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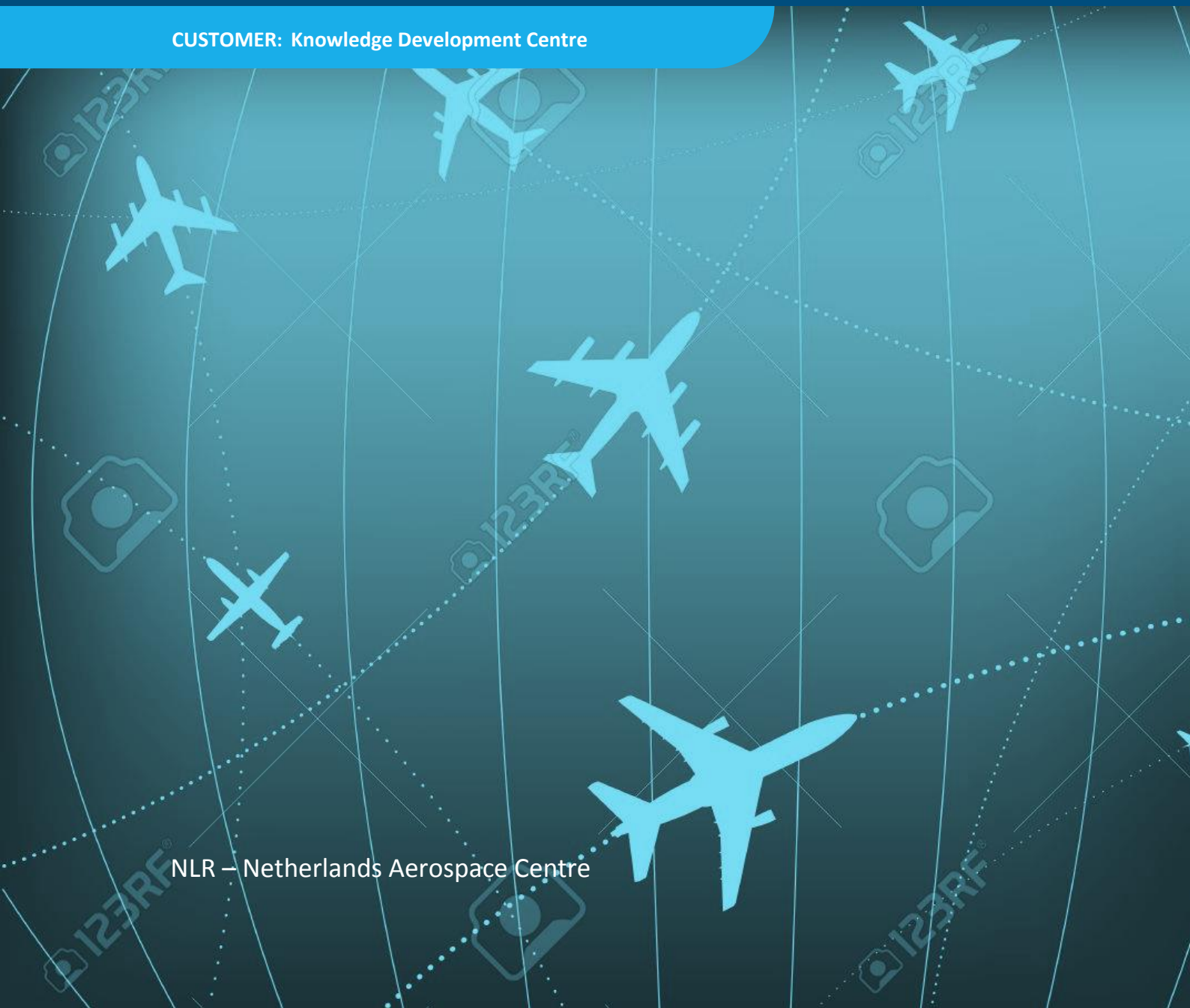
NLR-CR-2016-653 | KDC2016017

