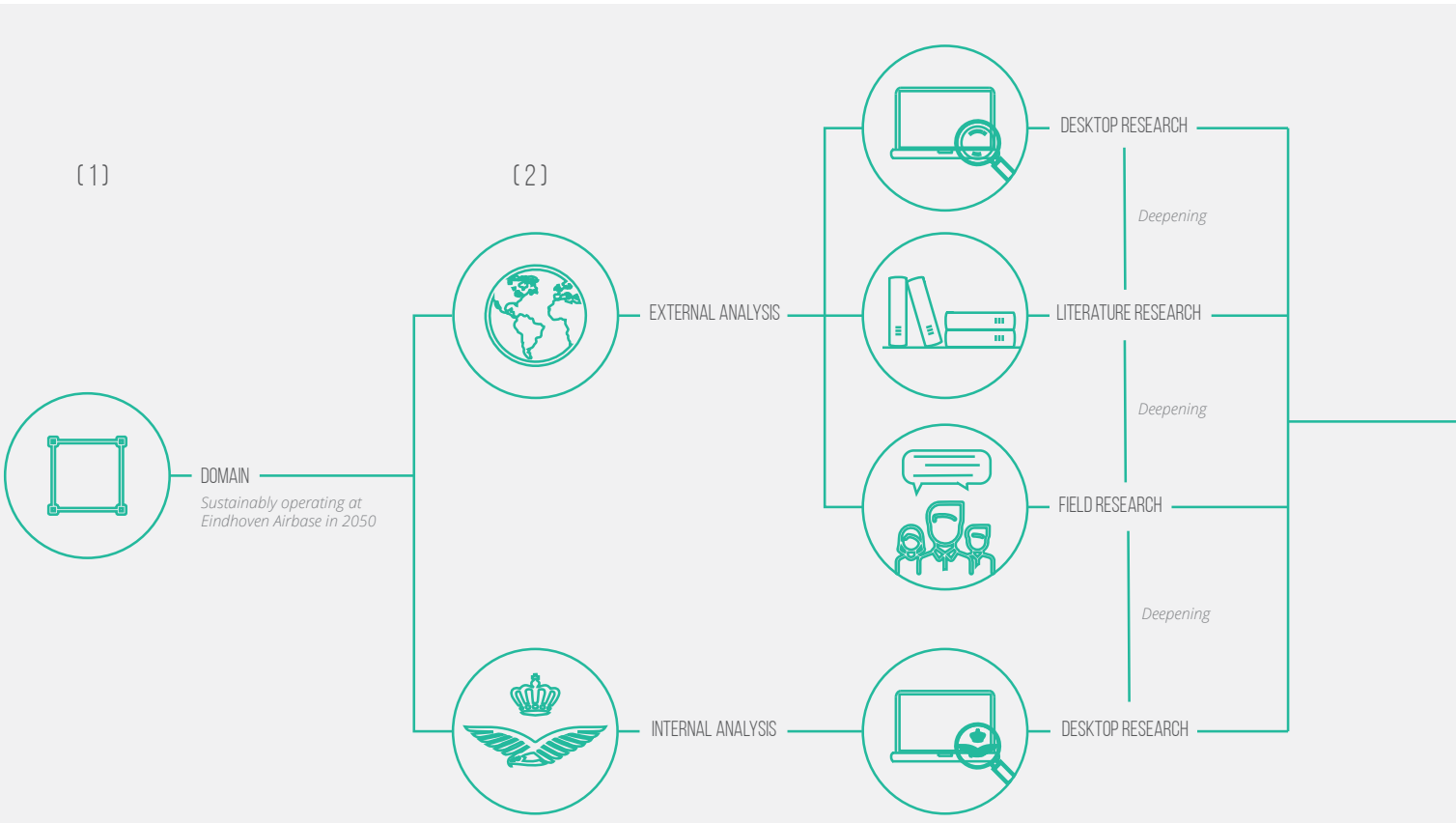
Furthermore, a research has been done within the domain (1), consisting of an internal- and external analysis (2) (appendix A). The insights of this research lead to context factors (3), which are relevant factors within the future context of the domain. The context factors will be clustered (4) and these clusters are grouped and translated to interesting topics. The interesting topics are divided among an axial system (5). A quadrant of this axial system is chosen and translated to an analogy, which is the base of a strategic direction. These strategic direction is translated to a statement, which is combined with the future interaction and product-service system qualities. This combination of statement, future interaction and product-service system qualities will be the context vision, which, in this case, will be the vision of Eindhoven Airbase in 2050 (6).

The vision consists of different concept fundamentals, which form the base of a concept within the future context. The concept is the base of different strategic directions, which are translated to recommendations. These recommendations are the guidance in a strategic innovation roadmap, for the development of Eindhoven airbase from 2018 till 2050.

Domain

The research is done within the following domain:

"Sustainably operating at Eindhoven Airbase in 2050"



As earlier mentioned, sustainably operating is key in a fast-changing environment. Eindhoven Airbase needs to be prepared to adapt to it quickly fast-changing environment.

Strategies

Within the domain, three strategies of the Royal Netherlands Air Force, Eindhoven Airbase and Eindhoven Airport need to come together.

Royal Netherlands Air Force

The strategy of the Royal Netherlands Air Force contains restoration of the broad employability, transition towards the Fifth Generation Air Force (appendix C) and focus on innovation (Koninklijke Luchtmacht, 2016).

Eindhoven Airbase

Eindhoven Airbase will supply, where and when needed, a contribution of Airpower of the Royal Netherlands Air Force by means of air transport and –operations with military transport airplanes. Next to that, Eindhoven Airbase is providing their platform for shared use and handling of aircraft related operations (Factsheet Vliegbasis Eindhoven, 2014).

Eindhoven Airport

Eindhoven Airport wants to grow from 6 million passengers in 2019 towards 9 million passengers in 2025. This growth is depending on all stakeholders, that is why they believe in connection and collaboration with the internal– and external environment. With a strong connection and good collaboration, the support of the environment regarding their ambition towards this, the growth will be stable (Eindhoven Airport, 2017).

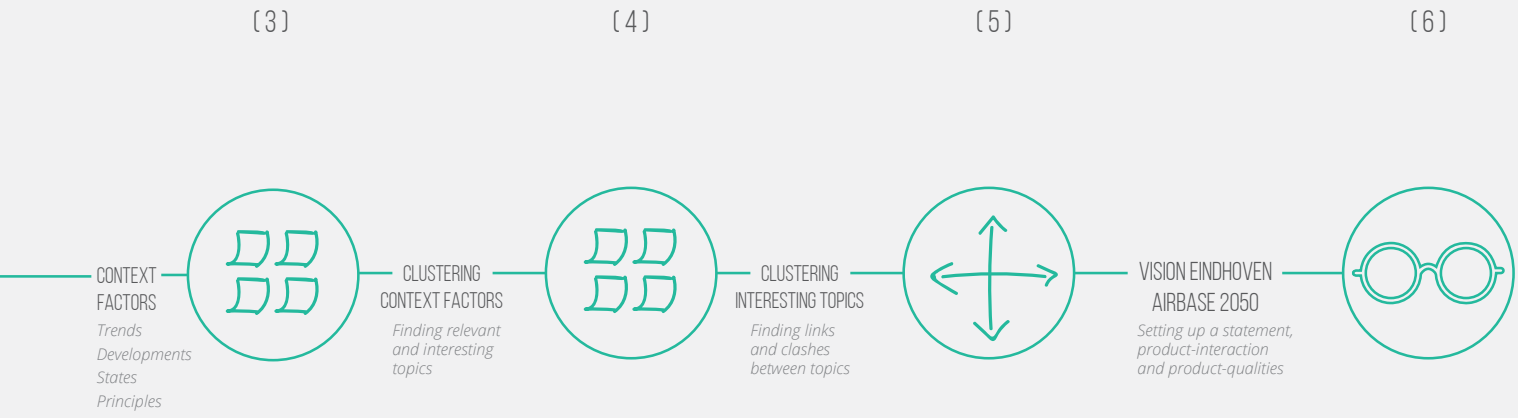


figure 7. Vision in Product Design approach


SE-MKG

CREATING THE CONTEXT

02. CREATING THE CONTEXT

RESEARCH

The research consists of an internal – and external analysis within the domain. These analyses consist of literature-, field- and desktop research. The analysis starts with defining the vision, mission and strategies of Eindhoven Airbase and Eindhoven Airport. Secondly, insights from both internal- and external stakeholders were gathered. Next to that insights considering the trends and developments concerning the airport of the future, safety and growth, sustainability and airside operations were gained (figure 8). All insights are translated to context factors, which contain states, principles, trends and developments.

02.1 COMPANIES

Royal Netherlands Air Force

The Royal Netherlands Air Force is a globally active, modern and technology-driven service branch of Ministery of Defence, which is part of the governmental organisation. The Royal Netherlands Air Force provides support for combatting international tension and bringing relief to (natural) disaster-stricken regions. In The Netherlands it provides security from airspace (Defensie, 2017).

Mission

The existence of the Air Force Command is expressed in the mission:
"The Royal Netherlands Air Force is committed to global peace, security and freedom. They do that, within and from a third dimension above the surface, by achieving and contributing towards political and military goals. Through intensive cooperation and continuous innovation they prepare themselves for the future and get the best out of the combination of human and technology." (Koninklijke Luchtmacht, 2017).

Vision

The vision defines the path of Air Force Command towards the future. This vision is expressed in the following ambition: "To successfully fight and win within the future, from both air and space, the Air Force Command will transform towards an information-driven and agile Air Force. Besides, they have the ambition to bring Airpower, on both tactical – and operational level (Koninklijke Luchtmacht, 2017).

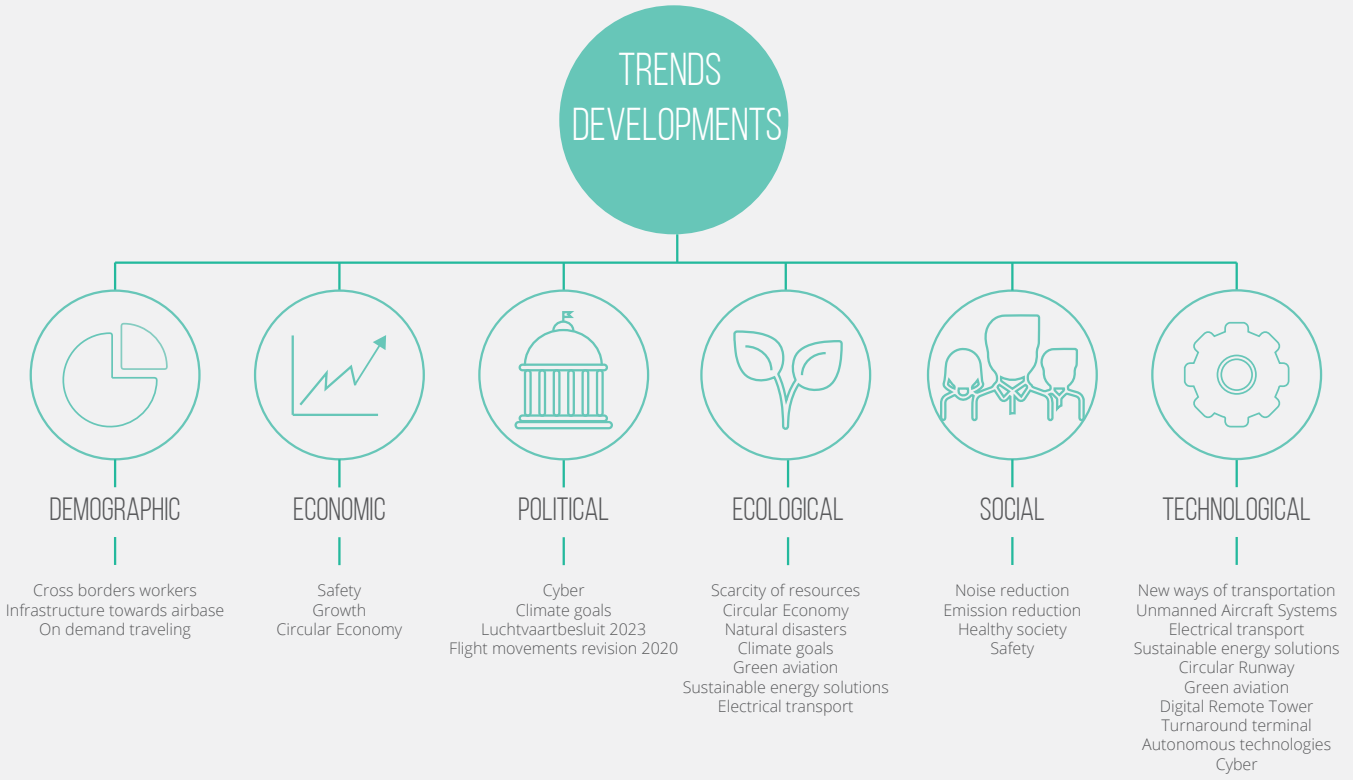


figure 8. Relevant subjects of the trends and development analysis

Eindhoven Airbase

The Royal Netherlands Air Force consists of several airbases, Eindhoven Airbase is one of them (figure 2). Since 1952, it has been a military airport (figure 9). Eindhoven Airbase provides strategic and tactical air transport and air-to-air refuelling (AAR) to other aircraft and it carries out coastguard duties (figure 10). Military personnel are deployed worldwide for maintaining peace and security. The movement of personnel, materiel, special cargo such as ammunition and helicopters via air transport is therefore indispensable. Air transport is a crucial capability, because it takes place in hostile and high-threat environments and areas difficult to reach (Factsheet Koninklijke Luchtmacht, 2016).

International cooperation

Most of the operations of Eindhoven Airbase are internationally orientated, because of the international partnerships it has.
Eindhoven Airbase is an established hub of international cooperation in (air)transport. Not only for cost-saving purposes, but also to increase the availability of transport aircraft capability during peak periods. Therefore the European Air Transport Command (EATC), the Movement Coordination Centre Europe (MCCE) and the Resolute Support Strategic Flight Coordination Centre are based at Eindhoven Airbase. The three main tasks of Eindhoven Airbase are providing tactical - and strategic support, host-nation service and airport – and ground support services.

Multi-Role Tanker Transport

In 2010 the Dutch government decided that Eindhoven Airport could incrementally grow towards 43.000 civil flight movements in 2019. The fleet of transport aircraft (MRTT) of the Royal Netherlands Air Force will also use the growth of the airbase.

Eindhoven Airbase possesses different aircraft for different purposes, these different aircraft are shown in figure 10. As shown in figure 12, the department of Flight Operations consists of two squadrons, namely squadron 334 and 336. Squadron 334 possess two KDC-10 Transport Tankers (figure 11). According to Jeroen van der Lely, project leader of the MRTT project at Eindhoven Airbase, these KDC-10s will be replaced in 2020 following the European MRTT project. Nowadays the KDC-10s are controlled by EATC and the flight crew is fully Dutch. Besides, the technical maintenance is also part of the Royal Netherlands Air Force.

