KDC Research Agenda 2020

KDC/2019/0054

Version 1

Version date: 20-12-2019

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Content overview

The Knowledge and Development Centre (KDC) is a foundation which objective is to support the development of the Mainport Schiphol. Within KDC, the sector partners KLM, AAS and LVNL co-operate coordinate their development activities and cooperate with knowledge institutes such as the Dutch Aerospace Laboratory, the NLR.

The research and development activities in KDC are managed on the basis of a KDC research agenda. The research agenda contains a description of studies that are currently active as well as proposed research topics. Furthermore, this document is used to set priorities between projects whilst maintaining a clear overview of proposed research questions. Research projects become active when the KDC board has given a formal ‘go ahead’, based on a study plan (or proposal) and the financial proposal by the KDC management team.

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1 Introduction

The Knowledge and Development Centre (KDC) is a foundation which objective is to support the development of Schiphol as a Mainport. Within KDC, the sector partners KLM, AAS and LVNL co-operate with knowledge institutes such as the Dutch aerospace laboratory NLR, Delft University of Technology, Amsterdam University of Applied Sciences and the Dutch meteorology institute KNMI. Industry partnerships are also incorporated within the KDC construction. The Joint Development Agreement with Boeing is an example of an industry partnership.

The KDC Research Agenda contains a work programme for the development of Mainport Schiphol, in particular the airside part of the Schiphol operation. Studies which require the involvement of multiple sector partners or knowledge institutes are candidate studies for the KDC Research agenda. KDC can initiate research projects if requested by e.g. the government or by one of the sector partners.

The objective of the research agenda is to provide guidance to the work program 2020 and beyond.

2 KDC Research Agenda

KDC sets itself the task of offering valuable and useful solutions for the sustainable development of the Mainport Schiphol. This task is executed by defining and realizing target orientated projects with close consultation of both the air transport sector and the government (Dept. of Infrastructure & Water Management).

2.1 Scope

The scope of the KDC-projects varies from applied research to the development of executable system concept. Examples are: technology explorations, scenarios for growth and development, ATM-process analysis and simulations, concept development, feasibility studies, performance analysis (e.g. economical security aspects and/or environmental aspects).

Fundamental/basic research is considered outside the scope of the KDC. This is a task of the universities and knowledge institutes. Engineering and realisation (implementation) is a responsibility of the individual sector partner and are normally also considered outside the scope of the KDC.

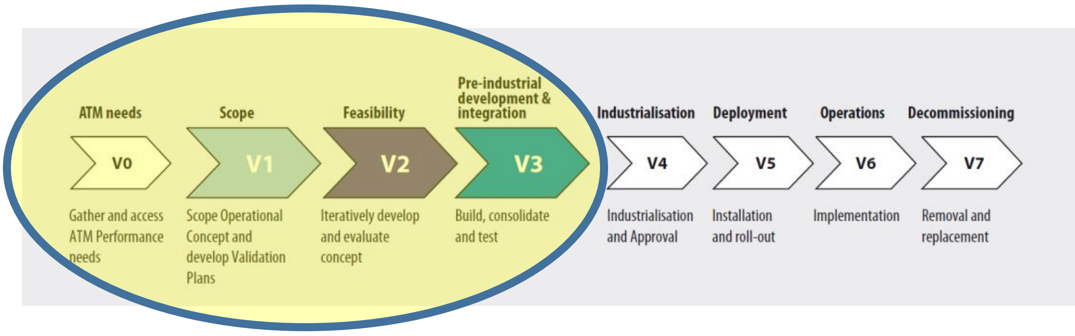

Figure 1: Scope of KDC-projects
(concept life cycle model, European Operational Concept Validation Methodology, E-OCVM)

2.2 Management of the Research Agenda

The initial version of the Research agenda was released in 2006, when KDC was established as a foundation. Since then the KDC Research agenda is maintained by means of annual updates (or in some cases two releases per year).

Priorities are set by the KDC-Board on the basis of proposals made by the MT-KDC, and in consultation with the Dept. of Infrastructure and Water Management. These priorities indicate the sequence of execution for the studies. The sequence can be based on the expected throughput time, urgency of the stated problem or on the assumed benefit for improvement of the ATM system in the short term.

Characteristics of KDC studies are:

- The assignment must have a direct relationship with the development of the Mainport Schiphol.
- Multiple stakeholders share the requirement(s).
- Collaboration between different (knowledge/expertise) parties to achieve a good/applicable solution (multidisciplinary solutions).
- The KDC studies focus on delivering results within approximately 1 to 2 years.

For each subject, a short description is given as well as the expected results and involved parties.

2.3 Environmental Sustainability

The transition to sustainable aviation is an important theme in the KDC research agenda. For KDC environmental sustainability means:

a) Finding solutions to reduce noise annoyance in greater Schiphol area
b) Finding solutions to reduce fuel burn and emissions

The topics that have been adopted in the KDC research agenda find their origin in the national airspace re-design programme, and noise annoyance reduction plans that the aviation sector develops in response to government policies.

2.4 Business perspective

A literature study, conducted in the analysis phase of the first version of the research agenda, revealed which of the research is relevant for each sector partner. Top priority for KLM as a hub carrier is to guarantee reliable capacity of the traffic stream in- and outbound Schiphol. Capacity and reliability of the capacity (also called “sustainability”) ensure passenger connections can be realised. An important part of the research agenda is aimed at improving the sustainability whilst increasing the capacity for various meteorological conditions.

For Airspace Users, including KLM, in general it is important to continuously improve its efficiency. Part of the research agenda aims at efficiency improvements at Schiphol and in the Dutch FIR in strong cooperation with LVNL and AAS.

The figure below (Figure 2) shows that certain runway combinations (indicated by roman numbers) deliver less hourly capacity compared to other runway combinations. Furthermore, the visibility conditions (good, marginal and poor) also have significant influence on the available capacity. Not all runway combinations are always available. Usage of less favourable runway combinations can result in reduced capacity.
The KDC research aims to increase airport capacity and sustainability as indicated by the arrows in Figure 2.

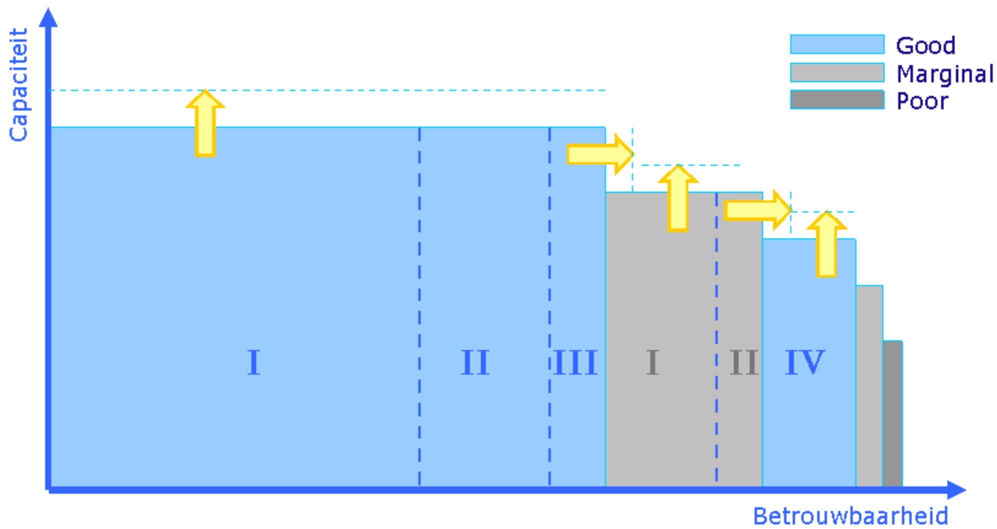

Figure 2: Sustainability (reliability of the capacity) vs. Capacity

2.5 Structure of the Agenda

The agenda is structured around the main objectives for the ATM system in terms of performance. These objectives are normally clustered in safety, environmental sustainability and capacity (and efficiency) benefits. A number of studies however, provide benefits in all these areas or can be seen as “enablers” for other developments. These kinds of studies have been labelled as “Future Concept” studies.