KDC Merge - concept refinement

Final report

CUSTOMER: Knowledge Development Centre



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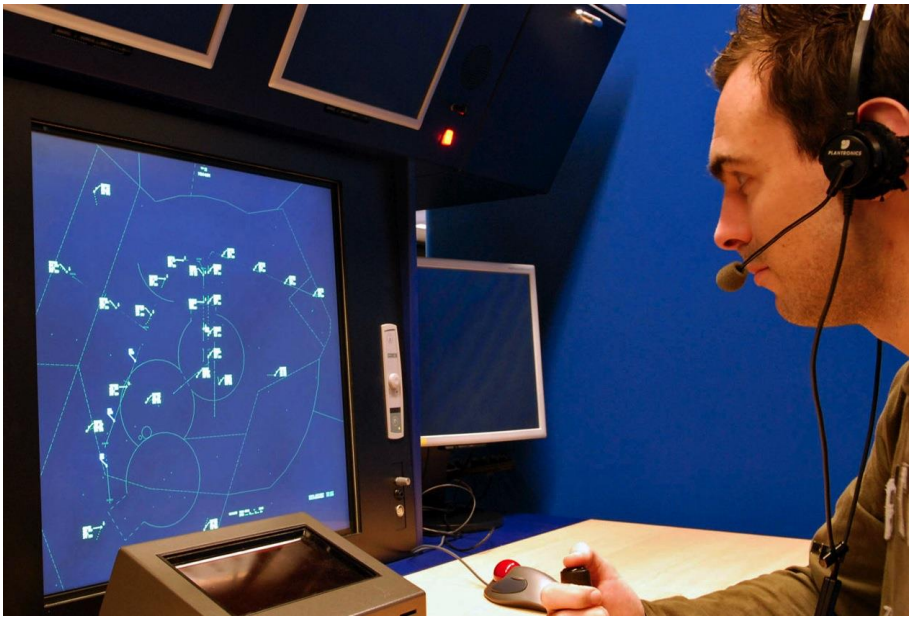

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AUTHOR(S)
D. Nieuwenhuisen
T.J.J. Bos
E.G. Knapen
J. Westland

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DESCRIPTOR(S)
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merge
tool
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NLR
Anthony Fokkerweg 2
1059 CM Amsterdam
p) +31 88 511 3113 f) +31 88 511 3210
e) info@nlr.nl i) www.nlr.nl

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AUTHOR(S):

D. Nieuwenhuisen	Netherlands Aerospace Centre
T.J.J. Bos	Netherlands Aerospace Centre
E.G. Knapen	Netherlands Aerospace Centre
J. Westland	LVNL

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D. Nieuwenhuisen							J. Teutsch							AOAP					
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Summary

From August 2016 to January 2017 NLR, in close collaboration with LVNL, has executed the "*KDC Merge – Concept refinement*" study. The goal of this study was to create the HMI and system requirements for a traffic merge support tool for approach controllers of Schiphol such that the tool is brought to a pre-implementation level.

The goal of the merging process at Schiphol airport is to merge three arrival streams (that follow fixed arrival routes) into one stream to generate a final landing sequence. The traffic merge support tool helps Schiphol TMA controllers to ensure that this merging process goes as planned. The focus of this study was on operation during the night.

In a previous study the main characteristics for a merge support tool have been determined. The main conclusions were that such tool is potentially very useful, that it should be simple and that it should be distance based.
Within this study these results served as a baseline. To bring the tool to pre-implementation level, this study used an approach in which several different evaluation strategies were used. The evaluation strategies included simulation sessions on the NARSIM simulator, creation of movie clips that were evaluated by controllers and discussion sessions with various experts. Using these strategies, an iterative approach has been used to answer a list of research questions. The joined answers to these questions form the main input for the requirements elicitation process. The study aimed for a broadly supported solution; not only by controllers, but also by e.g. the systems department of LVNL. The strong involvement of a AAA expert throughout the study ensured that the requirements are also realistic from a AAA implementation perspective.

The study has shown that controllers unanimously consider a merge support tool useful. Through discussion and evaluation there was consensus about how the tool should look like and how it should behave. During the execution of the study, it has been ensured that the resulting specifications are such that the tool is simple, intuitive and easily trainable.
The answers to the research questions have been translated into a set of 6 system requirements that together describe the HMI and behaviour of the tool. The impact of the implementation process from a AAA perspective has also been described such that a proper estimation can be made about the amount of work involved in the implementation process.