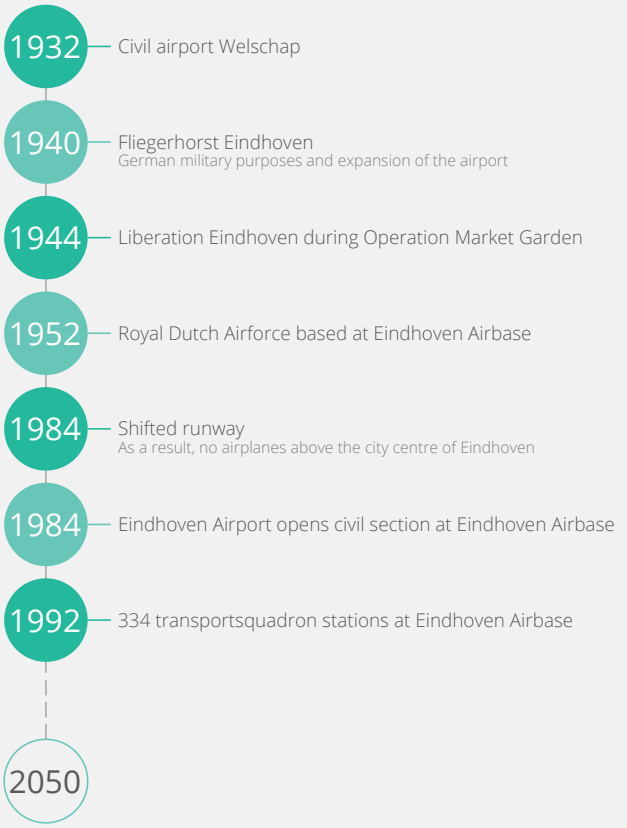


figure 9. Timeline of Eindhoven Airbase

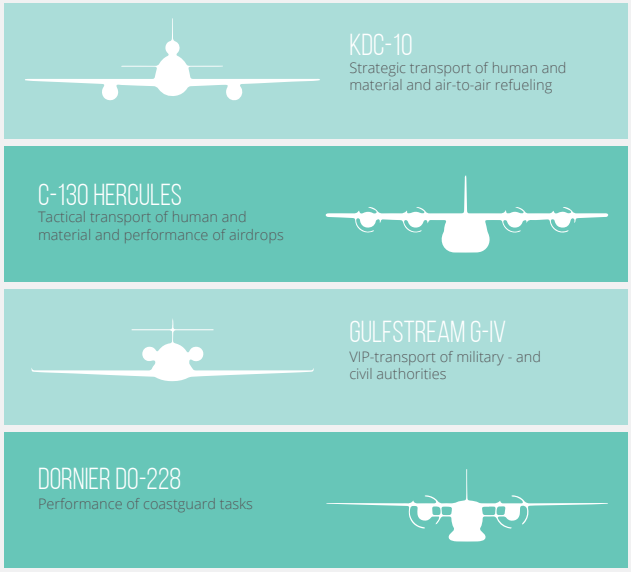


figure 10. Aircraft with different tasks stationed at Eindhoven Airbase

figure 11. Air-to-air refuelling of an F-16 by a KDC-10

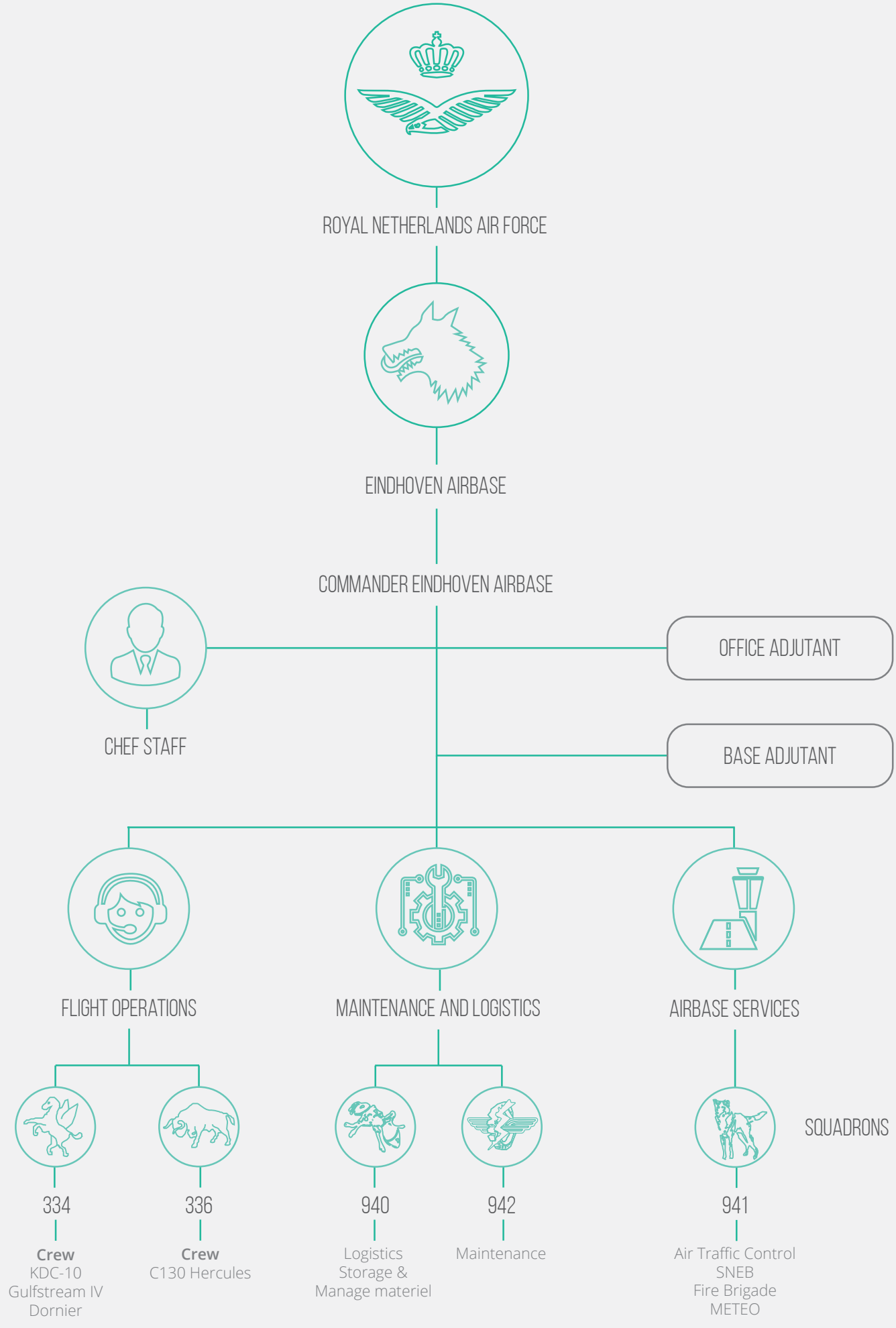


figure 12. Internal structure at Eindhoven Airbase

Furthermore the MRTT project is an international collaboration between five countries, namely Germany, Luxembourg, Norway, Belgium and The Netherlands. This collaboration provides shared forces during operations and transportation of cargo and military personnel. Divided over the years, starting in 2018, five A330s will come to Eindhoven Airbase and three will be based in Cologne-Bonn. The Netherlands will be the lead-nation within this MRTT project, with the headquarters located at Eindhoven Airbase (van der Lely, 2017). The Netherlands will get 20% of the flight hours, Germany will have 65%, the rest will be divided among the other countries. The aircraft will be introduced in the period May 2020 till November 2022. Each day, three missions will take place, two local missions and one international mission. This results in five take-offs and landings a day at Eindhoven Airbase (MRTT factsheet, 2017).

Additionally, the increase of flight movements will have an impact on the environment. Of course, the environment needs to stay liveable for society. The new MRTTs are more quiet than the old ones, but there is no clear picture of the impact the noise will have on society yet.

Besides, to become the lead nation of the project, a minimal change of infrastructure was required by the NATO. The hangar for the A330 needed to be adjusted, because the current size does not fit the norms. The growth will change operations at the airside, therefore flexibility in airport planning and design is essential (De Neufville, 2016).

Eindhoven Airport

Eindhoven Airport is a co-user of the runway for take-off and landing and the military airbase services facilitate the fire brigade, wildlife tracking and Air Traffic Control. Eindhoven Airport cooperates with Eindhoven Airbase regarding the maintenance of the runway.

Eindhoven Airport provides flights to 78 destinations in Europe and North Africa. Eindhoven Airport is a base for some low budget airlines. Low-cost carriers (LCCs) are footloose and can easily move from one airport to another. Airports compete with each other because the owners, often governments, recognize their airports' value in promoting economic growth in the region (Assaf, 2014; Brainport Development NV, 2017).

Civil air transport business is a rather complex macro-industry. Within the industry, a mass of activities are being undertaken by a complementary and combined network of actors: passenger and cargo airlines, integrators, airport authorities, handling agents, in-flight catering firms, general sales agents, car rentals, air brokers, hardware providers like aircraft manufacturers and air terminal building firms, tour operators and travel agents, all of them striving to satisfy, at least partly, demand needs (De Neufville, 2016; Jarach, 2001).

Vision and mission

Eindhoven Airport wants to grow from 6 million passengers in 2019 towards 9 million passengers in 2025. This growth is depending on all stakeholders, that is why they believe in connection and collaboration with the internal – and external environment. With a strong connection and good collaboration, the support of the environment regarding their ambition towards this the growth will be stable (Eindhoven Airport, 2016).

In summary both companies are acting from different angles. Eindhoven Airbase is part of the government institution, which means the airbase gets budget to use for the airbase operations and will not make any profit out of their operations, in contrast to Eindhoven Airport which is a commercial company, that does make profit out of their operations. On the other side both companies are (partly) cargo transport oriented (Kalakou, 2013), where Eindhoven Airport connects the (transport) companies within the direct environment, becoming an important stakeholder within the Brainport (Brainport Development NV, 2017) and Eindhoven Airbase focuses on strategic and tactical transport, host-nations services and airport- and ground support services. Next to that both companies are open for a strong collaboration, which is essential with regard to facilitating the future-proof airport.

Next to that, the core processes of both companies are partly comparable, this may lead to future opportunities where the companies could have a closer cooperation that follows from the shared services. Depending on the infrastructural change both companies can combine some airport operations, like logistics, cargo, refuelling and airport operations management.

02.2 STRUCTURE CORE PROCESSES

Eindhoven Airbase

Eindhoven Airbase can be divided into four different units, namely Chief Staff, Flight Operations, Maintenance and Logistics and Airbase Services. These four different units are differently divided into squadrons (figure 12). Figure 13 gives the core processes of these units of Eindhoven Airbase (Defensie, 2017).

Eindhoven Airport

Eindhoven Airport N.V. is led by the statutory board, consisting of two members, namely CEO Joost Meijs and COO Mirjam van den Boogaard. The board is assisted by a number of staff departments and leads the management team, which consists of an officer of Commercial Affairs and an officer of Financial Affairs & ICT (figure 14). The shares of Eindhoven Airport NV are held by Schiphol Nederland BV, the Noord-Brabant Provincial Authority and the municipality of Eindhoven (Eindhoven Airport NV, 2018).

The core processes of Eindhoven Airport at the airside are given in figure 13. Eindhoven Airport outsources most of their airport operations. As earlier mentioned it also cooperates and has a shared use of certain airport operations with Eindhoven Airbase.

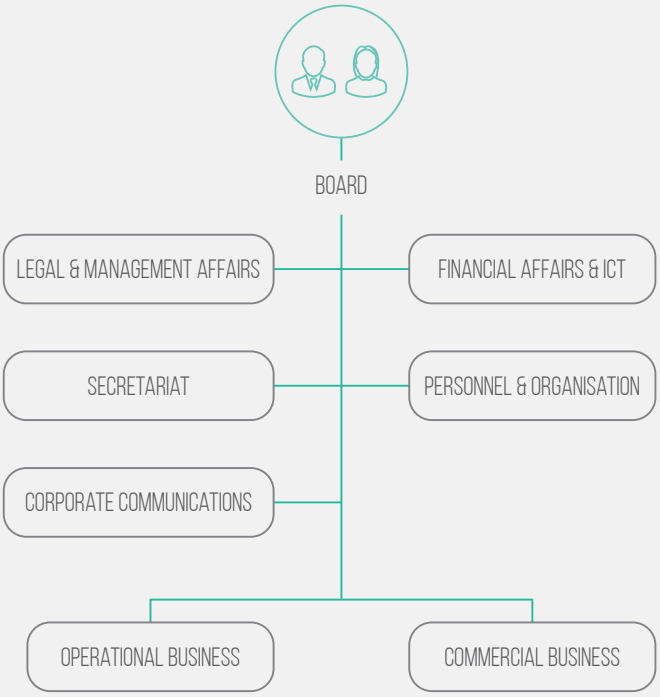


figure 14. Internal structure at Eindhoven Airport

EINDHOVEN AIRBASE

Core processes
Flight operations
Current operations
Providing flight crews

Maintenance and Logistics
Passenger handling
Cargo handling
Fuel supply
Telecommunication
Maintenance of military aircraft
Responsible ground-based systems

Airbase services
Air Traffic Control
Fire brigade
Section Nature Technology and Ecology Management
METEO

Maintenance of the runway

EINDHOVEN AIRPORT

Core processes
Airport Operations
Gate facilities
Maintenance platform

Outsourcing
Border control
Boarding
Aircraft handling
Fuel supply

SHARED USE

COOPERATION

figure 13. Shared - and core processes of Eindhoven Airbase and - Airport

02.3 MASTERPLAN 2035

Eindhoven Airport has made a masterplan towards 2035 based on transporting 15 million passengers. The masterplan consists of 5 terminals, which create 31 aircraft stands. In time these terminals will be built, next to that a second taxiway, rapid exit taxiways and multiple entries and exits at the civil platform will be created. Nowadays, de-icing of aircraft happens at the platform, but in the masterplan this takes place next to the runway, because of the limited space at the platform. This creates shared de-icing between both companies. The transition of this masterplan is given in figure 16.

Regarding to this masterplan Eindhoven Airbase has also made a transition plan for their operations. Figure 15 shows the transition of Eindhoven Airbase to the other side of the field towards 2035. In 2025 Eindhoven Airbase will partly be working on the other side of the field. The international operations will move to the other side of the field towards 2035. After this transition a connection with Oirschot (Royal Netherlands Army) can be made.

Challenges Masterplan 2035

Based on a consultation with Adrian Young (Aviation Consultant at To70) some challenges within the masterplan of Eindhoven Airport were discussed (appendix E). The main concerns are the sustainability of the masterplan, according to the platform operations and where and when the civil– and military part will eventually be connected (figure 17). Besides, the new taxiway could meet runway requirements. Then it could be used when there is an obstruction on the main runway.