The research agenda clustered as depicted below:
Safety:
Chapter 3: Safe Airspace and Airport Navigation
Environmental sustainability
Chapter 4: Environmental Sustainability
Capacity & Efficiency:
Chapter 5: Airport Capacity
Chapter 6: Airline Operational Efficiency
Chapter 7: Capacity Management
Chapter 8: Schiphol Airport Meteo Development
Future Concept:
Chapter 9: Fixed Arrival Routes and CDA’s

In figure 3 below, these clusters have been projected on a horizontal plane, indicating for which parts of the Airport/Airspace system the clusters are applicable.

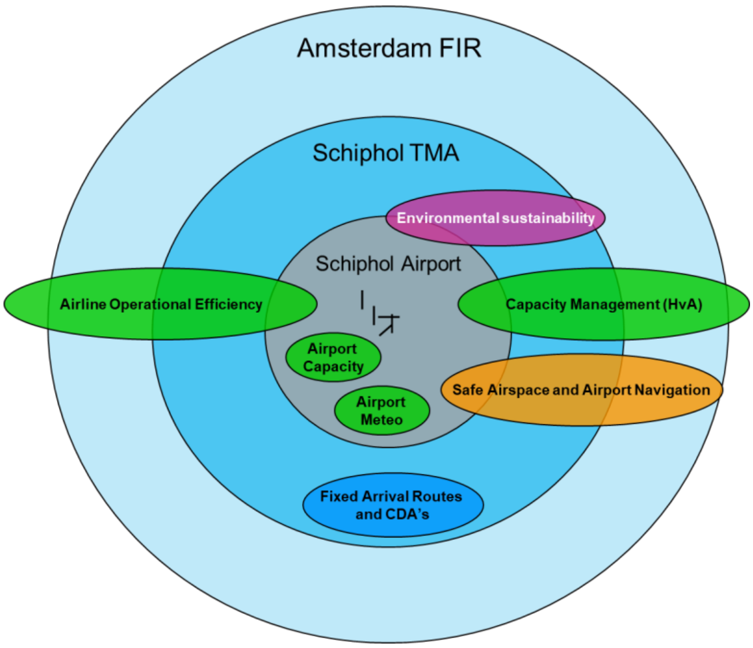

Figure 3: Research subjects projected on airport – airspace structure

2.6 The KDC Research Agenda and the Technology Readiness Levels

Furthermore, for each project a Technology Readiness Level (TRL) and a E-OCVM CLM phase have been assigned. The TRLs are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL scale varies from TRL 1 to TRL 9. A more detailed description of the TRLs may be retrieved in Appendix A.

The E-OVM methodology is described by Eurocontrol as a framework to provide structure and transparency to the validation of operational ATM-concepts, from early phases of development towards implementation. The complete lifecycle is subdivided into eight 'V' phases. The principal relation between the TRLs and Concept Lifecycle Model (CLM) phases is shown in the figure 4.

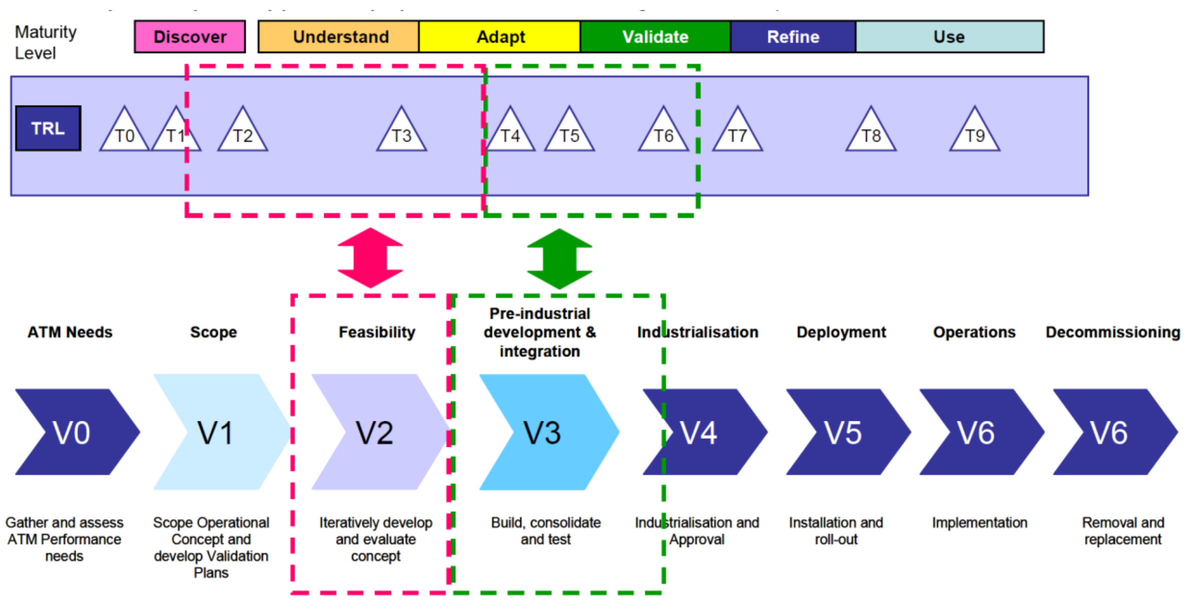

Figure 4: Principal relationship between the NASA TRLs and the E-OCVM CLM phases (source: Eurocontrol, 2018)

3 Safe Airspace and Airport Navigation

3.1 Converging arrivals & departures

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		✓	✓	✓	-
Financial Partner	DGLM					

Introduction:
Over the last years, a recurring incident has been the loss of separation as a result of a missed approach on convergent runways. The biggest example being departures on 24, with arrivals at 18C. In this scenario, missed approaches of 18C converge with the departing aircraft of runway 24. Currently, with good visibility, visual separation can be maintained. However, for lower visibility conditions, this is no solution. Multiple incident studies have addressed the issue of convergent arrivals & departures and published a list of observations and recommendations.

Goal / Expected benefit:
Converging arrivals & departure runways have safety issues that must be addressed. The goal is to find operational solutions that improve safety for converging arrivals & departures, but without significantly affecting capacity.

Assignment:
- Research possibilities to improve safety for converging arrivals & departures for the Schiphol runway system.
- Assess the solutions for a sustainable safety & capacity balance

Short term objective:
Finding safety solutions for convergent runway uses at Schiphol airport.

Midterm/Long term objective:
Finding a proper capacity & safety balance for converging runway use cases.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

3.2 Air-Ground datalink implementation strategy

Ref. Ext. Programme	-	**TRL**	7			
Customer	KDC Board	**Lifecycle phase**	Pre-industrial development & integration			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		✓	✓	✓	-
Financial Partner	DGLM					

Introduction:
The EUROCONTROL Link 2000+ program provides en-route Controller-Pilot Data Link Communication (CPDLC) services, which allow for the direct exchange of text-based messages between a controller and a pilot. The CPDLC messages automates routine tasks that can take up to 50% of a controller's time. In 2014, KDC completed a business case study that explored which datalink services are beneficial to the Schiphol operation below FL245, and implemented in the 2013-2016 timeframe.