The resulting requirements describe a tool that uses a single arrival route to project the ghosts on. For each flight that is on one of the shorter arrival routes a ghost is displayed on the longest arrival route. A distance-to-go measure is used to determine the exact location of the ghost. Ghosts are displayed even before a flight reaches the IAF as this provides the controllers with early information about the merge process. The controller may click on a ghost which results in the display of a mini-label with additional information about the corresponding flight (e.g. speed or aircraft type). The ghost symbol itself is a letter referring to the arrival route of the corresponding fight.

Some small issues remain open that can quickly be solved with one additional simulation session. One larger issue, which is related to the behaviour of the merge support tool in case of non-nominal traffic, is still open. The wish to have a simple intuitive tool is here at odds with the wish to show the ghost already before the flight reaches the IAF. It has been concluded that a solution to this issue needs to be found outside this project. Once this has been solved, the implementation of the tool on AAA can quickly start.


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Contents

Abbreviations & acronyms

ACRONYM	DESCRIPTION
AAA	Amsterdam Advanced Air traffic control system
ACC	Area Control Centre
ADD	Architecture Decision Document
APP	Approach
CCIS	Closed Circuit Information System
CDO	Continuous Descent Operations
CORADA	Converging Runway and Approach Display Aid
CSCI	Computer Software Configuration Item
EAT	Expected Approach Time
ETO	Estimated Time Over
FDP	Flight Data Processor
FMS	Flight Management System
HMI	Human Machine Interface
iCAS	iTEC-based Centre Automation System
KDC	Knowledge Development Centre
LVNL	Luchtverkeersleiding Nederland (ATC The Netherlands)
MRD	Machine Requirement Document
NARSIM	NLR ATC Research Simulator
Night-OWL	Night Optimal Way to Land
NLR	Netherlands Aerospace Centre
OE	Operational Expert
PoC	Point of Contact
RNAV	Area NAVigation
SDD	System Design Document
SIM	(LVNL ATC) Simulator
STO	Simulator Training Officer
TID	Touch Input Device
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level (NASA)
VNR	Vaste Naderingsroute (Dutch term for Fixed Arrival Route)

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1 Introduction

On request of KDC, NLR has performed a follow-up study to determine the HMI and system requirements for a merge support tool for approach air traffic controllers at Schiphol airport.

1.1 Background

The optimization of the Schiphol operation is an important aspect of the future Schiphol vision. This optimization consists of several elements. The greening of the Schiphol operation (including the reduction of noise pollution) is an important driver for this development as well as the overall optimization of the arrival stream. This strategy obviously has its reflection on the operation of Air Traffic Control The Netherlands (LVNL). LVNL has been working on environmentally friendly procedures for many years. Finding (the often complex) balance between optimizing the operation for efficiency and for the environment is an active topic of research reflected in many projects. An example of such research topic focussed on the introduction of Continuous Descent Operations (CDO) for the night operation of Schiphol. Inbound traffic performs a continuous descent path (as opposed to a stepped descent). Such descents lead to less fuel burn and less noise pollution. To maximize the benefits of CDO operations, interventions in the optimal paths of the aircraft need to be reduced to a minimum. Such reduction can only by achieved when a predictable and stable arrival stream towards the TMA is ensured.

To optimize the arrival stream, LVNL has introduced fixed arrival routes for the night operation. Instead of vectoring traffic in the TMA, with fixed arrival routes, aircraft follow a pre-defined route from TMA border to threshold. By making only minor speed adjustments, the traffic is delivered to the threshold following an optimal descent path. It is clear that fixed arrival routes limit the options for air traffic controllers to intervene in the traffic stream. Also for the success of fixed arrival routes (both night and day) it is important that the traffic stream towards the TMA is predictable and stable. To achieve the required level of predictability, the arrival management process is being optimized by absorbing delay upstream (outside the APP sector). An important critical step in this process is the current Night-OWL development project at LVNL which is supposed to define requirements for the next generation trajectory predictor for LVNL. Upstream delay absorption is a major enabler for both CDO operations and fixed arrival routes. Figure 1-1 provides an overview of the relation between the aforementioned developments.