2017

2035

figure 16. Masterplan Eindhoven Airport to reach 15 million passengers

figure 17. Concerns regarding the masterplan of Eindhoven Airport

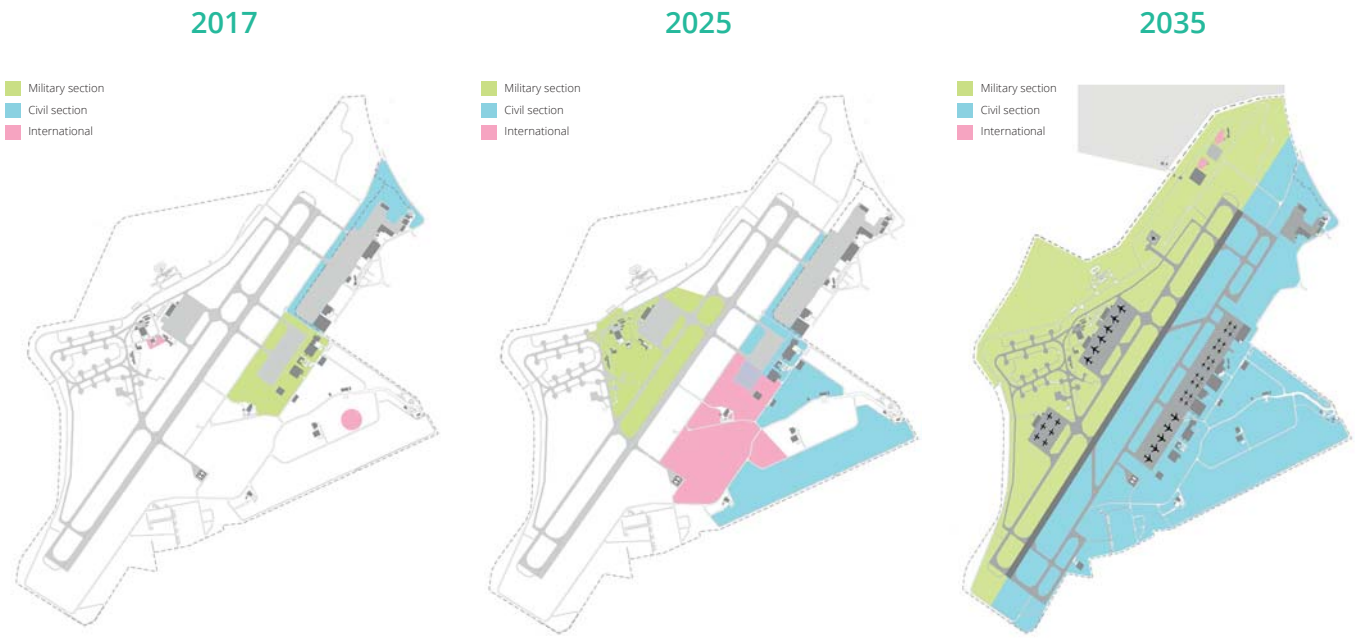


figure 15. Phase 3: Infrastructure change Eindhove Airbase

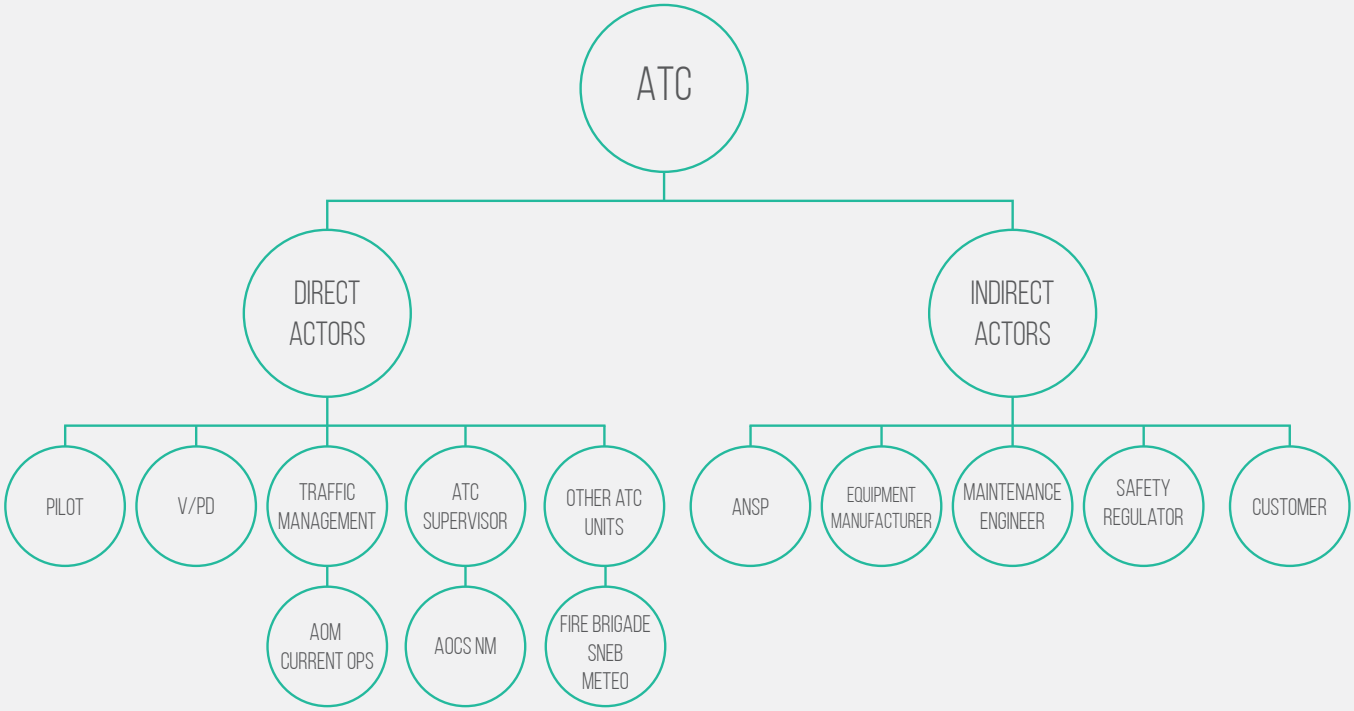


figure 18. Interaction of Air Traffic Control

02.4 STAKEHOLDERS

In this project different insights from internal- and external stakeholders were gathered. These insights provided opportunities and threats regarding the design challenge.

Airbase Services - 941 Squadron

Air Traffic Control

Air Traffic Control (ATC) operates on the side of Eindhoven Airbase, it controls the take-off and landing of every flight, including the civil flights of Eindhoven Airport. The ATC needs to guarantee the safety of all stakeholders at the airside interacting with the airplanes. The pressure for the ATC will increase with the growing numbers of civil and military flights towards 2029 (figure 3). The ATC interacts with the pilots, Section Nature Technology and Ecology Management, fire brigade, Airport Operations Manager (AOM), Current Operations and Air Operations Control Station Nieuw Milligen (AOCS NM) (figure 18).

Fire brigade

Part of 941 Squadron, Airbase services, is the fire brigade. It is part of Eindhoven Airbase, but also operates on the airside in the civil part of the field. It interacts with the ATC and Bureau Sports (figure 12). The fire brigade is the only unit at the airbase that is available 24/7. The fire brigade uses a category scale to indicate the impact of a crash at the airside, this means categories one till ten. The airside can handle a category eight crash, which means a crash of a Boeing 747 or KDC-10 (Personal interview fire brigade, 2017). The KDC-10 will be exchanged for A330s, which will not change the crash category. The increase of flights will give the fire brigade more work, but they will still be able to handle the category eight crash.

Section Nature Technology and Ecology Management

After the Hercules crash in 1996 at Eindhoven Airbase, due to a clash with birds, the section Nature Technology and Ecology Management (SNEB) became more important than ever before (NOS, 2016). The daily tasks of this section are to preserve nature on the airside and manage the species, so chances of an airplane crash reduce. The prospective growth will have impact on their way of working, because of the increase of flights, the opportunities to drive on the runway will decrease. This means that dislodging birds at the runway cannot be done frequently anymore. Next to that, the pressure will increase, because when a clash between birds and airplanes happens, they have less time to clean the runway (SNEB, 2017).

Airport Operations Manager

The main task of the Airport Operations Manager (AOM) is to monitor and manage all operations around Eindhoven Airport and at the civil platform. The AOM is providing a safe and efficient way of getting passengers from the entrance of the airport to the airplanes. Whereby the AOM is responsible

for smoothly running the processes at the civil platform. During the day, the AOM interacts with the airside security, Air Traffic Control and fire brigade of Eindhoven Airbase. Most of the time, this interaction is not face to face, which can increase human error. Human error is one of the most frequent causes of aviation accidents (Boeing Commercial Airplanes, 2006).

Changes in the types of traffic and modes of operation constantly modify the requirements and performance of airport facilities. To be effective, airport managers need to be able to easily adjust the capacity and capability of their facilities to new conditions (De Neufville, 2016). The AOM is connected with the safety consultation (Veiligheidsoverleg (VO)) between Air Traffic Control, Safety Manager of Eindhoven Airbase, Safety Manager Viggo and fire brigade. During these safety consultations all stakeholders build (new) initial safety assessments (ISAs). These ISAs need to be approved during OMO (Operationeel Management Overleg), because they have to fit the safety requirements around the airbase (figure 19) (AOM, 2017).

Current Operations

Current Operations (Current Ops) is the link between flight coordination, flight dispatch, Air Traffic Control and MRTT. Current Ops classifies military transport flights, taking into account the international collaboration within MRTT and EATC. When Current Ops can only fill half a flight, they try and see if they can cooperate with international partners to transport more goods with one flight. Current Ops gets points every time they fly more efficiently by preventing 'empty' flights. Next time a flight is half empty, Current Ops can arrange that their partner will transport their cargo, so there will be a balance in points. This will save money, time, employees for the flight crew, fuel and emission.

European Air Transport Command

The European Air Transport Command (EATC) is a multinational command located at Eindhoven Airbase (EATC, 2017). The EATC has experience in three domains, namely military air transport (AT), air-to-air refuelling (AAR) and aeromedical evacuation (AE). As a centre of this expertise in these three domains, it successfully pools and shares air capabilities and relinquishes costly air transport solutions (EATC, 2017). The EATC commands a large and diverse air transport fleet and chooses at any time the asset which best

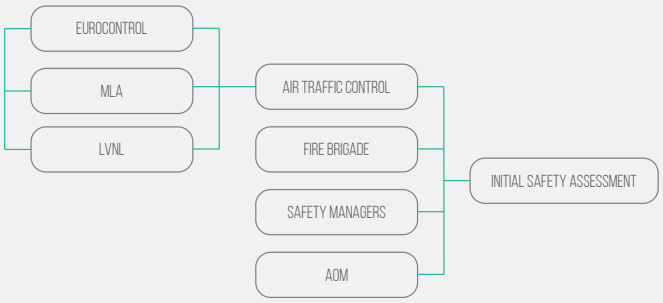


figure 19. Set-up initial safety assessment

fits the requirements of a mission and enhances efficiency and effectiveness. Next to that, the EATC plans, tasks, controls and reports missions on behalf of the nations both in peacetime and in times of war and tension. The nations connected to the EATC are Belgium, Germany, France, Italy, Luxembourg, Spain and The Netherlands.

Safety Manager

The main task of the Safety Manager (SM) is to maintain the safety within the airbase. The Safety Manager needs to adapt to the prospective growth, taking into account the increase of flights and change of infrastructure inside and outside the airbase. The change of infrastructure may lead to different emergency routes for the fire brigade, police and ambulance. The way leading towards the airbase (flight forum) is already a bottleneck. Because of the traffic jams the emergency routes are not always easily available. Hence the Safety Manager is key in safely facilitating the growth of the airbase (Safety Manager, 2017).

Military Aviation Authority

The main tasks of the Military Aviation Authority (MLA) should secure that the Dutch Military Aviation is running on conforming safety level. These tasks are:

- Publishing regulations (create aviation requirements, policy, aviation directions and advice)
- Reviewing (auditing, review and evaluation of aviation companies, aircraft and aviation authorities);
- Enforcement (enforcement and suspension, suspend or revoke of approvals, privileges, licenses, type of certificates of airworthiness).

Also, the Military Aviation Authority is keeping an eye on registers, like the aircraft register, licenses

register, recognition– and approval register, exemption register, aeronautical indication register and regulation register (Dutch Aviation Group, 2017). With the technology developments regarding Unmanned Aircraft Systems (UAS), aviation regulations around the world also need to be updated to prepare for the era in which skies are increasingly shared by both manned and unmanned aircraft. The task becomes even more complicated if the UAS is autonomous, i.e., flying without a human at the controls (Villasenor, 2014).

Municipality of Eindhoven

The municipality of Eindhoven has a future vision of the city regarding the 'sustainable healthy area development' in 2050. The city will be driven by a circular economy. Therefore the municipality strives to be CO_2 neutral in 2050 by deprecating fossil fuels and making use of social resilience as an indicator for a healthy system. The city wants to be a large junction, where bus lanes are underground, no cars are allowed in the city, there is a green lane towards the campus and the train is connected to Düsseldorf (European high speed rail) with less than an hour of travelling time. It is important to have an integrated vision with the municipality to connect the city and the airbase towards 2050.

Noord-Brabant Provincial Authority

A liveable environment is key for the Provincial Authority concerning the impact of the aviation around Eindhoven. A liveable environment has to meet two (main) requirements, namely low levels of noise and (air) pollution (figure 20). Eindhoven Airbase needs to take these two elements into account to create a liveable environment towards 2050. Noord-Brabant Provincial Authority will support the prospective growth, to preserve the international position of being a knowledge- and innovation region. This position is also due to the airport. Eindhoven Airbase is connected with Noord-Brabant Provincial Authority within a group of important stakeholders concerning the prospective growth. The communication within this group will be important for the implementation of the context vision.

Luchtverkeersleiding Nederland

Luchtverkeersleiding Nederland (LVNL) is an organisation for Air Traffic Control in the Netherlands. This organisation is responsible for the management of the civil airspace and the side tasks that come with it. In addition, LVNL works closely with Ministry of Defence, who manage the military airspace (LVNL, 2017).

In the civil sector LVNL is the link between the government and other stakeholders who are involved in Air Traffic Control. LVNL formalises Air Traffic Control with all stakeholders, regarding the pillars safety, efficiency, environment and quality.

The main office of LVNL is located at Schiphol Oost. Nowadays they are shifting to a Collaborative Decision Making (CDM) approach, because of the current growth of Schiphol Airport (LVNL, 2017). This approach could be interesting for Eindhoven Airbase as well. Within CDM all stakeholders are sharing information, to increase the predictability of handling processes and this gives the benefits of (Schiphol, 2017):

- Optimal runway usage
- Improved punctuality
- Reduced Air Traffic Control delay
- More feasible slots
- Reduced Air Traffic Flow Management (ATFM) delay

The challenge is to bring the stakeholders together. Over the years, the stakeholders have scattered around the Schiphol area, which makes it hard to implement the CDM approach easily. As a recommendation for Eindhoven Airbase, all stakeholders regarding these operations keep working close with each other. This may reduce human error and increase the predictability of handling processes.

Rijksvastgoedbedrijf

Rijksvastgoedbedrijf (RVB) is a governmental company for real estate as airbases and Ministery of Defence areas. The company formulates visions and policies and provides management and maintenance, purchase and sale, construction, renovation and (re)development of real estate (Rijksvastgoedbedrijf, 2017).

Part of the vision of RVB is 'sustainability and energy'. After 2018, new buildings need to be energy neutral. Next to that, RVB needs to reuse raw- or recycled materials regarding new constructions or redevelopments of real estate. Redesigning the airside of Eindhoven Airbase needs to fulfil the requirements of RVB.

The stakeholders, involving the approval of a new lay-out of Eindhoven Airbase, are (RVB, 2017):

- CLSK
- HDB
- DOSCO
- RVB

Teuge- and Twente Airbase

Teuge- and Twente Airbase will test a Digital Remote Tower. A digital tower provides everything a normal tower does, despite being several million pounds cheaper (NATS, 2018). In appendix D the elements of the Digital Remote Tower are shown. It keeps small airports open and it lets large airports expand (SAAB, 2017).

When the research of Twente Airbase in 2018 regarding the Digital Remote Tower is done, it is relevant to use the outcomes within Eindhoven Airbase, because currently Eindhoven Airbase is using an outdated Air Traffic Control Tower. In the past decades the electronic systems were updated in a never changing ICT infrastructure. Nowadays, the new Air Traffic Control technologies will not fit the outdated ICT infrastructure. The Digital Remote Tower only needs to be implemented, because it is already being used by several airports around the world. For this implementation the following stakeholders need to be taken into account:

- LVNL
- SAAB
- NLR
- CLSK

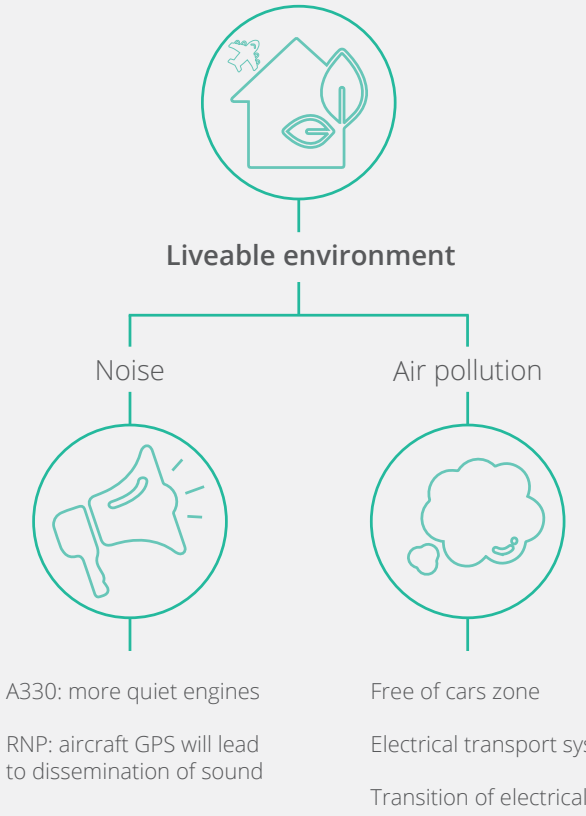


figure 20. Fundamentals for a liveable environement

In summary with the development of technologies and an increase of flights the coming years all stakeholders need to adapt to these changes. With the increase of flights, the communication between all stakeholders needs to be smoothed to lead the airport operations as efficient and safe as possible, because "human error" is one of the most frequent causes of aviation accidents (Boeing Commercial Airplanes, 2006). Human error is defined as an incorrect execution of a particular task, which then triggers a series of subsequent reactions in the execution of other tasks, resulting in a serious aircraft accident (Netjasov, 2008). With the technology developments regarding Unmanned Aircraft Systems (UAS), aviation regulations around the world also need to be updated to prepare for the era in which skies are increasingly shared by both manned and unmanned aircraft. The task becomes even more complicated if the UAS is autonomous, i.e., flying without a human at the controls. (Villasenor, 2014).