Since the publication of the business case, the technology availability has changed, and the industry has advanced. According to the SESAR Concept of Operations, routine voice communications shall be replaced by 2020 for en-route traffic above FL285. As almost all traffic at Schiphol is affected by this Data Link Services Implementing Rule (DLS IR) EC29/2009, technology equipage levels are expected to be very high, if not 100%. Therefore, implementation in lower airspace is possible. The business case for implementation of the Air-Ground datalink on the current AAA system used by LVNL was negative, however in iCAS, this is expected to be different. In 2023 iCAS will be operational, opening up new possibilities for the implementation of air-ground datalink.

Goal / Expected benefit:
The goal of implementing air-ground datalink is to increase capacity and safety in the airspace below FL245. This is done by replacing routine RT contact (e.g. transfer of control -, weather (QNH, wind data) -, or direct-to incentives) by text-based messages. The expected benefit is a reduced ATCo workload, and increased reliability as a result of redundant communication channels.

Assignment:
With the (upcoming) full equipage of airline datalink technology in accordance with DLS IR, investigate which Datalink services are beneficial to the Schiphol operation below FL245. Special focus should be applied on routine messages, such as: The transfer of control at the IAF, weather information such as wind data, and direct-to incentives. An implementation strategy should be created, outlining how the technology will be implemented into iCAS, and at what moment in time.

Short term objective:
An implementation strategy that outlines the transition from RT communication to (partially) sending commands over the air-ground datalink in the lower airspace.

Midterm/Long term objective:
Operational trial which demonstrates the technical feasibility of routine instructions via datalink instead of voice communications.

Involved parties:
KLM, AAS, LVNL, Min. IenW, KNMI

Source:
-

4 Environmental Sustainability

4.1 Traffic segregation

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		-	✓	-	✓
Financial Partner	DGLM					

Introduction:
Outbound traffic segregation is the concept of segregating traffic on the basis of a performance or aircraft noise. In case of noise segregation, the noisy or heavy aircraft can be assigned to the noise preferred runway, whereas the less noise producing aircraft are given the secondary runway. A similar strategy can be applied for segregation on the basis of performance, which can optimize runway throughput capacity. However, there are many limitations, especially with regards to maintaining capacity, that need to be explored and addressed.

Goal / Expected benefit:
Study the feasibility of the traffic segregation concept for Schiphol airport.

Assignment:
Develop a concept of outbound traffic segregation on the basis of noise load distribution and/or performance. After the concept development, assess whether or not the principal is operationally feasible, and what measures (tools, practices, etc.) are needed for traffic segregation to be implemented.

Short term objective:
Produce a feasibility study

Midterm/Long term objective:
Improve the spreading of aircraft noise over the noise preferred runways by means of traffic segregation.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

4.2 Dual SID concept

Ref. Ext. Programme		**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Scope and concept definition			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
The Schiphol outbound declared capacity is often times not achieved during departure peak periods. The reason for this loss of capacity is under investigation. Several potential causes are looked at, with CDM deficiencies as a prime suspect.

Demand unbalance between departure runways is another potential cause for loss of departure capacity. This unbalance is caused by differences in traffic load on the ACC sectors. As departure runways are “coupled” to an ACC sector, the traffic load on the departure runways is dependent on the balance of traffic load over the sectors.

A proposed solution could be to apply dual Standard Instrument Departures (SIDs). The idea is to have at least one ACC sector that can be fed from two runways. This will enable traffic load balancing over the departure runways.

Goal / Expected benefit:
Being able to feed an ACC sector from two different runways by dual SIDs would greatly benefit capacity of the sector, but mainly runway capacity. Also, the traffic load of the primary and secondary runway can be spread more equally. However, it might not be necessary to implement dual SIDs for every independent runway use case in order to obtain the capacity benefit.

Assignment:
Assess feasibility of a dual SID concept. The assessment consists of a preliminary airspace design exercise with operational experts and airspace design experts. System solutions (i.e. advanced departure management solutions) should be considered if no airspace design solutions can be found which support independent departure runway use.

Based on the current traffic distribution over sectors, build demo, a route structure & runway planning (static) to demonstrate runway load balancing on the basis of one ACC Sector which is fed from two runways and two SIDs.

Short term objective:
Develop a dual SIDs concept that maximizes outbound runway capacity.

Midterm/Long term objective:
-

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

4.3 CCO High altitude SIDs

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	31-1-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld			✓		✓
Financial Partner	DGLM					

Introduction:
The PCP and PBN Regulation require to implement RNAV routes in the Schiphol TMA with defined lateral navigation standards. SIDs at EHAM are already designed to RNAV1 standards. The goal is to design routes with a minimum 6% fixed climb profile for all aircraft types. The SIDs will be vertically and horizontally constrained with PBN design criteria, separated from all other routes. This 3D separation of inbound and outbound routes is expected to de-complex the TMA operations, and to deliver the maximum benefits in terms of safety, capacity and environmental sustainability.

It is foreseen that departure routes will be optimized above an altitude of typically 6000 ft. The connection to this upper layer in the TMA must be made by means of optimized continuous climb profiles.

Goal / Expected benefit:
Optimization of departure routes in the Schiphol TMA, based on continuous climb departures, making use of the advantages of precision navigation and increased trajectory uniformity. The goal is to support design options for the TMA with increased performance with respect to environmental sustainability and capacity.

Assignment:
Develop departure route design options for the top four preferential runway combinations at EHAM considering the following aspects:

1. RNP1 navigation performance
2. Increased climb profile uniformity:
    a. Climb profiles that at least 95% of the aircraft can fly
    b. Climb speed restrictions (if required)
3. Traffic bundling: Extended centre-line climb options (varying from 3000 ft – 6000 ft)

The route design options need to be assessed in terms of capacity, track-miles and noise effects (indicative).

Short term objective:
Feasibility of the concept as a major building block in airspace restructuring for the 2023+ deployment timeframe.

Midterm/Long term objective:
A safe and environmental sustainable TMA route structure that takes advantage of new technologies, providing high capacity to the airspace users.

Involved parties:
KLM, AAS, LVNL, Min. I&M

Source:
-

4.4 Future runway use

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		-	✓	✓	✓
Financial Partner	DGLM					

Introduction:
With increasing traffic demand, and increasing concerns about environmental impact the aviation sector has to develop a concept which is future prove, meeting existing and new stakeholder requirements. The main requirements can be categorized as follows:

- Stable and predictable airport operations in order to optimally use airport infrastructure and resources (AAS)
- Minimal airport delays and punctuality of the operation (no-connection rate as low as possible (airlines)
- Stable airport operations by predictable traffic flows (LVNL).
- Respected environmental regulations: handling traffic on the preferred runways and limited fourth runway movements (environment and surrounding communities).
- Operating the airport in an environmentally sustainable manner (governmental bodies).

Goal / Expected benefit:
To develop a concept for future runway use which ensures stable airport operations within the boundaries of the environmental regulations and enables the hub-function of Schiphol.

Assignment:

- Develop a concept for future runway use which ensures stable airport operations within the boundaries of the environmental regulations and enables the hub-function of Schiphol. In collaboration with airport and airline representatives and TWR/APP ATCo' s
- Evaluate the alternative concepts on the basis of the above mentioned KPIs

Short term objective (first year):
Support policy decision

Midterm/Long term objective:

Involved parties:
KLM, AAS, LVNL

Source:
-

4.5 Night-time CDAs

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		-	-	✓	✓
Financial Partner	DGLM					

Introduction:
At night, Schiphol airport is far less busy than during the day. This allows for more room to fly efficient Continuous Descent Approaches (CDA's). However, to do so, the ATCo should have its traffic synchronised in an early stage. By giving the planner a very accurate arrival time. The accuracy of the arrival time can potentially be improved by importing the ETA that is calculated on board by the FMS. With this information the ATCo can synchronise traffic such that CDA's can be flown.