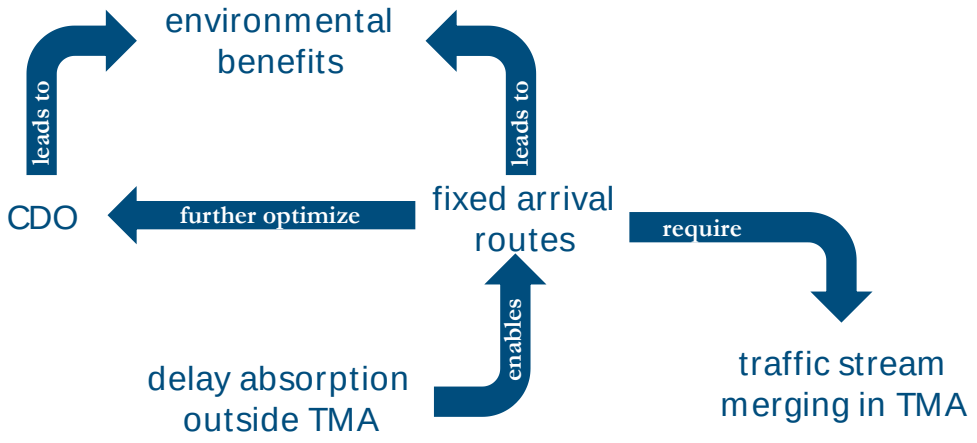

Figure 1-1: Relation between the developments. Environmental benefits include noise reduction on the ground.

The complex nature of Schiphol has led to the creation of several separate arrival streams. When vectoring in the TMA is replaced by fixed arrival routes, this leads to the necessity to merge the arrival streams in a seamless way. The merging process can however become complex and intense (leading to a high workload). Automated tools can be used to support the controller with the merging operation such that he/she can verify that the merging process goes as planned.

In 2014, a preliminary study has been conducted to select the optimal type of tool to support LVNL controllers in ensuring the merging process goes as planned. Part of that study was to make an overview of existing tools through studying literature. The outcome of this overview has been discussed with LVNL controllers in several workshops. The main conclusions of the preliminary study were that such tools should be distance based (as opposed to time based) with ghosting, i.e. applying mirroring of aircraft in one arrival stream to another (master) arrival stream, and that the information provided by the tool should be presented on the radar screen of the approach controller.

This study builds on the results of the previous study by bringing the tool to a pre-implementation level.

1.2 Summary of the 2014 study

In 2014 NLR conducted a preliminary study for KDC to create an overview of solutions to support the merge operations in the Schiphol TMA[1] for fixed arrival routes. Within this study, several different potential solutions to support the controller in the merge operations have been identified in a market survey. Within the study (that included several workshops with controllers), the results of the survey have been discussed and tested against the requirements for such tool in the Schiphol situation.
It has been concluded that a time-based tool would have a large impact on system architecture and in addition would not fit the current way of working. In addition, solutions in this category are solution oriented while LVNL prefers an informative solution. The complexity is larger and such solution would be too time-consuming to implement within the available time. Therefore the conclusion was that the focus should be on distance-based solutions with fixed arrival routes, such as Relative Position Indicator (RPI) and Converging Runway and Approach Display Aid (CORADA).

[1] *Voorstudie ter inventarisatie van oplossingen voor ondersteuning van merge operaties in de Schiphol TMA*, for Knowledge & Development Centre (KDC), NLR-CR-2014-092, September 2014.

The implementation should be as simple as possible, without wind information and with the aim to keep the radar screen free of too much information. Additional identified requirements for the tool include:

- There should be a probing function to get more information.
- The tool should be able to work with multiple merge points.
- The tool should preferably also support controller induced solutions such as speed control and vectoring.

The above requirements form the starting point of this study.

1.3 Goal

The goal of this study is to define (up to TRL level 6) the requirements for a merge support function for approach controllers of LVNL to support the operation at Schiphol airport. Several main choices on the functionality of such a tool have already been made in the preliminary study but many detailed questions about Human Machine Interfaces (HMI) and system requirements remain to be answered. In addition, the effects of strong wind on the usability of the tool will be assessed. This study has iteratively developed a prototype tool in the NARSIM simulation environment such that the final version of the prototype is able to provide the necessary requirements.