All of this means that the operations of all stakeholders need to adapt in a sustainable way. The stakeholders have to perform within a resilient system and maintain the international collaborations. Next to that, it is important to have an integrated vision with the municipality to connect the city and the airbase towards 2050 regarding the vision of Eindhoven city of being CO_2 neutral in 2050. Besides, Eindhoven Airbase needs to take into account that the municipality of Eindhoven and Noord-Brabant Provincial Authority are striving for a liveable environment around Eindhoven Airbase. Furthermore, the connection with Teuge- and Twente Airbase will be interesting for testing new equipment, which afterwards can be implemented within the Eindhoven Airbase operations. The other external stakeholders need to be involved in the transition of Eindhoven Airbase, because it needs their support and therefore they will play an important role in smoothly running the transition of Eindhoven Airbase.

Creating the future context of Eindhoven Airbase is strongly based on current developments and trends regarding the domain of sustainably operating at Eindhoven Airbase in 2050.

02.5 TRENDS & DEVELOPMENTS

Cross borders workers

Due to the affordable flight tickets, it became easy for people to work in a different country than where they live. The threshold has become low to go by plane, for some it feels the same as getting on a train. Sometimes a flight ticket is even cheaper than a train ticket (Keuchenius, 2017). When the infrastructure towards the airbase improves, it may result in more airport cities in the future, because of the development where traveling by plane becomes common.

On demand travelling

On demand is a serious trend at the moment and it is also popping up within the travel market. Previously, holidays were booked months in advance, but nowadays people often decide last-minute whether they go on holiday and where they want to go. Due to location-based technology, it is possible to order a taxi, reserve a car or book a private jet in your area via smartphones (Van Dijk, 2017). This trend will have an impact on the infrastructure towards the airbase and ad hoc operations at the airside, because of the new way of travelling.

Growth

Air transport is a key driver for social and economic development and its demand has increased steadily over the years. Since the mid-1980s, passenger numbers have more than doubled and freight traffic has increased almost three-fold (ATAG, 2005). This trend is expected to continue over the next 20 years, with world passenger traffic (by revenue passenger-kilometers) expected to grow 5% annually and air cargo (by revenue tonne-kilometers) 5.2% per year (Boeing, 2012).

Nowadays ticket prices are low, because of the lack of fuel tax on kerosene and ticket tax (de Koning, 2017). Due to the lack of these taxes, flight tickets are affordable for most people in Dutch society. As a result, the growth may find its way through.

As (civil) aviation expands, environmental aspects and fuel savings are becoming increasingly important. Amongst technologies proposed for more efficient flights, air-to-air refuelling (AAR), 'hopping' and flying in close formation (drag reduction), all have significant possibilities. In military use, AAR is virtually indispensable. Its benefits have been proven in hostile and demanding scenarios. By applying AAR in a civil context, overall savings, including the fuel used during the tanker missions, would be of the order of 30-40% fuel and 35-40% financial (Nangia, 2006).

In 2020 the government will determine a new number of flight movements and in 2023 the airspace will be revised. The new number of flight movements may facilitate the prospective growth, but this will ask a lot of the airport organisation.

Safety

From an operational perspective, airport surface operations require the interaction of five main stakeholders (airport authority (i.e. airport operator), pilot, air traffic control (ATC), ground handling, regulator) both to facilitate the ground movements of aircraft and vehicles, and to maintain the surface in working condition (figure 5). One key performance indicator (KPI) of such operations is safety, which can be defined as 'the state in which the possibility of harm to persons or the property damage is reduced to, and maintained at or below, an acceptable level through a continuous process of hazard identification and safety risk management' (ICAO, International Civil Aviation Organization, 2009). Because of the complexity of aircraft and related operations, the airport surface, however, has proven to be vulnerable and at risk of failure with the consequence that accidents and incidents may occur (Wilke, S. 2014).

The Royal Netherlands Air Force is, during execution of their operations, at continuous risk regarding:

- Flight safety
- A safe work environment for employees
- Ability to continue business operations
- Protection of nature and environment

A Safety Management System is necessary for the company, to fulfil the requirements of external authorities. This Safety Management System needs to result in:

- Full control of the safety within the business processes
- Understanding and managing safety risks
- Being in control of diverse safety compliances

The safety aspects will be identified early on regarding future risks by applying 'Management of Change' within the Safety Management System. As a result, the Air Force maintains the control of the internal processes (Koninklijke Luchtmacht, 2017).

Climate targets

Transport is the second largest polluting sector in the Netherlands. The emission within this sector has increased since 1990. Therefore the climate targets of the government apply strictly to the transport sector in the near future. It has been agreed internationally to limit the global temperature rise to 2°C compared to the temperature before the rise of the industry. The European Union goals for 2020 (i.e. 20-20-20 goals) are (Europa Nu, 2017):

1. 20% less CO_2 emission compared to 1990
2. 20% less energy consumption
3. 20% of the total energy usage needs to come from renewable energy, like wind- and solar energy.

The specific goals for the Netherlands, regarding the EU 2020 goals, are:

1. 15% reduction of greenhouse gas emission
2. 14% renewable energy of the total energy consumption

Regulations supporting the European Union goals for 2020 are:

- Revision of the carbon credit trade system
- To set up national goals to reduce emission by 10% regarding the sections that are not part of the carbon credit trade system
- New regulations for stimulating the collection and storage of CO_2
- 20% of renewable energy within the total EU energy consumption

The European Union goals for 2030 are:

1. 40% less CO_2 emission compared to 1990
2. 27% of the total energy usage needs to come from renewable energy, like wind- and solar energy.
3. 30% of energy efficiency improvement
4. 1,5% energy savings per year

The European Union goals for 2050 are:

1. 80% reduction of greenhouse gas emission

To conclude, the specific goal of renewable energy in the current system could be interesting to implement within Eindhoven Airbase.

Scarcity of resources

Many energy analysts label natural gas as a 'bridging' fuel to non-carbon green sources. However, Shell and others consider that natural gas will be a key energy source for many decades. Natural gas will certainly supplant coal, oil and nuclear energy in many markets (Pyke, 2012). Nowadays, renewables are limited by viability, scalability, suitability and low returns on investment as compared to fossil fuels (IBM, 2011). Changing towards these alternative green sources depends on new policies, where governments agree to reduce fossil fuel consumption through greenhouse gas emissions, and the phasing out of fossil fuel subsidies and global agreement is reached to reduce carbon emissions to below an atmospheric concentration ceiling of 450 ppm CO_2 by 2030, where 350 ppm CO_2 is safe (Pyke, 2012).

Besides considering a moderate economic growth and taking into account the established policy and autonomous improvement in technology, the energy demand can be 15% higher compared to the current energy demand. The energy demand can be reduced by 30% within all sectors towards 2050, with a powerful energy-saving policy, that needs to consist of expensive saving measures and needs to supplement a behavioural change (Energieonderzoek Centrum Nederland & Planbureau voor de Leefomgeving, 2011). An important factor is the adaptation of Eindhoven Airbase to the 'bridging' period, to easily change its operations according to the new policies and eventually change its way of transporting cargo and military personnel. Next to that, Eindhoven Airbase could generate their own energy to use for their operations.

Natural disasters

Since 1970, the number of disasters worldwide has more than quadrupled to around 400 events a year. Another dataset of less serious types of weather- and climate-related events, defined as causing at least one death or a set amount of monetary damage, shows an increase, too. By this measure, compiled by Munich Re, there are six times more hydrological events now than in 1980. The total of 2016 was the highest ever seen (Hoeppe, 2015; The Economist, 2017). Therefore, Eindhoven Airbase maintains relevance due to

their stategic and tactical air transport.

Sustainable energy solutions

The Royal Schiphol Group has announced that all of its business units are set to run on sustainable power from the beginning of 2018. The clean energy will supply Amsterdam Airport Schiphol, Rotterdam The Hague Airport, Eindhoven Airport and Lelystad Airport and amount to 220 gigawatt hours annually for the next 15 years (CNBC, 2017). The potential of gaining electricity from wind turbines, nuclear power plants and solar panels is enormous, but difficult to organise. When the energy demand shifts from fuel towards electricity (i.e. electrification), these sustainable energy solutions will offer the base for a new clean system. The risk of the clean electrical solutions, especially solar and wind, is the limited controllability of the offer. Offer- and demand curves will be more uniform and reliable, when electricity is exchangeable within a European electricity network. The realisation of a European electricity Network requires a strong cooperation with all European countries. The alternative is converting electricity surpluses to energy carriers as hydrogen or hydrocarbons (Planbureau voor de Leefomgeving, 2011).

Circular economy

An interesting opportunity, for the core processes at Eindhoven Airbase, is to close the loop within them. This will require a circular economy at Eindhoven Airbase, this means that the system is regenerative (figure 21). Currently a linear economic system is used, which is less sustainable compared to using a circular economy. Regarding the design challenge, Eindhoven Airbase needs to find a sustainable system towards 2050, even when there is no growth. Next to that, the municipality of Eindhoven is creating a circular economy, this creates the possibility to connect Eindhoven Airbase with the city.

Green aviation

Royal Aeronautical Society of U.K. has identified 25 new technologies, initiatives and operational improvements that may make air travel one of the greenest industries by 2050 (Agarwal, 2012). This list can be found in appendix F. The most relevant insights of this list, concerning transportation and the airbase environment, are given below.

Transportation

Civil aviation can learn from the military aviation regarding close formation flying and air-to-air refuelling of airliners. The close formation will help saving energy by using the slip-stream of other airplanes. Air-to-air refuelling could save up to 45% in fuel efficiency. Next to that, the development of the open-rotor engines could promise 30%+ breakthrough in fuel efficiency compared to current designs. By 2050, coupled with new airplane configurations, this could result in a total saving of 50% (Arcs, 2012; Agarwal, 2012). When using air-to-air refuelling in combination with the development of open-rotor engines, a shift in operations will take place at the airside of the airbase.

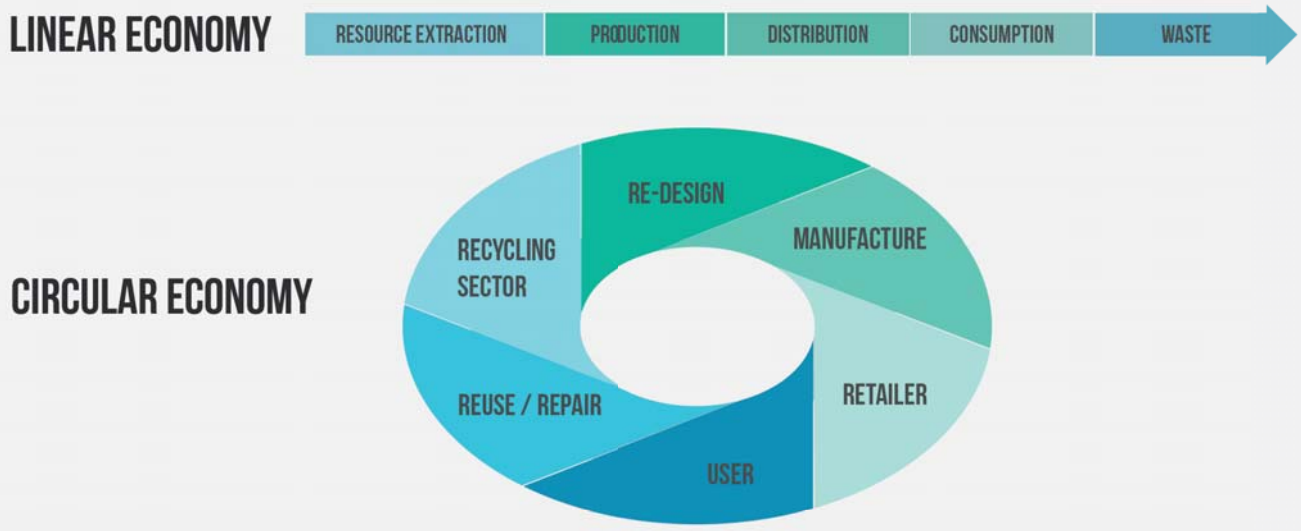


figure 21. Circular economy

Environment airbase

The increase of flight movements will put some pressure on the airbase environment. The technological development of more quiet aircraft will reduce some pressure, because research by Cambridge University and MIT has shown that an airliner with an imperceptible noise profile is possible, this will open up airport development and growth (Agarwal, 2012). Another environmental impact is the pollution from the airbase operations and emission of the aircraft. Use of electric, hybrid or hydrogen powered ground support vehicles at airports will reduce the carbon footprint and improve local air quality. Next to that, green airports of 2050 could draw their energy needs from wave, tidal, thermal, wind or solar power sources. Lastly, the future airports will connect passengers seamlessly and quickly to other destinations, by rail, Hyperloop, Maglev or water, encouraging them to leave cars at home. Leaving the cars at home will reduce the impact on the environment by decreasing the noise, traffic jams around the airbase and air pollution. The environmentally related burden of disease is caused in the Netherlands for nearly 90% by air pollution and noise (Gemeente Eindhoven, 2017). Therefore reduction of noise- and air pollution around the airbase is necessary for maintaining a healthy society.

New ways of transportation

Hyperloop is the concept of a fifth mode of transportation that is faster than commercial air travel, more energy efficient than train travel, and as accessible as a personal automobile (Musk, 2013) (Werner, 2016). To get the Hyperloop into the current infrastructure, it needs mass attention and support. It is a multi-billion-dollar infrastructure undertaking and the first megaproject funded via crowdsourcing (Hyperloop Transportation Technologies, 2014)(Urban, 2015). Hyperloop could be the new way of transporting cargo and passengers towards the airbase, which will reduce the noise of cars, traffic jams and air pollution. On the other side, it could also be the new way of transporting cargo instead of flying, because of the noise and air pollution of airplanes on the environment and it will save travel time.

Next to the Hyperloop, another project called SpaceX is showing a new effective and fast way of transportation. The great potential of passenger space travel for 'space commercialisation' has also been acknowledged in reports published by NASA (O'Neil, 1998); the American Institute of Aeronautics and Astronautics (AIAA) which concluded: "In light of its great potential, public space travel should be viewed as the next large, new area of commercial space activity" (Gerard, 1998)(Collins, 2002). This would change the airbase completely, in terms of the processes at the airside and the airbase infrastructure. Nowadays, an estimation of the total ozone depletion that can be attributed to humans caused by rocket launches is roughly 1 percent (Rastogi, 2009). It is hard to estimate the pollution of rockets when when space travel becomes more commercial in the near future. It will not be as sustainable as the hyperloop, but it will save travel time compared to traditional air transport.

Unmanned Aircraft Systems

We are rapidly moving toward a future in which a majority of aircraft will be unmanned. Unmanned Aircraft Systems (UAS), are poised to revolutionise the domestic aviation landscape, raising complex questions regarding privacy, property rights, and airspace safety. UAS can be used for search and rescue, news reporting, crop spraying, air quality monitoring, after-the-fact crime scene investigation, surveying, disaster response, wildlife tracking, research into the dynamics of violent storms, spotting wildfires, filmmaking, and traffic monitoring (Villasenor, 2014).

In the coming years, UAS will help save lives after natural disasters. UAS will help search-and-rescue teams to find lost hikers and allow police forces that cannot afford manned helicopters to obtain vital, potentially lifesaving, overhead imagery during hostage standoffs. When used safely and in a manner respecting privacy, domestic UAS can become important tools for private citizens, firefighters, scientists, news reporters, filmmakers, and others to more effectively observe the world around them. More broadly, the 21st century will, in many ways, be the century of robotics, and UAS will be an important part of that story. A strong robotics industry and thus a strong UAS industry will be an essential ingredient to economic competitiveness (Villasenor, 2014). In the case of Eindhoven Airbase, wildlife tracking, disaster response and traffic monitoring are important within the company's operations.