Goal / Expected benefit:
Currently many aircrafts fly unnecessarily inefficient when approaching Schiphol at night. Deployment of continuous approaches at night, will result in:

- Reduction of noise nuisance during nights
- Improved efficiency for airlines

Assignment:

- Develop an implementation concept that enables night-time traffic to fly CDA's based on the FMS data.
- Develop a trial and validation plan for the implementation concept.

Short term objective:
Study the feasibility of synchronizing traffic for CDA's during night operations.

Midterm/Long term objective:
Design and implement operational support by support tools or straightforward procedures. Implement the concept for flying CDA's during night operations. Alternatively, operations can be supported by a tool during approaches at night.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
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5 Airport Capacity

5.1 Business case - Optimising preferred use of Schiphol runways through flexible ILS maintenance (project OPUS)

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	Sept 2017	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		-	-	✓	✓
Financial Partner	DGLM					

Goal / Expected benefit:
The goal for this activity is to assess the feasibility of additional permanent ILS signal quality monitoring, enabling a more flexible planning of ILS ground inspections at Mainport Schiphol Airport. If this study proves that additional ILS monitoring is technically feasible, this will allow the ground inspections deadlines to be loosened, and hence reducing the risk that ground inspections interfere with operational use of preferred runways.

These inspections are necessary to guarantee the required performance for ILS installations (per ICAO Annex 10). In current practice, they are done periodically using a special measurement vehicle on the runway for several hours and thereby blocking the runway for operational use. Most inspections are performed quarterly, within strict deadlines. With the increase of traffic this is increasingly conflicting with the preferred use of runways at the airport, especially with the use of the busy primary runways and night preferential runways 06 and 18R. At Mainport Schiphol these preferences are related to noise abatement and optimizing the airport capacity.
It is expected that this activity will demonstrate that additional ILS monitoring is technically feasible and will provide an improved status of the ILS signal quality, allowing the ground inspections deadlines to be loosened, and hence reducing the risk that ground inspections interfere with operational use of preferred runways.
In potential, and subject to follow-up studies, this additional way of ILS monitoring can be used diagnostically, as a trigger for a-periodic ground inspections. As the ILS installations are highly stable and ground inspections seldomly reveal any problems, a large reduction of ground inspections can be achieved.

Background:
The ILS is a safety critical system enabling aircraft to land in adverse weather conditions. In order to guarantee the extremely high ILS performance in terms of accuracy, integrity and continuity, an ILS is designed with multiple layers of performance monitoring, each covering different types of failure modes. As a final check, it is required to periodically measure the ILS Signals-in-Space in the EM far field (at a distances where aircraft receive the ILS signals). This is done by both flight inspections and ground inspections, requiring special measurement vehicles physically present at locations on the runway and in the ILS coverage area in the air.
The rationale for periodical inspections is that the confidence about the ILS signal quality is decreasing with time. Once an inspection is done this confidence is restored. Historically, the ILS inspection deadlines are such that the uncertainty is retained within limits acceptable to LVNL.
Alternatively, if ILS Signals-in-Space quality properties can be monitored in a permanent way, this will provide permanent additional insight in the ILS signal quality, which allows for a reconsideration of the inspections deadlines, leading to an increased sustainability of the Mainport Schiphol (reduced risk of conflicts between inspections and use of preferred runways).
This activity fits in the LVNL Roadmap for Navigation Maintenance Management.

Assignment:

- Perform a theoretical assessment of permanent ILS monitoring configurations, in terms of antenna types and positions as well as expected measurement quality.
- Provide a proof of concept for permanent ILS monitoring by building a test setup in a controlled environment, that is representative for ILS at Schiphol and perform tests that reveal measurement quality and stability.
- Determine the operational benefits: provide a rationale to what extent ground inspection deadlines can be reconsidered based on the permanent ILS monitoring data.
- Consult LVNL on the practical implementation of permanent ILS monitoring at Mainport Schiphol, in terms of optimal antenna types and positions, data distribution and software processing.

Involved parties:
LVNL

Source:
-

5.2 RECAT-EU for departures

Ref. Ext. Programme	-	**TRL**	6			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		-	✓	✓	✓
Financial Partner	DGLM					

Introduction:
EUROCONTROL has developed a re-categorization of the wake turbulence categories as defined by ICAO. The initiative splits the "Heavy" and "Medium" categories into "upper" and "lower". This results in new longitudinal separation minima for traffic. The new categories yield lower separation minima for certain traffic combinations. This can potentially benefit runway throughput, while still maintaining acceptable safety levels.

Goal / Expected benefit:
Implementing the new wake turbulence categories are expected to lower the separation minima for certain traffic combinations. It is expected that Schiphol airport will see a runway throughput increase, as the traffic combinations are expected to be positively affected by the new separation minima.

Assignment:
Assess the performance of RECAT-EU time table implementation for departure capacity at Schiphol. The following aspects must be taken into account:

a) Benchmarking expected benefits with EUROCONTROL experience (runway through-put programme)
b) Operational limitations which stem from SID design (respecting separation minima on climb-out)
c) Airline company procedures

Short term objective:
Quantify the capacity increase which can be expected when implementing RECAT-EU for departures.

Midterm/Long term objective:
-

Involved parties:
KLM, AAS, LVNL, Min. IenW, EUROCONTROL

Source:
-

5.3 Runway sequence bays

Ref. Ext. Programme	-	**TRL**	6			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		-	✓	✓	✓
Financial Partner	DGLM					

Introduction:
The current departure manager, the CPDSP, will be replaced by a new departure manager, the outbound sequencer. One of the improvements that will be incorporated in the new outbound sequencer is to make the departure manager more simple. It was recognized by the CDM program that the CPDSP performed sequence optimizations that were in fact not warranted. For instance WTC sequence optimizations were sometimes not realistic due to uncertainty about taxi-time. In fact some of the sequence optimization is also performed at the runway. The new outbound sequencer therefore acts more of a “faucet” regulating the flow to the runway, and less of a sequence optimized. The purpose of this development is to create more stability in the outbound planning and to better align the planning with operational practice.

One of the ways to optimize the WTC sequence at the runway is to use intersections. However, there are limitations to the use of intersection take-offs. When visibility drops below phase-A intersection take-off are not allowed. Furthermore, intersection take-off are not allowed during night-time. When runway 36L is operated from TWR-C, intersection take-offs are also not allowed from runway 36L.

In the US, so-called sequence bays are used. A sequence bay consist of a widened runway entry, at the runway head, which allows for two aircraft to hold side by side. A sequence bay allows for the same WTC sequence optimization as intersection take-offs, but with a number of advantages.

Goal / Expected benefit:

1) Sequence bays lead up to the same line-up point on the runway and can be used under all visibility conditions. WTC optimization therefore can be done at all times, which makes the outbound capacity less dependable on visibility.

2) Departures from the runway head will be higher on the SIDs than departures from an intersection. Thus sequence bays reduce noise in the areas close to the SIDs.

3) Sequence bays avoid the risks associated with intersection take-offs.

Assignment:
- A noise impact analysis when runway sequence bays are in use
- Model the capacity benefit of runway sequence bays
- Model the safety benefit of runway sequence bays.
- Feasibility assessment for the implementation of runway sequence bays

Short term objective:
Capacity increase of runway throughput

Midterm/Long term objective:
Noise decrease for close surroundings

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

5.4 Optimize ground movements in relation to taxiway renovation

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Erik Derogee		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
Ground movements have increased in recent years. This has also put pressure on execution of taxiway renovation works and modifications. However, renovation works are inevitable in order to maintain a safe, compliant and sufficient quality taxiway system. Recently, renovation of taxiway A8 showed that maintenance often conflicts with operational performance. Following on the runway maintenance strategy, AAS initiated a program for optimization of the taxiway maintenance strategy within a sector wide perspective.