1.4 Scope and assumptions

Using the results of the 2014 study, OE input and input from other experts, several assumptions have been defined that form the starting point for this study. These assumptions include:

- The study only considers the **night** operation at Schiphol airport. Results may be used for a future support system if fixed arrival routes are used during daytime, but this is not the focus of this study.
- The study takes into account the night transitions for runways 06 and 18R (see Appendix A for an overview). For other runways, there are currently no night-transitions defined.
- The results of the first preliminary KDC Merge study from 2014 are accepted and used as starting point.
- For each design decision, potential implementation issues on AAA/iCAS are considered and discussed. In case there are several equivalent options, then AAA/iCAS considerations can be decisive for the final choice.
- The first NARSIM prototype of the merge tool will consist of the CORADA code (the version used for SESAR project 5.6.6).
- In the first simulation session, the focus is on the HMI aspects of the tool. Therefore the traffic samples will not have to be highly realistic and will be simplified to keep focus on the HMI; all flights in the simulation are flying directly towards the IAF when they emerge in the simulation. In the second simulation session also non-nominal cases are considered and more complex flight paths are used.

1.5 Overview

In Chapter 2, an overview is provided of how the project was organized, how it was executed and which methodology has been adopted for evaluation. Next, in Chapter 3, the results of the study are presented including the requirements for AAA/iCAS and the open issues. In chapter 4, the results are discussed for several topics. Finally, in Chapter 5 conclusions are drawn and recommendations are provided.

2 Execution and methodology

This chapter describes the methodology that was adopted in this study to answer the main questions. It provides details about the simulation sessions and finishes with the list of research questions necessary to reach the goals of the study.

2.1 Methodology overview

The main tool that was used to create the requirements was the development of a *prototype* in the NARSIM simulation environment. The first implementation of the prototype merge tool was based on the CORADA code (the version used for SESAR project 5.6.6) taking into account the input that was provided during the kick-off meeting. Over the course of the study, an *iterative design methodology* has been used in which in each iteration the prototype was further refined. This was done mostly by creating movie clips that showed the key features of the prototype. These were then shared/discussed with the OEs, either directly or through email. Feedback was used to refine the prototype and the cycle was repeated. At two key moments in this design cycle, simulation sessions with controllers in-the-loop have been conducted with the prototype which led to a full assessment of the state of the prototype at that moment.
Throughout the study, input was further acquired through discussions with experts, both from LVNL and from NLR. In particular HMI issues and AAA/iCAS impact of choices were active topics of discussion. The final version of the prototype served as a blueprint for the requirements definition as described in Chapter 3.

Further activities that have been conducted in this study include:

1. Preparation and exact definition of the simulation sessions;
2. Tuning of NARSIM environment and creation of scenarios for the simulation sessions;
3. Definition of evaluation strategy for the simulation sessions;
4. Reporting and discussion of the results of the simulation sessions in various project meetings;
5. Reporting and drawing final conclusions (this document).

Early in the study, a list of research questions has been created that, if answered, would lead to the list of requirements that forms the main result of the study. The research questions are formed by using expert input (operational, HMI and/or system expertise). This list has been updated several times in the course of the study. The final list is shown in Table 2-3. The answers to the research questions eventually led to the requirements definition. In Figure 2-1 the path from research question to requirement is shown. Depending on the question, it has been answered either through

- expert opinion and discussion;
- OE opinion through off-line evaluation (i.e. movie clips);
- OE opinion through simulation sessions and subsequent evaluation and discussion.

Many research questions can be answered by showing the issue at hand to the OEs using a recorded movie of the radar screen. These movie clips were used for the first few iterations and led to a stable version of the prototype which was suitable to conduct the first simulation session with the OEs. In this first session, the focus was on the *HMI* aspects of the tool. The evaluation of this session led to a more mature version of the tool. After some more development cycles, the second simulation session was conducted which had a focus on the *system aspects* of the tool

(i.e. behaviour of the tool in several circumstances). The evaluation of the second simulation session has led to the final version of the tool which provided the final HMI and system requirements described in this document.