The UAS, as mentioned before, are electric battery-powered aircraft and already in service. As battery power improves one can expect to see battery-

powered light aircraft and small helicopters as well in 2050 (Agarwal, 2012). Scaling up the use of small drones from a niche market to widespread use in civilian applications depends on two related prerequisites: the capability to autonomously and safely manoeuvre in confined spaces and the removal of the legal requirement of supervised operation within the line of sight. There are almost no scientific or technological roadblocks to achieve higher levels of autonomous control in research and commercial drones within the next five years. However, the regulations need to be changed to facilitate this technological development, it will depend on the reliability and safety of small drones in the future (Floreano, 2015).

Transition towards electrical aircraft

A new trend is the development of the electrical aircraft, where Zunum Aero, the Boeing and JetBlue-backed hybrid-electric aviation start up, just set a delivery date for its first next-gen airplanes: 2022 (Williams, 2017). Zunum's hybrid-electric aircraft promises door-to-door air travel, flying quietly and enconomically friendly to thousands of underused local airfields and bypassing more inefficient and often congested larger airports. The initial concept will be able to carry 12 passengers up to 700 miles, but it has been designed with scalability in mind. The idea is to develop a family of aircraft of increasingly larger size and longer range. Although it starts as a hybrid, its design allows for a smooth transition to full electrical propulsion when new battery technology becomes available (CNN travel, 2017).

Besides, EasyJet could be flying planes powered by batteries rather than petroleum to travel short-haul routes such as London to Paris and Amsterdam within a decade (The guardian, 2017). As earlier mentioned the fossil fuels will be determined over time, therefore this development is important for the new infrastructure and way of transporting at Eindhoven Airbase 2050. Within thirty years from now, a smooth transition of conventional airplanes towards electrical aircraft needs to be made.

Autonomous technologies

Aviation offers many possibilities when it comes to autonomous technologies. They could be applied in different areas of the airport operations, like drones (Floreano, 2015), GPS controlled aircraft, refuelling- and cargo-loading machines. All these autonomous technologies will reduce conventional jobs, because there is no need for human interaction anymore. According to McKinsey, automation will result in new adaptive jobs. In the future, adaptability is key, and people are more adaptable. So when they set up the machine line and it is all machines, there is a huge amount of retooling to shift from line one to line two, whereas the people are much easier to shift (McKinsey, 2014).

Cyber

Together with the digitalisation, and therefore automation, the chance of cybercrime will increase. According to Dijkhoff, the government needs to invest more in the digital resilience. "The past years, structurally more money was made available in the budget of the Ministry of Security and Justice to strengthen cybersecurity. For example, public-private partnerships have been strengthened and the approach to cybercrime and the detection of digital threats have been intensified. With an eye on the worrisome picture of 2017, these actions and investments remain extremely necessary." (Dijkhoff, 2017).

In summary the increase of natural disasters will give the Royal Netherlands Air Force, and therefore Eindhoven Airbase, more work in the future. Next to that, Eindhoven Airbase needs to adapt to the bridging period, where electrification of their operations is required. An important opportunity is implementing the electrification in a circular economy, which can result in a self-sustaining system at the airbase. A self-sustaining system is a big difference compared to the conventional system and therefore a profound and long-term transition needs to be made. Development processes of innovative technologies will cover decades. In addition, it takes a lot of time to replace existing products and processes with new ones and to set up the corresponding production chains and infrastructure. Regarding the return on investment, companies are strongly dependent on each other and that will result in incremental steps and a more cautious approach. A period of thirty years for the transition to a new energy system is difficult and complicated, but necessary for Eindhoven Airbase to be prepared for the future, to react on events and to be adaptive in times of need.

Furthermore, the new developments will need adequate transitions towards 2050. The military transport will depend more on drones and the conventional civil air transportation will change to an on demand service. New ways of transportation such as hyperloop will save time, costs, noise and emission concerning the European destinations. Smaller electric (unmanned) aircraft could provide intercontinental flights. This future context results in an infrastructural change towards and within Eindhoven Airbase, where Eindhoven Airbase will be a major junction, and therefore an important connection of international and national transport through the air and via land. The analysis brought up four themes, namely connectivity, automation, electrification and liveability. These themes will be implemented in the context vision.


VIS


ION

03. VISION

Previous research provided a lot of starting points, which were translated to the most relevant context factors (appendix G). Next step is to think about which factors support the context the most and to what extent personal motives, interests or intuition play a part. Moreover, the where and how to involve the mission of the client and developments in the market are considered.

03.1 CONTEXT VISION 2050

Context factors

The context factors are clustered until interesting patterns, a storyline or conflicts are found. The goal is to develop a clear and consistent picture of the future world of the stated domain. This reveals opportunities to contribute to or change things in this future world (Hekkert & van Dijk, 2011).

In figure 23 in depth information is given about the process leading towards the context vision. This flow chart illustrates the example of the interesting topic *'Becoming a transport city'*.

Starting with clustering the context factors to named clusters provides different insights. These insights within the clusters were the start of identifying links, clashes and patterns. These clusters were grouped and translated to interesting topics, when needed a deepening research was done regarding the interesting topics. In appendix H all clusters of the context factors and the interesting topics are listed.

Analogy

The first step after grouping the clusters into interesting topics is distributing the interesting topics along different axes. Each quadrant of this axial system provides an analogy. This analogy is translated to a strategic direction, which is the starting point for defining the context vision.

The axes were divided into human interaction versus automation and connectivity versus independence (figure 24). Different combinations of axial systems were evaluated and can be found in appendix I, together with all created analogies of the chosen axial system.

Automation

According to the trends and developments automation will become more and more important for the operations of Eindhoven Airbase. The operations can be applied to different areas, namely infrastructure towards the airbase, aircraft ground handling, coordinating airport operations and operations at the airside.

Connectivity

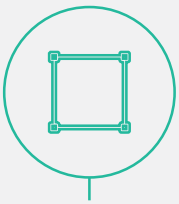
Another interesting topic supporting the future context is connectivity. Connectivity can be found in different areas like international collaboration, (inter)national junction, data-driven airport operations and circular processes. In short, this means the internal – and external connection of Eindhoven Airbase on different levels.

Regarding the axial system of automation and connectivity each quadrant can provide an analogy. The combination of the quadrant of connectivity and automation gives the analogy of:

"Go with the mutual flow"

The analogy is the start of a strategic direction, which can be interpreted as the mutual connection within automated operations at the airside. This analogy is illustrated in figure 22 and can result in resilient and sustainable operations and will benefit both companies.

figure 22. Illustration of the strategic direction "Go with the mutual flow"



DOMAIN

Sustainably operating at Eindhoven Airbase in 2050

INTERNAL- AND EXTERNAL ANALYSIS

Includes field-, literature- and desktop research

CONTEXT FACTORS

Context factors are a result of the analysis. Links, patterns and clashes of different context factors were turned into clusters. Below an example of these clusters is given (appendix H). The combination of these clusters created the interesting topic of "Becoming a transport city".

FUTURE TRANSPORT

The KDC-10s will be replaced in 2020 within the European MRTT project, according to Jeroen van der Lely project leader at Eindhoven Airbase of the MRTT project.

Hyperloop is the concept of a fifth mode of transportation that was faster than commercial air travel, more energy efficient than train travel, and as accessible as a personal automobile touched a nerve (Musk, 2013).

Multi-modal airports - Future airports will connect passengers seamlessly and quickly with other destinations, by rail, Maglev or water, encouraging them to leave cars at home.

INTERNATIONAL SUSTAINABLE SYNERGY

When Current Ops can only fill half a flight, they will see if they can co-operate with international partners to transport more goods with one flight. Current Ops get points every time they fly more efficient by preventing "empty" flights. Next time Current Ops can arrange that the partner will transport the cargo, so there will be a balance in points. This will save money, time, employees for the flight crew, fuel and emission.

As (civil) aviation expands, environmental aspects and fuel savings are becoming increasingly important. Amongst technologies proposed for more efficient flight, air-to-air refuelling (AAR), 'hopping' and flying in close formation (drag reduction), all have significant possibilities. In military use, AAR is virtually indispensable. Its benefits are real and largely proven in hostile and demanding scenarios. By applying AAR in a civil context overall savings, including the fuel used during the tanker missions, would be of the order of 30-40% fuel and 35-40% financial (Nangia, 2006).

ACTIVITY TRANSITION TOWARDS AIR

Close formation flying - Using GPS systems to fly close together allows airliners to exploit the same technique as migrating bird flocks, using the slip-stream to save energy.

Air-to-air refueling of airliners - Using short range airliners on long-haul routes, with automated air-to-air refueling could save up to 45% in fuel efficiency.

Eindhoven Airbase provides strategic and tactical air transport and air-to-air refuelling to other aircraft.

"Becoming a transport city"

INTERESTING TOPICS

The clusters were grouped and translated into interesting topics.

ANALOGIES

The interesting topics were distributed according to different axes. Each quadrant of the axial system provides a strategic direction, the most relevant strategic direction consists of the following interesting main topics.

INFRASTRUCTURE TOWARDS AIRPORT CITY

BECOMING A TRANSPORT CITY

CONNECT LOGISTIC TRANSPORT SYSTEM

VISION EINDHOVEN AIRBASE 2050

figure 23. Strategic design process: "Translating the analysis into a context vision"

It will create the connection with (inter)national junctions, shared operations and –coordination and supports both companies in adapting to future developments.

The interesting topics within this strategic direction are:

- Infrastructure towards airport city
- Becoming a transport city
- Connect logistic transport system

An explanation of each topic can be found in figure 25.

As earlier mentioned the combined internal- and external analysis brought up four themes, namely connectivity, automation, electrification and liveability, which is included in the strategic direction. All of this was formed into the following context vision (figure 27):

"Eindhoven Airbase needs to mutually operate as the first self-sustaining transport city in the world in 2050."

An explanation of the three elements from the vision are explained below.

Mutually operating
Mutually operating can be explained as combined coordination and operations with benefits both companies.

Self-sustaining
Self-sustaining contains adaptive and circular operations within the airbase. It provides the support of adapting to future developments and fast changes.

Transport city
Transport city can be seen as a junction of seamless and resilient transport around and towards the airbase, which provide a connection of air- and land transport.

The context vision will be translated to a product-service system, which consist of an interaction with the product and product qualities.

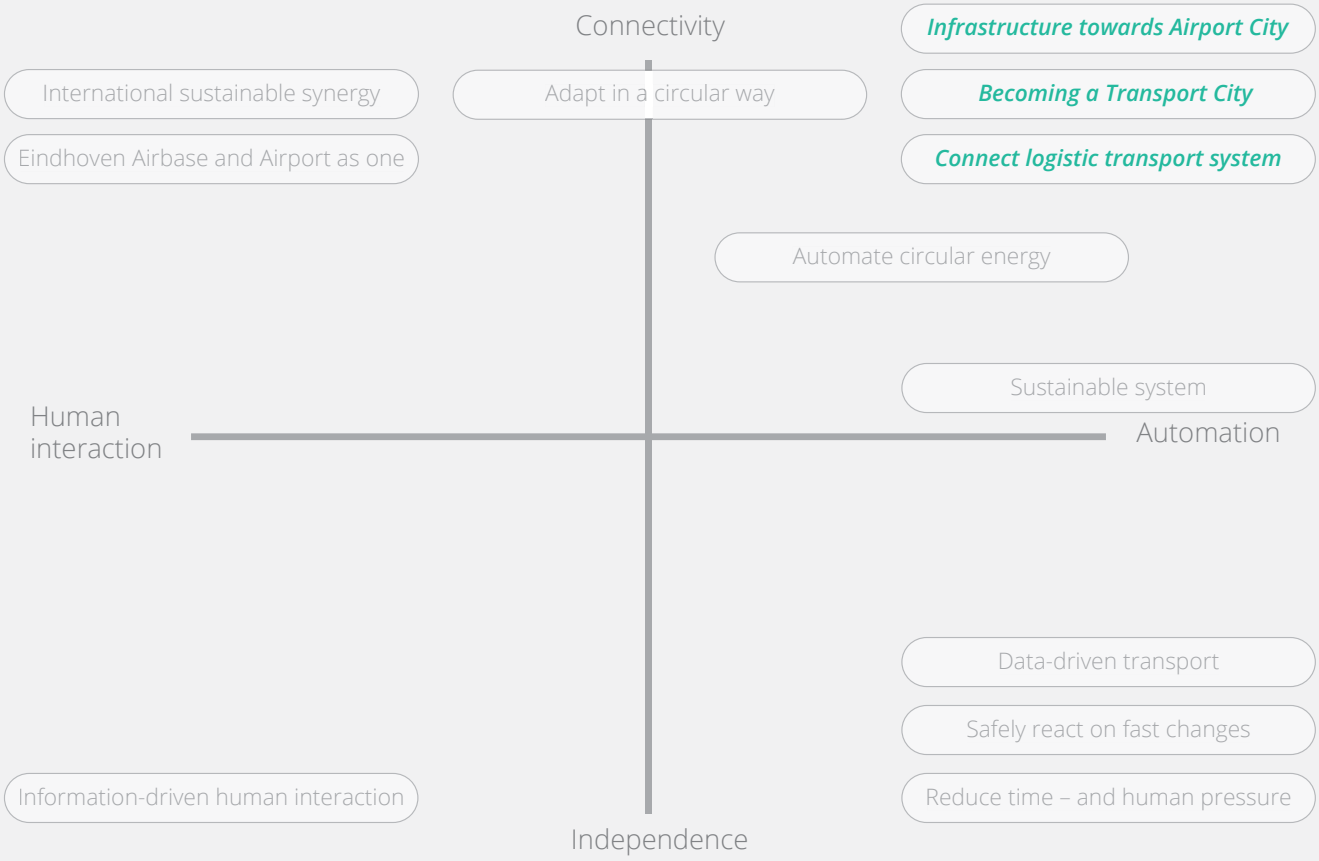


figure 24. Analogy axes a combination of automation and connectivity

Infrastructure towards airport city

The complexity of aircraft - and related operations have proven to be vulnerable and at risk of failure with the consequence that accidents and incidents may occur (Wilke, S. 2014). Taking into account the technology developments regarding Unmanned Aircraft Systems (UAS), aviation regulations around the world need also being updated to prepare for the era in which skies are increasingly shared by both manned and unmanned aircraft. The task becomes even more complicated if the UAS is autonomous, i.e., flying without a human at the controls (Villasenor, 2014). Next to that, it is important to facilitate ground transport which will have a positive impact on the environment by being fast, seamless, silent and non-polluting, such as Hyperloop. Important is to create the infrastructure to support this technological development towards 2050. With a strong connection and good collaboration the support of the environment regarding their ambition towards the prospective growth will be stable (Eindhoven Airport, 2016).

Becoming a transport city

The current traffic situation around the airbase is chaotic, with a lot of traffic jams. Next to that the airbase is not easy to reach via public transport. A development in terms of transportation is the Hyperloop. Hyperloop is the concept of a fifth mode of transportation that is faster than commercial air travel, more energy efficient than train travel, and as accessible as a personal automobile (Musk, 2013). The new ways of transportion will not replace the air transport activities of the Royal Netherlands Air Force, because some places are only accessible by plane. Next to a better infrastructure towards the airbase, the development of more quiet airplanes is also relevant, this creates the possibility to live closer to the airport.

As a result of the MRTT project, Eindhoven Airbase can become an international hub where all participating countries connect and it can establish a strong international collaboration. This can be combined with using air-to-air refuelling (AAR) in the civil sector, where Eindhoven Airbase can create a shared service for providing fuel in the air. By applying AAR in a civil context overall savings, including the fuel used during the tanker missions, would be of the order of 30-40% fuel and 35-40% financial (Nangia, 2006).

Connect logistic transport system

Eindhoven Airport is open for a collaboration to create a strong connection. Furthermore the developments of automation, electrification and integration are high. Next to that, the world is rapidly moving toward a future in which a majority of aircraft will be unmanned. Unmanned Aircraft Systems are poised to revolutionise the domestic aviation landscape, raising complex questions regarding privacy, property rights, and airspace safety. Therefore, Unmanned (electric) Aircraft Systems can become the new way of transporting within and around the airbase.

figure 25. Description of the main interesting topics of the chosen strategic direction

The interaction of the product-service system is formulated as:

"The interaction with the product-service system is like operating in an infinite loop."