Goal / Expected benefit:
The goal is to define an optimal long term taxiway maintenance strategy in which operational use and capacity, risks and costs have been considered sector wide. Expected benefits are in the area of efficiency of use of the Schiphol taxiway system and maintaining runway capacity during taxiway renovation.

Assignment:
The assignment is to set up a model as means for an optimal long term taxiway maintenance strategy, by conducting a study/simulation of taxiway renovation scenarios under various conditions (e.g. traffic, visibility (good, marginal, poor), runway use and type of maintenance). Thereby analysing:

- Capacity impact
- Aircraft routing alternatives
- Possible benefits of temporary taxi lanes
- Maintenance phasing alternatives
- Technical system configurations (e.g. lighting)
- Safety issues

Midterm objective (two-three years):

- Optimisation of the maintenance strategy for the total Schiphol taxiway system based on model outcomes
- Implement the strategy for each section of the system
- Development of a long term (<15 year) taxiway renovation plan within sector wide criteria as ground movement and runway capacity, safety and costs.

Long term objective (> three years):

- Monitoring, optimisation and adjustment of the model, simulations, maintenance strategy and plan based on advanced insights.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

5.5 Schiphol Airport Operations Centre (APOC)

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Erik Derogee		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
As of January 2020 Schiphol will launch the Airport Operations Centre (APOC). Its main purpose is to plan and monitor the complete airport operations process together with stakeholders. By taking a D-7 approach, it will look constantly 7 days ahead of the day of operations. APOC will therefore forecast events and proactively identify capacity constraints that might influence performance. By means of scenario planning APOC will be able to establish different scenarios reflecting a balance between capacity and demand, enabling it to take additional operational measures to anticipate on upcoming disruptions. This will help all parties at Schiphol to work less reactively and incident based. Therefore the effort, energy and resources which are now allocated to damage control and recovery of events can then be put in to the actual improvement of processes. This could lead to a significant On Time Performance (OTP) improvement.

Goal / Expected benefit:
The goal is to define a methodology to execute scenario planning in order to anticipate on events such as adverse weather conditions, strikes, severe asset / IT disruptions and the like, that could impact the on time performance at Schiphol. With as expected benefit an OTP improvement.

Assignment:
Help with creating a methodology for scenario based planning in the APOC
- How can we make scenario's for different situations?
- How should a decision model look like in order to collectively make the right decisions benefiting performance?
- How can simulation tooling help with this development?

Midterm objective (two – three years) :
- Ready to implement scenarios for the most common disruption influencing on time performance
- Decision making in APOC will facilitate a common ground in the sector on how performance and capacity is used most efficiently
- An improvement of the on time performance as a significant negative influencer of the performance by anticipating collectively instead of reacting to it in daily operations.

Long term objective:
SESAR APOC/AOP implementation

Involved parties:
KLM, AAS, LVNL, KDC partners

Source:
-

6 Airline Operational Efficiency

6.1 Multi-airline inbound priority sequencing

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
In the crowded airspace around Schiphol airport, delays are inevitable. However, the impact of delays can differ significantly for individual flights. For example, the impact of delay for a flight with many connecting passengers can cost the airline significantly more than a flight without any connecting passengers. Inbound priority sequencing (IPS) is a concept that provides an algorithm to the Extended Arrival Management (XMAN) planner to prioritize one inbound flight over the other. Thereby trading delays between aircraft of the same airline, and potentially even inter airline delay trading. The goal is to reduce the overall impact of delay to the airlines and its passengers.

Goal / Expected benefit:
Reducing the impact of delay for airlines by prioritizing certain flights over the other.

Assignment:
Demonstrate the principle of multi-airline priority sequencing on the basis of, or as an input to extended arrival management. The demo should involve two types of airlines, a hub carrier and a low-cost airline/charter. An example can be a demo concerning KLM and Transavia for inbound priority sequencing.

Short term objective:
Demonstrate the potential benefit to an airline when delay is traded by multi-airline IPS

Midterm/Long term objective:
Implement inter airline inbound priority sequencing to reduce the total impact of delay at Schiphol.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

6.2 Drones at Schiphol Center for lightning strike inspections

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board, KLM E&M	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Bas de Glopper (KLM)		-	-	✓	-
Financial Partner	DGLM					

Introduction:
Unscheduled inspections, mostly caused by a lightning strike, result in major financial and operational strain for an airline, and in addition pose constraints for the logistics of an airport. Drones offer a potential smart and fast solution to perform these inspection within the turnaround time of an aircraft. Such inspections can be performed in the maintenance hangars but have a much higher impact (saving time) when executed at the gate. Alternatively, aircraft parking places or designated locations on the airport can be appointed for fast automated inspections by drones. Other benefits of using this modern technology is the option to advance the digitalization and automation of the aviation maintenance industry, making use of data collected by drones. For all parties to benefit most of the impact, automated drone inspections after lightning strikes should be performed at Schiphol Center. To find out how to implement and execute this safely, is most important goal of this project.

Goal / Expected benefit:
Application of automated drone inspections for lightning strikes at Schiphol Center (within CTR)

Assignment:
Step 1:
Research all relevant boundary conditions and setup guidelines for the safe deployment of drones at airports. Realize involvement of all the stakeholders associated with drone inspections at airport to validate assumptions.
- Form consortium with stakeholders: airlines, authorities, airport, air traffic control.
- Perform systematic risk analysis (SIRA) and assessments.
  - Identify potential risks involved with drone inspection at airport.
  - Develop plan for mitigation of found risks.
  - Setup safety requirements for drones in compliance with regulations.

Step 2:
Ensure functional readiness of developed technology and perform elaborate testing for the operational execution of inspections.
- Develop drone technology to execute inspections, keeping in mind factors such as:
  - Implementation of inspection in coordination with other air traffic, e.g. by maintaining communication and visibility with air traffic control.
  - Safety measures: such as geofencing, collision avoidance, abort/kill switch.
  - Weatherproof: wind, water, etc.
- Controlled testing of outdoor inspection procedure.
  - Test run inspections in a lower traffic CTR than Schiphol, to minimize disruptions.
  - Perform inspections at Schiphol at designated outdoor locations.
  - Coordinate inspections with regular ground activities handled during turn-around at an airport (maintenance, baggage, fuel trucks, other ground activities).

Step 3:
- Validate impact of the inspections and re-assess risk.
- Formulate follow-up steps for the actual implementation and adoption of automated drone inspections.
- Compile recommendations for including drone inspection in regular maintenance cycle of an aircraft.

Short term objective:
Finding safety solutions for convergent runway uses.

Midterm/Long term objective:
Finding a proper capacity & safety balance for converging runway use cases.

Involved parties:
KLM, AAS, LVNL, Min. IenW, Mainblades Inspections BV

Source:
-

6.3 FF-ICE

Ref. Ext. Programme	-	TRL	7			
Customer	KDC Board	Lifecycle phase	Pre-industrial development & integration			
KDC Board Approval	3-12-2019	Performance Targets	S	Ec	Es	Env
KDC PoC	Evert Westerveld & Coen Vlasblom		-	✓	✓	✓
Financial Partner	DGLM					

Introduction:
Flight & Flow Information for a Collaborative Environment (FF-ICE) is a real time data exchange system in which actual airspace and aircraft parameters are shared to support ATM operations. It is an ICAO proposal that should replace the current ICAO flight plan standard. FF-ICE is a 4D trajectory planning tool that can increase flight planning reliability and 4D optimization. FF-ICE also opens up possibilities to plan trajectories through restricted areas that are available at the planned crossing moment. This reduces the amount of fuel that needs to be reserved for the detour, thereby decreasing emissions. Lastly, FF-ICE is a far more collaborative format that makes it easier for the ATM community to exchange information. All parties involved in the ATM process will have a great level of awareness to where an aircraft is at what point in time. (ICAO.int, 2011)

Goal / Expected benefit:
FF-ICE is expected to enable shorter and safer route planning, and an increased data exchange between ATM partners. As a result, FF-ICE has many expected benefits. First off all, flight plan reliability will be increased by reducing the time difference between the flight plan and the actual flight time. Furthermore, it is expected to reduce on board fuel reserves, which reduces emissions. Lastly, it is expected that the planned arrival time of aircraft at the FIR boundary is more reliable.