The interaction is illustrated in figure 26.
The product-service system has the following product qualities:

"The product-service system is seamless and resilient."

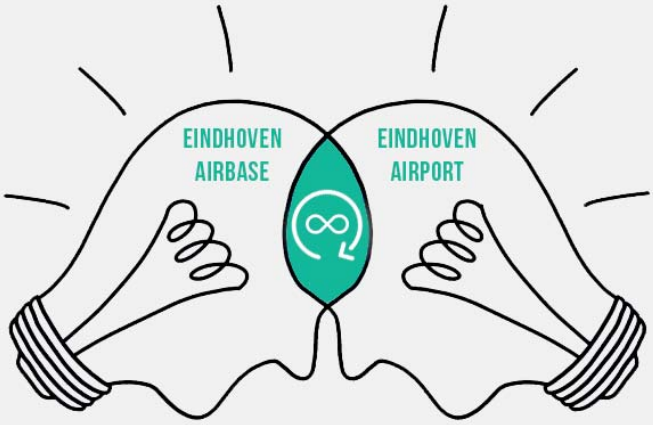


figure 26. Interaction vision of the product-service system

Seamless
The concept always needs to run as smoothly as possible. External factors cannot have a negative influence on the system, but can contribute to improve the system. Automation and connectivity can support the seamless product-service system by means of replacing human interaction, which will speed up and smoothly run operations.

Resilient
Next to a seamless product-service system, the system needs to handle pressure in times of need. The pressure could be in the form of growth of civil flight movements, increase of global threats and therefore an increase of tension in the world. Therefore the product-service system needs to be resilient to easily adapt to these changes.

In summary, the starting point of the ideation- and conceptualisation phase is the context vision with associated interaction and qualities of the product-service system.

Context vision:

"Eindhoven Airbase needs to mutually operate as the first self-sustaining transport city in the world in 2050."

Interaction of product-service system:

"The interaction with the product-service system is like operating in an infinite loop."

Qualities of the product-service system:

"The product-service system is seamless and resilient."

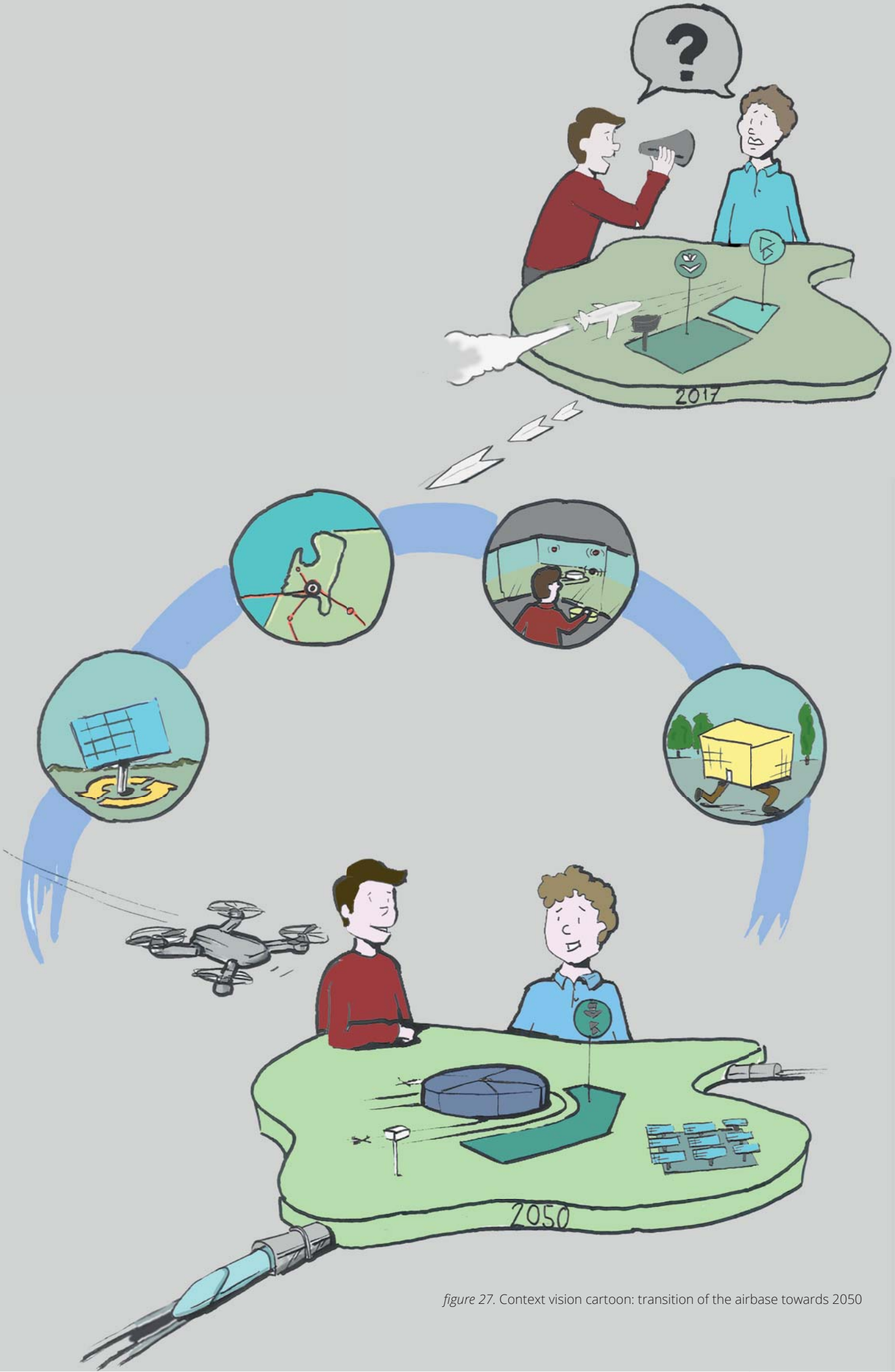


figure 27. Context vision cartoon: transition of the airbase towards 2050

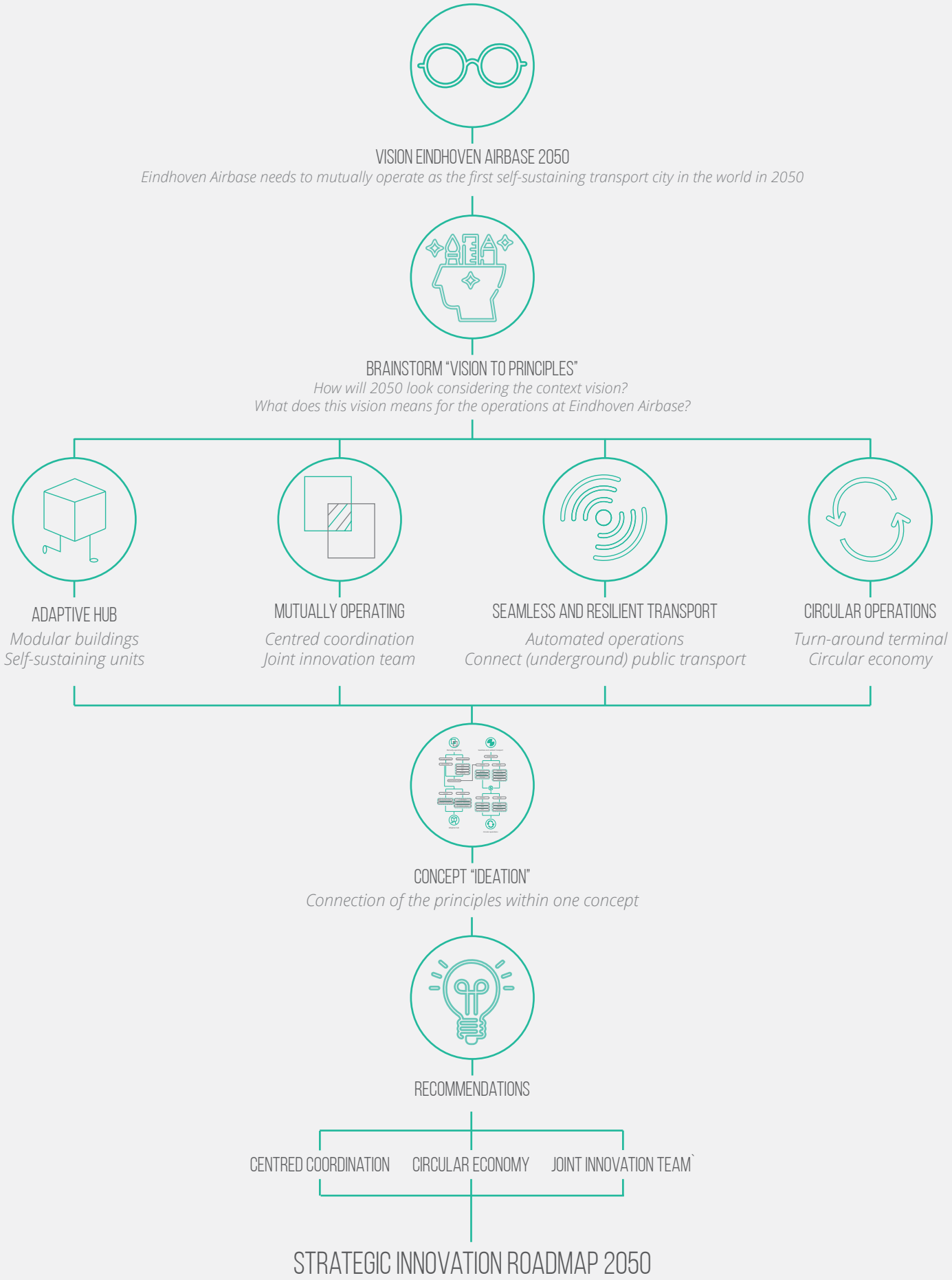


figure 28. Strategic design process: "Translating the context vision into product-service systems"

Translating the context vision into a product-service system consists of serveral ideation steps (figure 28). Starting with a general brainstorm about how will the airbase look considering the context vision of 2050. *This brainstorm provided the four key principles, which were the start of a second brainstorm. This brainstorm provided different ideas per key principle. A third brainstorm created a concept combining several ideas from the key principles.*

03.2 CONCEPTUALISATION

Ideation

The context vision consists of four key principles, where the airbase needs to be an **adaptive hub**, internationally connected and adaptive within the organisation, where the airbase could be used by all units of Ministery of Defence. And where Eindhoven Airport and Eindhoven Airbase will be **mutually operating** at the airbase, so they can give growth a direction together, reduce human error and replace human interacted operations by automation. The airbase needs to have **circular operations**, to achieve environmental challenges. Next to that **seamless and resilient transport** around the airbase is necessary to become an (inter)national junction (appendix J).

The principles are based on literature-, desktop- and field research. This provides a strong base of inspiration to start with. The principles are the foundation of the final roadmap and will accomplish the context vision.

The concept

The connection of the four principles is the foundation of the concept. The concept was built on a ideation phase, which can be found in appendix K. This second brainstrom gave four interesting elements linked to the principles of the context vision. The four elements are:

1. Circular economy
2. European (electric) network
3. Centred coordination
4. Centred operations

As a result, the principles are integrated within the concept. The principles are linked with the the four elements within this concept (figure 29). The concept is explained below.

Mutually operating

Mutually operating can be divided in two segments, namely coordination and operations. Both can be centralised, thus the core processes of Eindhoven Airbase and Eindhoven Airport can be connected. This will improve and optimise the core processes, guarantee safety by reducing human error and will facilitate the resilient transport system.

Adaptive hub

In times of peak loads the airbase must be able to resiliently adapt and adjust. The airbase must ensure that it constantly is one step ahead with regard to disruptive innovations, by means of an adaptive way of working. This can be made possible by a shared innovation team between Eindhoven Airbase and – Airport. In addition, relevant companies must be attracted towards the environment around the airbase. This will enrich the airbase with the right knowledge, leading to the establishment of disruptive innovation. Thence the airbase can work adaptively and resiliently by being able to test and execute immediately. Furthermore, the airbase can be a hub for international collaborations and other branches of the armed forces to enable performing relevant operations.

Circular operations

In the future all operations should be circular in the way of running on (a)biotic materials instead of raw materials, like electric energy instead of fuel. The operations need to be flexible, so they can react to external factors and adapt to growth when needed. Over time the operations within the field of Eindhoven Airbase will be automated, electrified and data-driven. The energy source, such as solar and wind energy, will be found in the field itself. Next to that different heat sources (i.e. runway) can be used, more precisely this heat can be stored and used when necessary.

In summary the energy will be produced, used and stored in the field. Storage is required for use during peak loads. In addition, co-developers will be added to the airbase so that (parts of) aircraft can be disassembled, repaired and/or recycled on site, consequently a circular economy can develop around the airbase.

Seamless and resilient transport

Reducing the impact on the external environment of the airbase by transporting in a seamless and efficient way around the airbase can lead to becoming an international hub. Both the internal and external connection must seamlessly connect, where automation of operations is central, but also the infrastructure towards the airbase needs to run smoothly concerning the

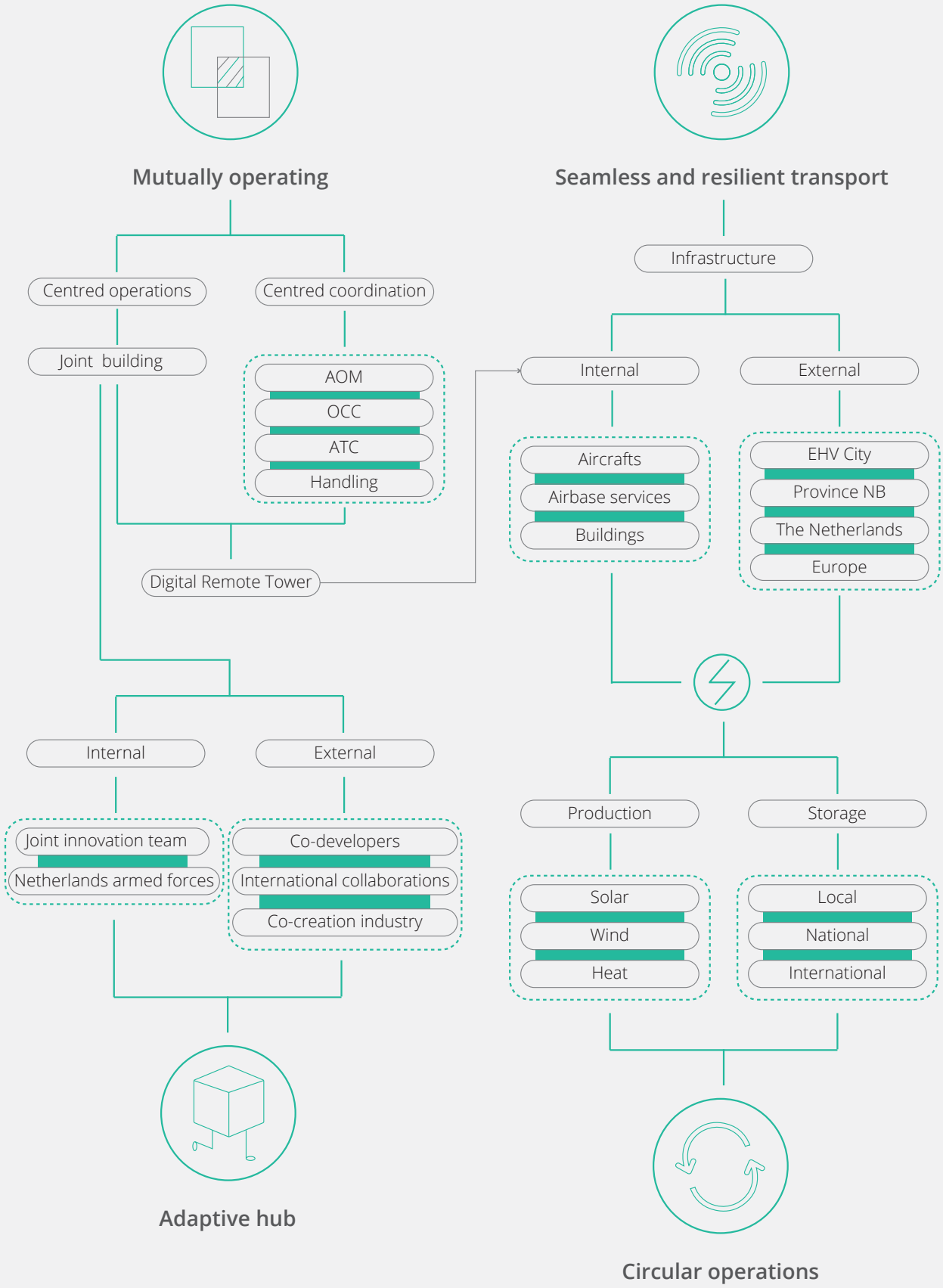


figure 29. Final concept as a result of the context vision

external environment. For example, the airbase together with the city of Eindhoven can become an important junction in terms of knowledge, sustainability and transport. Additionally both will be nationally and internationally oriented.

Evaluation of the concept

An evaluation of the concept was done during an "Eindhoven in Beweging" session. In this session sixteen participants, with manager roles at Eindhoven Airbase participated. Firstly, the vision of Eindhoven Airbase 2050 was explained to the managers. Then the managers were asked to create, in teams of four, a mindmap and/or sketch of *what their ideal world would look like in 2050 regarding the airbase* (appendix L). After creating the ideal world, the managers were asked to find bottlenecks on the way to 2050. Afterwards the bottlenecks were evaluated, two bottlenecks were translated into an opportunity and were eventually included in the concept. These bottlenecks are the level of adaptivity within the organisation and the mindset of the managers concerning the mutual operations with Eindhoven Airport and will be explained below.

Level of adaptivity within the organisation

During the creative session, the managers experienced limitations concerning the level of adaptivity within the organisation. The managers see the value of adaptivity and are open to change, but are not always able to get their ideas upward. Therefore a joint innovation team, with Eindhoven Airport, can be added to the concept. Besides a joint innovation team delivers new ideas for the operations, the ideas can be tested and implemented directly from the centred coordination point. Therefore, the system is always up-to-date and enables adaptive action.

Mindset mutual operations

Besides adaptivity, mutual operations were discussed during the session. In this case, the managers are open for centred coordination and – operations and do not see any limitations regarding the coordination. The only requirement is to make arrangements with Eindhoven Airport. Therefore it is important to set strict rules when the situation asks for it, military interests precedence over commercial interests when needed and vice versa.

The system

The concept will be translated to a strategic innovation roadmap. This roadmap will be suited for three stakeholders, namely Eindhoven Airbase, Eindhoven Airport and the municipality of Eindhoven. This system of stakeholders encloses three boundaries, namely knowledge, transport and sustainability (figure 30). These core principles are translated to strategic directions. These strategic directions can be found in chapter 04 *Roadmap*.

figure 30. The boundaries of the system the final concept will be placed in

STRATEGIC INNOVATION ROADMAP


2050

04. STRATEGIC INNOVATION ROADMAP

As figure 28 shows, the concept was translated to three recommendations. The three recommandations fit the stated system of Eindhoven Airbase, -Airport and -city (figure 30) and are aligned with the strategic directions resulting from the system. These directions are evaluated in a strategic innovation roadmap. Likewise each recommendation is implemented within the roadmap and also has a more specified timeline for 2018.

04.1 ROADMAP

Regarding the design challenge of the sub-optimal operations, the prospective growth and with that maintaining safety and a liveable environment, the research question for the design challenge was:

"How can Eindhoven Airbase create sustainable operations towards 2050?"

The research question can be answered by implementing the following vision:

"Eindhoven Airbase needs to mutually operate as the first self-sustaining transport city in the world in 2050."

The vision is turned into a system consisting of four principles, namely mutually operating, being an adaptive hub, creating circular operations and connecting seamless and resilient transport.

The system is implemented in a strategic innovation roadmap towards 2050. This roadmap is attached to this report. The three boundaries, knowledge, transport and sustainability (figure 30) in combination with the concept, were translated to strategic directions. The strategic directions are:

- Creating a strong position within a co-creation industry
- Strengthening the transport infrastructure within the system
- Establishing a sustainable system

These directions consist of needs. To fulfil these needs, the actions Eindhoven Airbase has to take are stated in this roadmap. The strategic directions are explained below.

Creating a strong position within a co-creation industry

Within this strategic direction, Eindhoven Airbase has to build long-term strategic relationships with the external environment, which will result in environmental, social and economic agreements.
To meet these needs, two main actions has to be taken by Eindhoven Airbase. Firstly they have to connect with Eindhoven Airport. Secondly Eindhoven Airbase needs to attract co-developers to the airbase, which can provide the transition of electrification, automation and connectivity. These actions also need to focus on the internal employees to facilitate adaptivity in internal processes.

Strengthening the transport infrastructure within system

Strengthening of the transport infrastructure within the system is necessary to align strategic infrastructure developments with future needs to be innovative, adaptable and ready for future changes.
Eindhoven Airbase will have to improve and connect their infrastructure around the airbase with Eindhoven city. As a result the connection with a European network can be created. Due to this, Eindhoven Airbase will establish a linked and combined air- and land transport system. This connected transport system will facilitate the attraction of relevant stakeholders, which can be linked to the network of co-developers around the airbase, resulting in a loop of aircraft and materials with suppliers and experts around the airbase.

Establishing a sustainable system

The last strategic direction, establishing a sustainable system, will align strategic goals and aspirations with sustainable business practice and support of the local community by engaging them in the process for maintaining a liveable environment. Eindhoven Airbase will achieve this by improving the electric infrastructure in current operations at the airbase. After improving this infrastructure it has to connect with Eindhoven city, so a shared electric network can be created.

To collaterally improve the electric infrastructure, the development of energy generation at the airbase needs to expand and implement usage in current operations. Furthermore, the airbase has to keep upgrading the system with renewables. This includes creating an automated and connected electrical system. As a result the system at the airbase will be self-sustaining, this can be connected to the loop of materials linked with the co-developers. Considering the mutual operations, this creates a self-sustaining circular economy connected to the external environment, which can fulfil the vision of 2050.

04.2 CONCLUSION

Valuable design

The concept fulfils the desirability of the company and its employees, the viability within the business approach and feasibility regarding technological innovations. In this case the employees desire the increase of adaptivity and optimisation of the operations at the airside. The concept is supporting the business case of the Royal Netherlands Air Force of striving to be an adaptive organisation by connecting the airbase with Eindhoven Airport and -city, but it also facilitates the possibilities for strong international collaborations. Adapting to technology developments will support the concept towards 2050. However, this will only be feasible when Eindhoven Airbase slightly adjusts its coordination and operations in collaboration with Eindhoven Airport.

It is important to communicate the value of the concept (appendix E) for Eindhoven Airbase to its most important stakeholders like Eindhoven Airport, Eindhoven city, the provincial authority Noord-Brabant and internally to the staff of the Royal Netherlands Air Force. In figure 31 the value, key activities, -partners and -resources of Eindhoven Airbase are given. Also, the value of the design for Eindhoven Airport and Eindhoven city can be found in figure 31.

People, planet and profit

EIndhoven Airbase needs to take into account people, planet and profit. These three elements are key to succeed in the future. Integration of these three elements within the concept will create sustainable developments and will make the concept feasible towards 2050 (figure 32). The concept creates new ways to support profitable growth and it positively connects capitalism and environmental issues. Next to that, the concept creates a competitive advantage by including social and environmental issues in the operations. Rethinking, reframing and reinventing the core processes of Eindhoven Airbase created and will support this future world (Fisk, 2010).

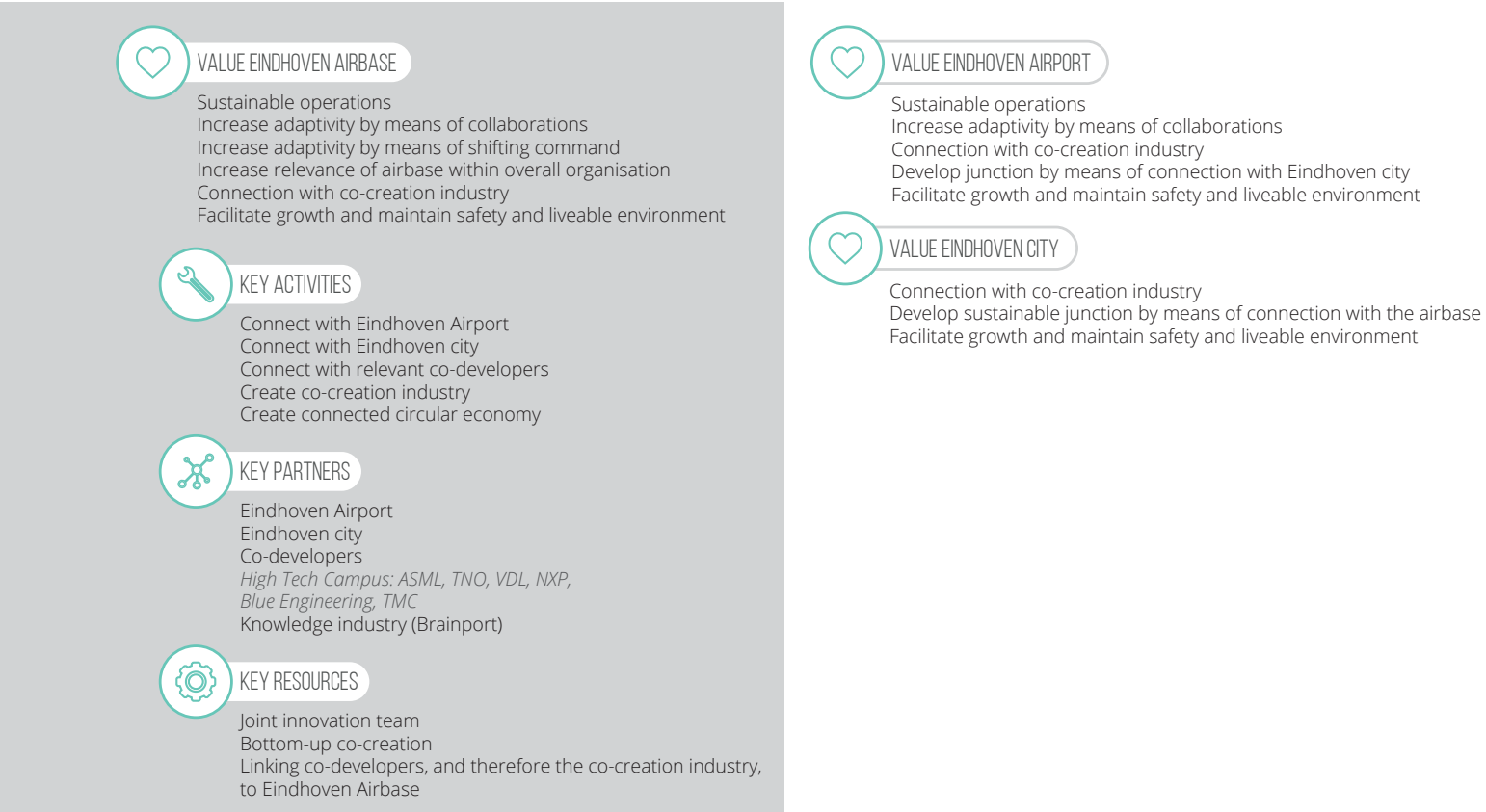


figure 31. Value proposition of Eindhoven Airbase, - Airport and - city

Bearable environment
Mutual- and circular operations in combination with resilient and seamless transport will provide and maintain a bearable internal– and external environment by connecting all stakeholders within the system (figure 32). A bearable environment can be achieved by reducing noise and decreasing the emission of the transport systems which will result in maintaining a healthy society.

Economic sustainable environment
Eindhoven Airbase needs to build long-term strategic relationships with relevant stakeholders, such as co-developers. Connecting the airbase with relevant co-developers around it will support creating a circular economy within the system. Combining this connection with the mutual – and circular operations concerning the automation, connectivity and electrification transitions will support the circular economy towards 2050. Besides the industry around the airbase could get a boost by connecting their operations with the airbase.

Equitable environment
It is important to provide the employees at the airbase with the opportunity of working in an adaptive way. This can lead to economic benefits, by reducing time for defining, testing and implementing new (product-service) systems. Next to that, by connecting the external environment with the airbase, a liveable environment can be created with the nearby society and investing in local community initiatives is key in providing environmental, social and economic outcomes.

04.3 RECOMMENDATIONS

The concept gave an overview of how the connection with Eindhoven Airbase, -Airport and –city could work. This chapter gives an overview of three recommendations. These can give a more concrete view on what the possibilities of implementing some ideas in this concept system could be within the airbase.

Centred coordination

Figure 33 shows a set-up of the centred coordination when Eindhoven Airbase and -Airport will be mutually operating. The centred coordination consists of ATC, AOM, Handling and OCC. Where ATC and handling can be outsourced and OCC will have a close connection with EATC and a joint innovation team. As earlier mentioned mutually operating of the airbase and airport will decrease human error and the amount of employees needed for certain tasks. It will increase adaptivity and it will save money in the end. In addition, it will prevent the fragmentation of the operations during growth. Eindhoven Airbase will be leading this centred coordination, because they can run both military- and civil operations. When necessary Eindhoven Airbase is able to take action easily. The first step Eindhoven Airbase has to take is establishing regulation concerning finances and task devision of both companies.

Joint innovation team

In figure 34 an example of the possible way of working for a joint innovation team is given. The joint innovation team is the follow-up of the joint implementation team. This implementation team will provide the implementation of the strategic innovation roadmap within the organisation. After

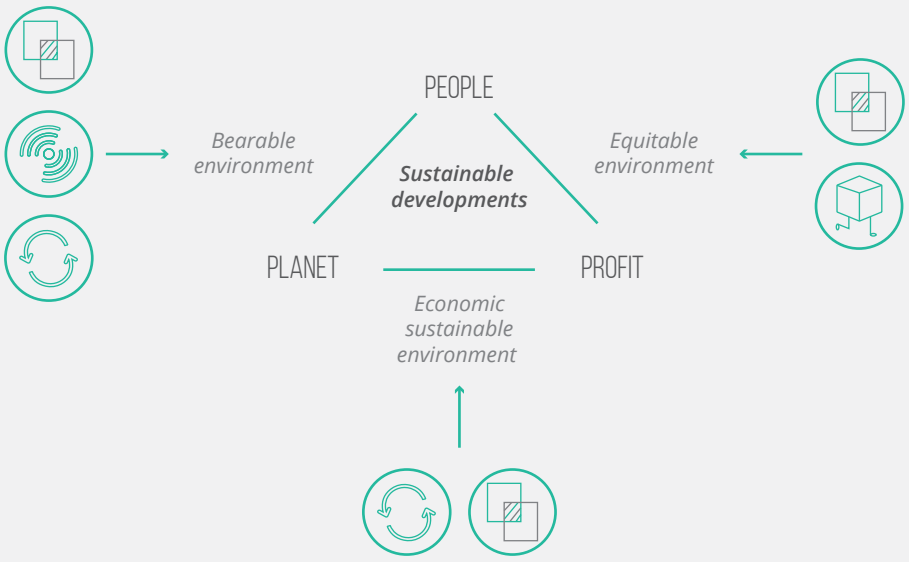
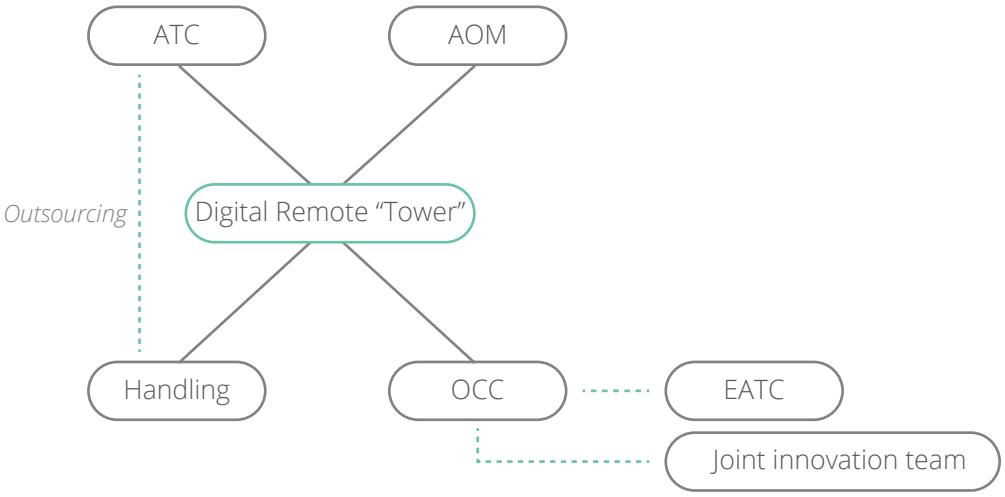