Assignment:
Construct an implementation strategy, detailing what measures need to be taken to implement FF-ICE in the Dutch FIR.

Short term objective:
An implementation strategy for the ATM actors in the Dutch FIR.

Midterm/Long term objective:
Dynamic 4D flight planning; enabling shorter and safer routings, reduction of emissions, and increased punctuality with respect to the flight plan.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
ICAO.int. (2011). *FF-ICE Leaflet*. [online] Available at: https://www.icao.int/airnavigation/FFICE/Documents/FF-ICE%20Leaflet%20final.pdf [Accessed 27 Nov. 2019].

7 Capacity Management

7.1 Multi-airport concept

Ref. Ext. Programme	Project Luchtruim Herindeling	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld		✓	✓	✓	✓
Financial Partner	DGLM					

Introduction:
Schiphol as well as regional airports grow. Traffic streams from different airports use the same airspace. Therefore it is needed that, parallel to a new airspace design, airports are jointly managed, to efficiently use the available airspace. This concerns strategic, pre-tactical as well as tactical planning. In the strategic domain for example, currently schedules of slot regulated airports do not take other airports' schedule into account. In the pre-tactical domain, the Schiphol D-1 planning, Schiphol sector briefings, LVNL workload model, and management of disruptions can be studied.

Goal / Expected benefit:
The goal of this study is to propose measures for an efficient use of airspace with multiple airports. This concerns strategic, pre-tactical as well as tactical planning measures.

Assignment:

- Research how the management of traffic flows in Dutch airspace can be improved, taking in account the location and function of Dutch airports. Options under consideration are: alignment of flight schedules, coordination of peak hours, refinement of flow measures, tactical complexity management measures.
- Develop a concept for the planning and management of traffic flows.

Short term objective:
Produce measures that streamline the multi airport operation with regard to the project of airspace redesign.

Midterm/Long term objective:
-

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

7.2 Schiphol Target Time of Arrival (TTA) Concept

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	7-12-2018	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld & Coen Vlasblom		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
In 2017 traffic numbers for LVNL peaked at their highest on record. More than 600,000 flights were handled by Amsterdam ACC and almost 500,000 commercial flights (without general aviation) arrived and departed at Schiphol Airport. These record traffic numbers resulted in a significant increase in delay as well. To counter these delays and looking to improve its performance.

In current operations LVNL is facing traffic demand well above the declared capacity on daily basis. Regulations are put into place to counter these Schiphol inbound traffic peaks. As such safety and orderly handling of traffic are ensured. With the increase in traffic, the delay caused by these regulations has increased as well. In 2017 Amsterdam Airport generated 13.8% of all European airport arrival ATFM delay (ATFM stands for Air Traffic Flow Management). According to the Network Manager, Schiphol Airport is one of the most congested airports in Europe and its generated delay has the largest impact on the network.1 ATFM delays are a problem for the aviation business mainly for the airline operators. Delays increase airline operating costs (cost of ATFM delay is around €80-€100 per minute) and it disrupts airline operations (including reactionary delay). Furthermore delays can disrupt airport operations (need for use of less environmentally preferable runways, gate planning, planning of ground handling, etc.). Finally the use of ATFCM-measures (regulations) decreases the planning flexibility of the European Network (due to the increased issuing of CTOT's).

To counter these delays, LVNL is seeking to increase capacity and to balance capacity & traffic demand in more efficient ways. One of the potential improvements is the use of "less stringent" regulations (potentially using higher rates and/or smaller regulation periods) by increasing the effectiveness of these regulations. In current operations, LVNLs experience is that regulations, used to reduce traffic peaks / bunches, do not always results in a sufficient safeguard for traffic overloads Often traffic peaks reoccurs before or after the planned peak moments. Different root cause generate the deviations, for example deviations in flight plan filed versus actual flown, different offset in the regulation model developed and in use by the Network Manager. Furthermore ATC in en-route sectors can issue directs to aircraft, resulting in further deviations. In addition airlines sometimes try to recover endured delays by flying more efficient (routes, heights and speeds). All mentioned root causes result in regulations (and capacity) that are managed with some conservatism to overcome these effects.

KDCs is interested in the concept of improving the regulation concept and target times solutions (TTO/TTA) as measures to increase effectiveness of regulations by preventions of bunching. TTO stands for Target Time Over (TTA Target Time Arrival) and represents the target time for a flight to enter an (regulated) airspace according to the flight profiling done by Network Manager. When pilots are able to operate more according to these times, risk of traffic bunches occurring may decrease.

In Europe some ANSP's have conducted trials for TTO/TTA (Target Time Arrival). TTO/TTA is incorporated in SESAR as one of the future operational concepts. Therefore it is expected that understanding of this concept can be acquired by a short study of already available information and trial experiences.

Goal / Expected benefit:
More effective EHFIRAM regulations, less Airport ATFM delay and (in longer term) increased capacity

Assignment:
KDC requires a sort study addressing the following topics:
What is the TTO/TTA concept, how does it work?
- SESAR Network Manager regulation concept
- Trials at ANSP's
- Collaboration between Network Manager, ANSP's and Airlines

Which performance benefits can TTO/TTA deliver

- Effectiveness of ATFCM measures (regulations)
- Improvement of the regulation model (decreasing offset/ flight plan deviations)
- Performance effects on capacity and ATFM-delay

Feasibility of TTO/TTA use at Amsterdam Airport Schiphol / Amsterdam ACC

- Improvement of the regulation model (decreasing offset/flight plan deviations)
- Incorporation of TTO/TTA in current and/or future operations
- Possibilities to conduct trials in current operations
- Effectiveness for non-regulated flights (e.g. intercontinental traffic)
- Relations with current and future developments (like AMAN 2.0 and XMAN-trials)

Short term objective:
Delivery of a report addressing the benefits and feasibility of the regulation model and TTO/TTA concepts at Amsterdam Airport Schiphol and Amsterdam ACC

Midterm/Long term objective:
Depending on the feasibility study:
Midterm objective is the conducting of one or multiple trials at Amsterdam Airport Schiphol and Amsterdam ACC

Depending on trial results:
Long term objective is to introduce TTO/TTA at Amsterdam Airport Schiphol and Amsterdam ACC

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

1 Source: PPR2017, Performance Review Report 2017, https://www.eurocontrol.int/sites/default/files/publication/files/prr-2017.pdf
2 Source: European airline delay cost reference values Final Report (Version 3.2), https://www.eurocontrol.int/sites/default/files/publication/files/european-airline-delay-cost-reference-values-final-report-v3.2.pdf

7.3 Traffic buffering concept

Ref. Ext. Programme	-	**TRL**	6			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		-	✓	✓	-
Financial Partner	DGLM					

Introduction:
Traffic buffering means: structural stack holding of aircraft. This means that (structurally) more aircraft are allowed in the Netherlands airspace than the available landing capacity. Aircraft have to fly orbits at the TMA boundary to wait their turn to land, to absorb delay.
Currently LVNL does not operate a buffering concept. The stack holdings are used incidentally, not structurally. The stack holdings are used to smooth traffic bunches and to cater for large demand-capacity unbalance as a result of unforeseen circumstances.