figure 32. People, planet and profit connected with the concept fundamentals



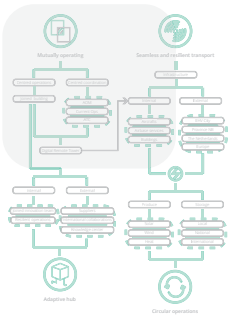
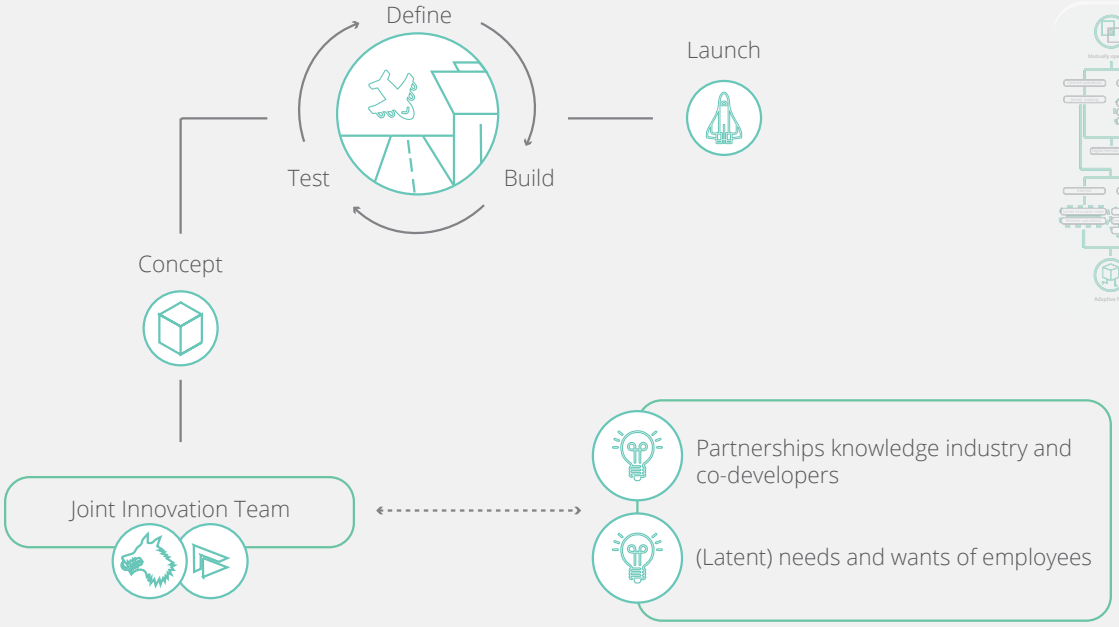


figure 33. Centred coordination



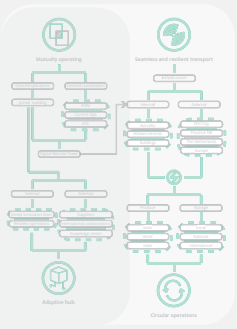
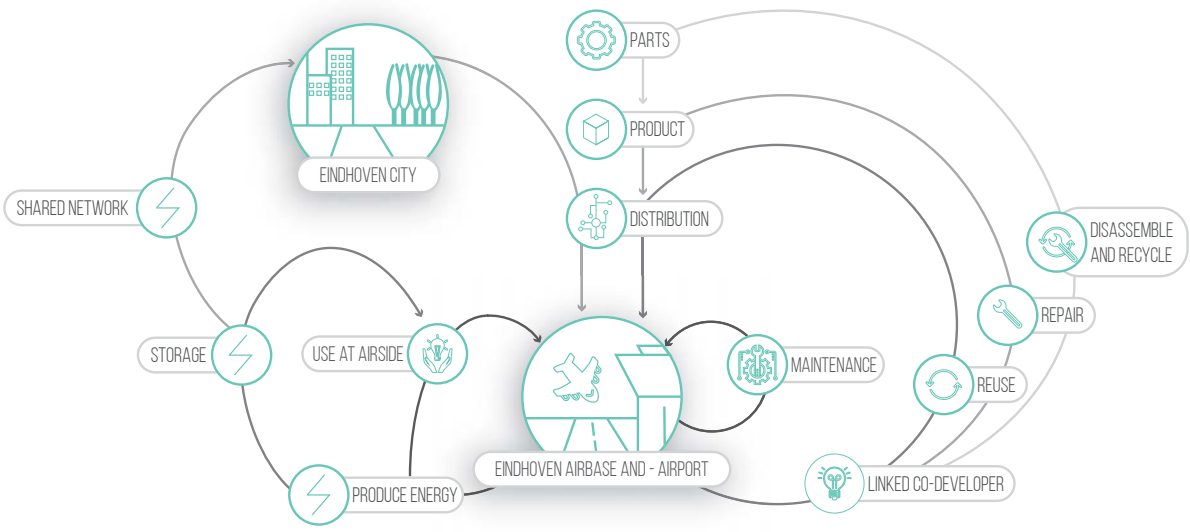


figure 34. Joint innovation team



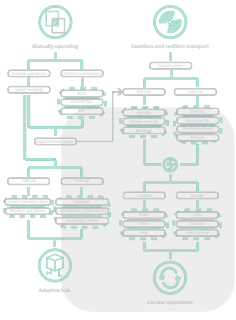


figure 35. Circular economy

implementing the strategic directions by the joint implementation team, the joint innovation team will take over. This team can increase the adaptivity at Eindhoven Airbase and create the connection with the nearby co-developers, which keeps the airbase up-to-date and creates a co-creation industry together with the external environment. Next to that, this team will be operating at the airside and is therefore close to the needs of all employees on that site. A joint innovation team supports the restoration of operational readiness. Additionaly, this joint innovation team has to repeat the strategic design process annually. This process supports quick adaptation to the fast changing environment.

Circular economy

In figure 35 an example of a possible circular economy is illustrated. Important in this figure is the connection of Eindhoven Airbase with Eindhoven city and nearby co-developers. The circular economy can consist of multiple flows, which will circle within and around the airbase. Firstly, it is important to close the flow of vehicles, aircraft and materials. Maintenance can remain an operation that is carried out by the airbase, but repairing and recycling can be done by external co-developers. The parts of aircraft, vehicles and other materials can be reused within the closed flow or recycled. All these processes take place nearby the airbase, which could result in decreasing transportation time, energy and positively influence the adaptivity and thus speeding up material readiness. Secondly, the energy flow will also be important to support the operations at the airbase. Eindhoven Airbase needs to produce this energy at the airbase, to become a self-sustaining airbase and provide buildings, aircraft and operations with it. Considering the electrification it is important to find possibilities to store the energy to use it in times of need.

04.4 DISCUSSION

The project resulted in a strategic innovation roadmap, with three specified recommendations. This roadmap provides directions Eindhoven Airbase can follow to sustainably operate in 2050. Where Eindhoven Airbase needs to mutually operate as the first self-sustaining transport city in the world in 2050. In this section the process and outcomes are discussed.

The method gave a structured way of defining a context vision, which vision is based on context factors that are highly relevant within the domain. To fulfil the context vision in 2050, Eindhoven Airbase needs to frequently update the reliability and validity of the context vision. The validity of the vision is high, because of the broad analysis. Striving for a high reliability is hard, but deepening the broad analysis made the vision more reliable (figure 36). Nevertheless, the future will be uncertain and therefore Eindhoven Airbase needs to monitor their way to this future by adapting to new possible context factors. Therefore the joint innovation team is crucial, because it creates the possibility of adapting quickly to future changes.

Shifting Eindhoven Airbase to this future will influence the entire organisation. Mainly the operations at Eindhoven Airbase will change by creating the centred coordination and joint innovation team. These changes will influence the decision-making system within and between both companies. To support the way of being adaptive at the airbase, it will need another structure for quickly approving relevant changes. Next to that, it is important to implement the adaptive way of working in the organisation bottom-up, for example shifting the command to the commander of Eindhoven Airbase instead of going through all levels of the organisation. Therefore (partly) shifting the command will provide a close connection of Eindhoven Airbase and -Airport.

Another important step is to support enlarging the horizons of the employees. Nowadays the duration of a function is three years, which creates a short-term view on operations at the airbase. To fulfil the context vision 'behavioural change' in the way of working, the employees being more adaptive, is required. As a result the organisation needs to support this change. Therefore, the Royal

figure 36. Reliability and validity of the vision

Netherlands Air Force needs to provide a strategic innovation roadmap, including regulation and finances, to lead the whole organisation towards 2050, which can support Eindhoven Airbase on the way there as well.

The implementation of the roadmap can result in infrastructural changes at the airside, which might be an entire project on its own. Regarding the context vision it could be relevant to connect with Oirschot, which is a barrack of the Royal Netherlands Army. This connection would support the concept of being an adaptive hub. Regarding infrastructural changes, Eindhoven Airbase needs to stay focused on the core competences and needs to use the centred coordination and -operations to prevent fragmentation as a result of growth.

Lastly, long-term relationships with stakeholders need to be built, whereby it is essential to frequently communicate the relevance of Eindhoven Airbase. Creating awareness of the relevance can result in new connections with co-developers. These connections can support both the circular economy and the joint innovation team.

05. REFLECTION

In this section the process of the graduation project is evaluated. The reflection consists of personal insights of using methods, analysis, time management and the collaboration with the Royal Netherlands Air Force.

DISCOVER

The start of the Discover phase was hard, because of how abstract the design challenge was. Participating in the creative session of Aviation meets design of Design Management Network was an important step of kickstarting my analysis. Sparring with companies like KLM, Schiphol and different design agencies created awareness of different relevant topics to include in my analysis.

Next to that, the opportunity of gaining insights from and sparring with different internal stakeholders gave a clear overview of the operations at Eindhoven Airbase. The analysis provided a lot of insights, which was a strong base for the further process, although made it hard to choose a direction. It was hard for me not knowing which direction would be the right one, but during the process I slightly adjusted the direction several times, which I learned on the way. I think it was a strong analysis in the given amount of time.

DEFINE

Defining the context vision took more time than I first thought, because of the amount of context factors. Creating a comprehensive context vision takes a lot of time and consists of multiple design loops, which is a lesson I learned, and this made the project more meaningful in the end for Eindhoven Airbase.

During the analysis I had many conversations with various stakeholders, which gave a more in-depth analysis, but made it difficult to connect all stakeholders in one vision. Although it created a good overview of the complexity of the system Eindhoven Airbase participates in. In the end, the vision includes most of the gained insights of the stakeholders and as a result most stakeholders can identify with this vision.

Defining the system of Eindhoven Airbase with two main stakeholders provided a more concrete Design phase, which made the concept a strong connection between Eindhoven Airbase, -Airport and -city.

DESIGN AND DEVELOP

The start of the Design and Develop phase was conducting brainstorms with students at the Faculty of Industrial Design Engineering. These brainstorms were also a validation of the comprehensibility of the vision concerning various people. The brainstorms resulted in four key principles, which created a clear framework for the ideation phase. I have translated existing concepts in combination with new Eindhoven Airbase-specific ideas into one concept.

In the end I held three creative sessions and many individual conversations regarding the concept. The Eindhoven in Beweging session was a nice validation of the understandability of the vision and the concept. This session provided a reality check, because the participants were the managers who need to support and execute this vision and it resulted in substantive recommendations for the strategic innovation roadmap. Next time I would rather do one more session, because they had little time to dive deep into this vision. Therefore a second session would maybe have provided a more in-depth validation.

I participated in two meetings with Eindhoven Airport, which were a great experience and gave me a lot of insights about the connection of Eindhoven Airbase and Eindhoven Airport. Unfortunately there was no time for a creative session, but in the end the vision was communicated to Eindhoven Airport and it has been the first step towards a strong collaboration between both companies.

DELIVER

The Deliver phase consists of different products, namely the thesis report, roadmap, poster, animation and presentation. In the beginning I already tried to structure the thesis report as

much as possible, which made it easier to compile the report in the end. The thesis report offers a clear overview of the process and the results of the graduation project. The thesis report also contains the roadmap. This roadmap was the hardest part of the process for me, because it was hard to implement all relevant information in one clear overview. In the end the roadmap is complete and clear, but I need to practice more with making infographics in next projects to excel in this skill.

From the beginning I wanted to learn an extra skill during my graduation project. I chose to make an animation because I had never done this before. Combining drawing and animation made it hard, but I learned to use two new programs (Adobe Fireworks and After Effects). As a result I have a new communication tool that I can use.

The in-between presentations were useful to create more structure in the process, because presenting my findings in an organised way gave specific in-depth feedback, which resulted in strong time management.

In general I am satisfied about the result. Altogether, the final product has a lot of depth, because of the conversations with various stakeholders and different loops within the design process. I think time management is a capability I have done well in and may even have taken to a higher level. The project was really challenging, which I really enjoyed because my learning curve regarding aviation has been enormous, specifically within the Royal Netherlands Air Force at Eindhoven Airbase. Next to that, I learned to translate an abstract design challenge to a concrete and feasible concept.

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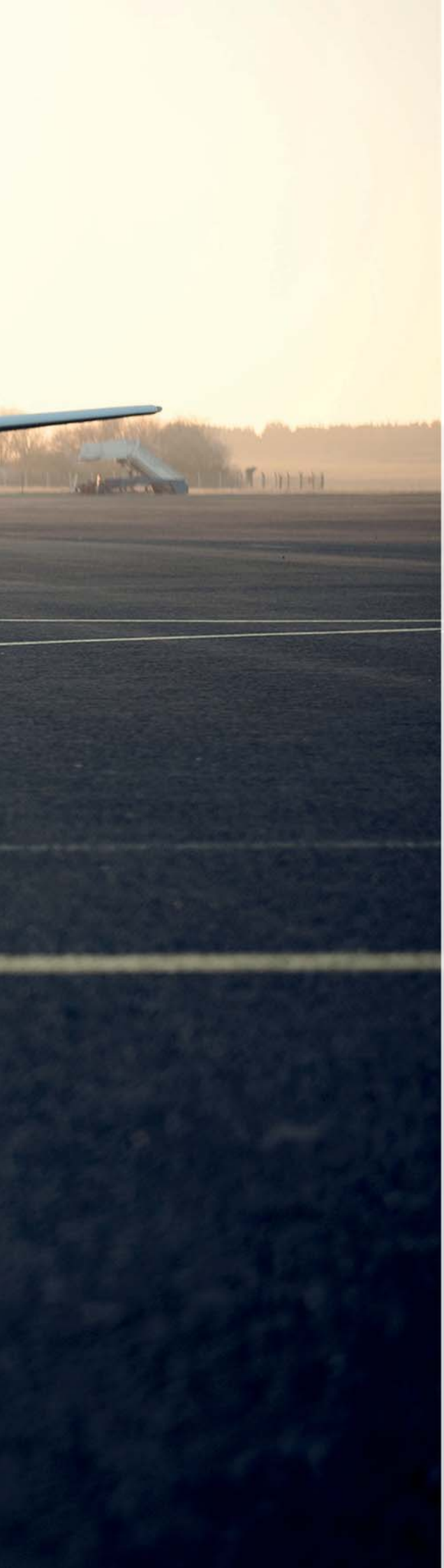

ACKNOWLEDGEMENT

I want to thank my supervisors, Sylvia Mooij and Bart Bluemink for providing critical feedback during presentations and giving insights regarding the Vision in Product Design approach on the road of translating an abstract complex design challenge to a feasible concept. Last but not least, I want to thank Marcel de Pee for providing me with this challenging project and all interesting conversations with the various stakeholders. Your insights from the company took this project to a higher level and with that it gave me the opportunity to quickly get to know the company.

COLOPHON

A future vision of Eindhoven Airbase
Giving growth a strategic direction towards 2050
Master thesis - TU Delft
April 4th, 2018

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