Goal / Expected benefit:
Investigate whether benefits can be obtained by means of buffering aircraft in the AMS FIR.

Assignment:
Perform a benefit analysis of a buffering concept. What are the benefits of implementing the traffic buffering concept at Schiphol, and what are the implications.

Analyse the traffic buffering concept on:
- What benefits can be expected in terms of ATFM delay reduction, or peak-hour capacity.
- What are the design implications for the ATM concept: how many stack holdings would be required to support the concept?
- What are the strategic implications in terms of:
  - Compliance with PCP regulation 716/2014 to expand the planning horizon of the AMAN system to 180 NM to optimize descent profiles
  - Compliance with PCP regulation 716/2014 to implement fixed arrival routes in the TMA.
  - and low altitude CDA's.
- What drawbacks should be expected in terms of:
  - Environmental impact in terms of gaseous emissions (Cox and NOx)
  - Negative cost impact on the airlines (fuel burn)
  - Negative cost impact on the ANSPs (staffing costs)

Short term objective:
-

Midterm/Long term objective:
-

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

8 Schiphol Airport Meteo Development

8.1 Improved weather forecasting for airlines

Ref. Ext. Programme	-	**TRL**	6			
Customer	KDC Board	**Lifecycle phase**	Pre-industrial development & integration			
KDC Board Approval	31-1-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		✓	✓	✓	-
Financial Partner	DGLM					

Introduction:
Accurate weather prediction is increasingly important for airlines. In the first place customers demand upfront information on possible delays. Secondly the impact of weather increases in a congesting airspace with high utilization rates. Significant weather has a tremendous impact on the efficiency of an airline and its operation. For KLM a disrupted day equals a loss of more than 1 million euros spent on passenger claims, operational- and hotel costs. Furthermore KLM loses valuable customers. Early information (>24h in advance) on the impact of significant weather in terms of capacity and runway usage helps airlines anticipate for example by cancelling specific flights. This reduces the operational loss significantly. Furthermore it helps to reduce the number of dissatisfied customers.

In the past few years improvement on weather models have been realized and accuracy margins have increased. However a number of situations were experienced where airlines were confronted with significant weather (e.g. fog) which was not forecasted. Also a number of times significant weather occurred in a different time interval, not according forecast.

Goal / Expected benefit:
Operational efficiency, reduction of operational cost

Assignment:
A study has to be carried out how weather forecasting can be improved to better serve airlines in anticipating on significant weather:

1. Which weather phenomena and parameters have the highest impact on airline cost and passenger dissatisfaction (and relevant restrictions taken by LVNL and AAS)
2. Which meteorological improvements are currently foreseen to improve prediction of those phenomena and parameters.
3. What is the implementation timeframe for candidate improvements

Short term objective:
Finding safety solutions for convergent runway uses.

Midterm objective (two-three years):
Implement candidate improvements and carry out evaluations

Involved parties:
KLM, AAS, LVNL, Min. IenW, KNMI

Source:
-

8.2 Lightning strike prediction

Ref. Ext. Programme	-	**TRL**	6			
Customer	KDC Board	**Lifecycle phase**	Pre-industrial development & integration			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Coen Vlasblom		✓	✓	✓	-
Financial Partner	DGLM					

Introduction:
Recently, thunderstorms in the Schiphol vicinity caused lightning to strike several aircraft. Those incidents caused unplanned returns to Schiphol creating delays for those particular flights while increasing the work for air traffic controllers to accommodate unplanned returns. Nowadays, no systems exist to accurately predict lightning strikes to warn operational units (ATC, OCC) effectively and take measures to reduce the chance to encounter a lightning strike.

Goal / Expected benefit:
Increased safety level for airspace users. Reduction of disruptions in the Schiphol operation caused by outbound traffic returning to Schiphol after being struck by a lightning strike

Assignment:
- Exploratory market research to identify research, tools and systems which would support prediction of lightning strikes.
- Determine potential research to be carried out to enhance the accuracy to predict lightning strikes
- Propose a concept of operations of a system that predicts lightning strikes
- Determine needs of operational units to effectively use output of a system described above

Midterm objective (two – three years) :
- Create a prototype lightning strike predictor
- Carry out trials with prototype

Long term objective (> three years) :
-

Involved parties:
KLM, AAS, LVNL, Min. IenW, KNMI

Source:
-

9 Fixed Arrival Routes and CDA's

9.1 Transition to high capacity fixed arrival routes

Ref. Ext. Programme	-	**TRL**	3			
Customer	KDC Board	**Lifecycle phase**	Feasibility assessment			
KDC Board Approval	3-12-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	t.b.d.		✓	✓	✓	✓
Financial Partner	DGLM					

Introduction:
In the national ATM strategy it is outlined that in 2024 traffic in the TMA is guided over fixed arrival routes with low altitude CDA's. This measure is meant to reduce noise annoyance and gaseous emissions, as the fixed arrival routes will be optimized to avoid overflying of habited areas.

Currently LVNL has published one fixed arrival route for daytime use in the Schiphol TMA: the ARTIP1X approach from ARTIP to runway 36R. In practise this fixed arrival route is not used because runway 36R is a secondary runway and can only be used during inbound peak periods: The demand during these periods is too high relative to the capacity of the ARTIP1X arrival route.

The capacity of ARTIP1X is estimated to be about 30 movements per hour. This figure however has not been validated and may also be lower. In order to be able to use fixed arrival routes in the daily operation, the capacity of fixed arrival routes needs to be increased. There are several measures to increase capacity of fixed arrival routes, for example:

1) Improved delivery accuracy at the IAF
2) Allowance of flexibility (e.g. tromboning)

For fixed arrival routes to the primary runways, merging support for approach will be required, as these routes merge traffic from two IAFs.

Goal / Expected benefit:
Calculate and validate the capacity of fixed arrival routes for Amsterdam airport and the benefit to capacity of the aforementioned optimizations.

Assignment:

- Design a rough concept of fixed arrival routes for EHAM that resemble 2024 implementation.
- Perform a real time simulation to validate the capacity of ARTIP1X and the proposed arrival routes.
- Optimize the capacity of the fixed arrival routes before Interval Management implementation, and validate the capacity benefit of the optimizations.

Short term objective:
Defining the expected capacity for fixed arrival routes at Amsterdam airport.

Midterm/Long term objective:
Capacity increase for fixed arrival routes.

Involved parties:
KLM, AAS, LVNL, Min. IenW

Source:
-

9.2 ASAS Interval Management Business Case

Ref. Ext. Programme	-	**TRL**	6				
Customer	KDC Board	**Lifecycle phase**	Pre-industrial development & integration				
KDC Board Approval	31-1-2019	**Performance Targets**	S	Ec	Es	Env
KDC PoC	Evert Westerveld & Coen Vlasblom		✓	✓	✓	✓
Financial Partner	DGLM					

Introduction:
The airspace vision for the Netherlands (2012) has adopted a concept for the Schiphol TMA, the area around Schiphol with a 50 km radius, which is based on fixed arrival routes and low altitude continuous descent approaches. The concept is founded on accurate delivery of traffic to the TMA, typically within 30 seconds of the planned TMA entry time. However, there is a concern that fixed arrival routes negatively affect arrival capacity, compared to the current arrival capacity which is based on vectoring traffic to the runway.

It is expected that the airspace redesign project that takes place in the 2019 – 2023 timeframe will be based on the principles laid-out in the airspace vision. Note: The implementation of fixed arrival routes is also demanded by the European PCP regulation (716-2014). Thus the future relationship with the surrounding communities in the greater Schiphol area is based on (carefully designed) fixed arrival routes and (the already existing) standard instrument departure routes (SIDs). This will enable better planning of areas that are affected by (some level of) noise annoyance and areas that are not affected.

Besides the planning of noise affected areas in the greater Schiphol area, the Schiphol operation is bound by rules and regulations for use of the runways. These regulations ensure that the noise preferred runways (the Kaag runway 06/24 and Polder runway 18R/36L) are used as much as possible to protect communities close to Schiphol. Furthermore, how these runways are used follows the pattern of arrival and departure peaks as much as possible, in essence the 2 + 1 runway concept. In addition, the use of a fourth runway in the overlap of arrival and departure peaks is limited.

The key point is: The demand for air travel keeps growing, also at Schiphol airport. If Schiphol is to accommodate greater volumes of air traffic, runway capacity needs to be increased to operate within 2 + 1 runway concept, and within the boundaries of the runway use regulations. However, to meet environmental requirements of the greater Schiphol area, and to comply with European regulations, fixed arrival routes need to be implemented which tends to drive down the arrival capacity. Thus the future of Schiphol airport is defined by two requirements which are difficult to reconcile.

Interval Management (IM) is a technology that can increase safety and capacity of fixed arrival route operations. IM requires technology on board of the aircraft which supports the time/distance achieving and keeping functions. This technology has been developed but airline equipage levels are currently zero. However, American Airlines decided in 2018 to equip some 200 A321 aircraft with ADSB-IN technology in order to fly IM procedures into Phoenix, Arizona, becoming the first early adopter of the IM concept

In the 2009 – 2016 timeframe an NLR led consortium has looked into the potential of IM for Schiphol, through fast-time and real-time simulations. The technology looks promising in terms of capacity benefits, but a business case has not been made yet. It is apparent that the dominance of KLM in the arrival peaks poses a business opportunity for IM deployment. It may turn out that, similar to the Phoenix situation, equipage of only KLM aircraft is sufficient to carry the business case.

Goal / Expected benefit:
Fixed arrival routes and low altitude CDA's with high capacity. Stable, safe and environmental friendly TMA operations with high capacity.

Assignment:
Build a business case which supports the aviation sector, and KLM in particular, to move forward with the implementation of Interval Management.

The business case must address the following aspects:
- Business problem or opportunity,
- Capacity benefits on fixed arrival routes with various levels of airline equipage
- Associated risks,
- Expected costs for KLM of equipage, including certification costs
- Deployment timeframes,
- Impact on operations, and
- Organisational capability to deliver the project outcomes.

Make use, where possible, of the decision making process that took place at American Airlines.

The business case is needed in order to be able to take next steps in the validation process. Foreseen steps that are needed are largescale demonstrations of the concept and technology.

Short term objective:
Finding possibilities and motives to implement Interval Management by means of a business case.

Midterm/Long term objective:
-

Involved parties:
NLR (project lead), KLM, LVNL, Schiphol Group, TU Delft
Possibly expanded with partners like Rockwell Collins, EUROCONTROL, Boeing and Airbus.

Source:
-

10 List of Acronyms

AAA	Amsterdam Advanced Air traffic control system
AAS	Amsterdam Airport Schiphol
ACC	Area Control Center
ADSB	Automatic Dependent Surveillance-Broadcast
AMAN	Arrival Management
AMS	Amsterdam
ANSP	Air Navigation Service Provider
AOP	Airport Operations Plan
APOC	Airport Operations Centre
APP	Approach
ASAS	Airborne Separation Assurance System
ATC	Air Traffic Control
ATCo	Air Traffic Controller
ATFCM	Air Traffic Flow & Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
B-KDC	Board – Knowledge & Development Centre
CCO	Continuous Climb Optimisation
CDA	Continuous Descent Approaches
CDM	Collaborative Decision Making
CLM	Concept Lifecycle Model
Cox	Carbon Oxides
CPDLC	Controller-Pilot Data Link Communication
CPDSP	Collaborative Pre-Departure Sequence Planning system
CTOT	Calculated Take-Off Time
CTR	Controlled Traffic Region
DGLM	Directoraat-Generaal Luchtvaart en Maritieme Zaken
DLS IR	Data Link Services Implementing Rule
E_C	Efficiency related to capacity
EHAM	ICAO: Amsterdam Airport Schiphol
Env	Environment
E-OCVM	European – Operation Concept Validation Methodology
E_S	Efficiency related to sustainability
ETA	Estimated Time of Arrival
FF-ICE	Flight & Flow Information for a Collaborative Environment
FL	Flight Level
FMS	Flight Management System
FIR	Flight Information Region
ft	Feet
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
iCAS	iTEC-based Centre Automation System
ILS	Instrument Landing System
IM	Interval Management
IPS	Inbound Priority Sequencing

KDC	Knowledge and Development Centre
KLM	Koninklijke Nederlandse Luchtvaartmaatschappij
KNMI	Koninklijk Nederlands Meteorologisch Instituut
KPI	Key Performance Indicator
LVNL	Luchtverkeersleiding Nederland
Min. IenW	Ministerie Infrastructuur en Waterstaat
MT-KDC	Management Team – Knowledge & Development Centre
NLR	Nationaal Lucht- en Ruimtevaart Laboratorium
NM	Nautical Miles
NOx	Nitrogen Oxides
OCC	Operations Control Center
OTP	On-Time Performance
PCP	Pilot Common Project
PBN	Performance Based Navigation
PoC	Point of Contact
QNH	Query: Nautical Height
RECAT-EU	Re-categorisation for Europe
RNAV	Area Navigation
RT	Radiotelephony
S	Safety
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SIRA	Systematic Risk Analysis
t.b.d	To Be Determined
TMA	Terminal Control Area
TRL	Technology Readiness Level
TTA	Target Time of Arrival
TTO	Target Time Over
TWR	Tower
TU	Technische Universiteit/ University of Technology
WTC	Wake Turbulence Category
XMAN	Extended Arrival Management

Appendix A: Project Template

Template for describing research subjects within KDC. This template differs over the years, as the format is optimized.

Chapter No.	**Project title**					
Ref. Ext. Programme	Programme reference	**Status**	Status of project. Can be Initial, Active, Completed, Stopped, On Hold			
Project Number		**Research Cluster**	Group of projects serving the same goals.			
Customer	Entity which accepts and uses the result	**Performance Targets**	S	Ec	Es	Env
Assignment	Reference		-	✓	✓	-
Project Plan	Reference	**ATM concept**	ATS	ATFCM	ASM	
KDC Board Approval	Date		✓	-	-	
Project Lead		**TRL**				
Sponsor	*Person who provides active support and exerts leverage to progress the work.*	**Lifecycle phase**				
Financial Partner	*Provider/Stakeholder which financially supports the project*	**Priority**				

Introduction:
Short description in common language of the research subject.

Assignment:
Short description of assignment made by the customer. What does the customer expect to be achieved by which date.

Short Term Goal (0 - 3 years):
Breakdown of goals in short term, midterm and long term. The short term goal must be achieved within 0 - 3 years.

Midterm Goal (3 – 5 years):
This goal must be achieved within 3- 5 years.

Long term Goal:
This goal must be achieved within 5 – 10 years.

Relationship with other projects/research:
When considered essential to understanding the place of this research subject in relation to other developments, this paragraph can be added to the description.

Involved Parties:
A list of parties which actively participate in the research.

Background information:
Any other relevant information which helps understanding the relevance of the research subject.

Source:
The source of the research.

Result report:
Reference to the outcome of the project.

Technology Readiness Levels (TRL):
TRLs are a systematic metric/measurement system that supports assessment of the maturity of a particular technology and the consistent comparison of maturity between different types of concept. The definitions of the different TRL levels are given in the table below.

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Appendix B: Relationship between TRL levels and the ATM System Development Phases