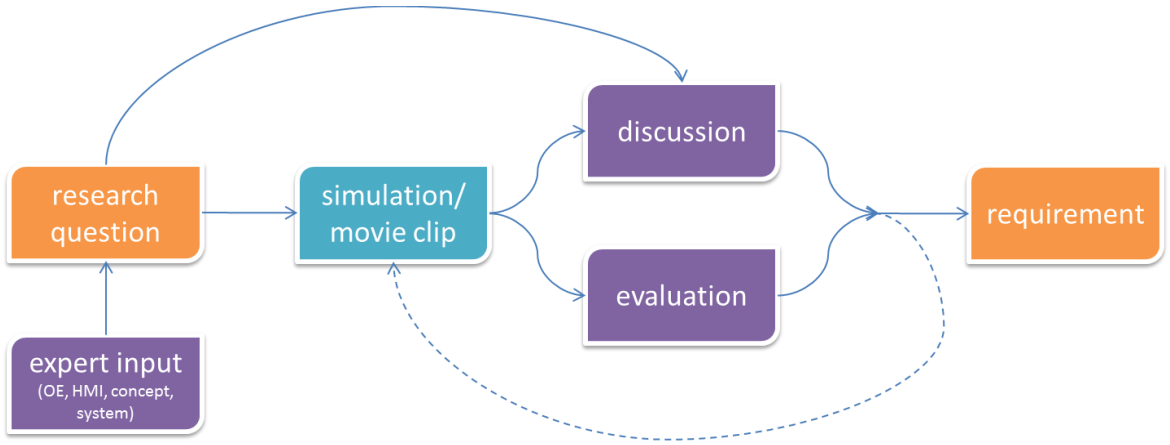

Figure 2-1: Path from research question to requirement

The expertise used during the study is summarized in the table below.

Table 2-1: Overview of expertise used in the study.

Name	Company	Team	Role/Expertise
[redacted]	NLR	Core team	Project manager / ATM expert
	LVNL	Core team	LVNL Project manager / Strategy expert
	NLR	Core team	Technical lead / Developer
	LVNL	Core team	Program manager
[redacted]	LVNL	Core team	Operational expert
	LVNL	Project team	Operational expert
	LVNL	Project team	Operational expert
	LVNL	Project team	Operational expert
[redacted]	LVNL	Core team	Procedure expert
	NLR	Core team	HMI Expert
	LVNL	Core team	Coördinator OSD
	NLR	Project team	HMI Expert
	LVNL	Project team	Consultant operations
	LVNL	Core team	Performance expert
	LVNL	Core team	AAA expert
	LVNL	Core team	Human factors expert

During the execution of the study, several meetings were held to discuss results and to provide input for the development iterations and simulation sessions. The main meetings are summarized in the table below.

Table 2-2: Meeting overview.

Date	Type of meeting	Goal
25-08-2016	All project team members	Kick-off of the project
13-09-2016	Core team	Preparation of the first simulation session
29-09-2016	Core team	Preparation of the first simulation session
11-10-2016	Simulation session	Execution of the first simulation session

25-10-2016	All project team members	Discussion of the results of first simulation session and preparation of the second simulation session	
02-11-2016	Simulation session	Execution of the second simulation session	
15-11-2016	All project team members	Discussion of the results of the second simulation session	
06-12-2016		Core team	Final project outcome discussion

2.2 Research questions

During the kick-off meeting, a mind-map with potentially relevant issues was presented. These issues were considered important contributions for the answers to the main questions of this study. During the kick-off and thereafter, these issues have been translated into *research questions*. The answers to the research questions together form the answer to the main questions and as such form the main output of this study (see Chapter 3). After the kick-off, some items have been added/removed/modified because of progressive insight. The final list of research questions is depicted in the table below. For each research question, an indication is provided about what the best method is to answer the question. This indication is expert judgement by the project team and has the following categories:

- **No interaction**: the question can be answered on the basis of movie clips.
- **Interaction**: the question can be answered during one of the simulation sessions.
- **Other**: the question needs other methods to be answered (e.g. other expertise, discussions etc.).

Some research questions, in the end, required multiple sources of input and some answers have been refined throughout the study.

Table 2-3: List of research questions.

ID	Question/issue	How to answer?
1	Where on the radar screen should the ghosting information be displayed?	No Interaction
2	What should the ghost symbol look like? Full label or just number/letter/line etc.?	Interaction
3	Should there be a ghost label with additional information? When should this label be displayed? What information should be displayed with the ghost label? Should the label presentation be a personal setting?	Interaction
4	When should a ghost be visible? When should it be displayed? When should it be hidden?	Interaction
5	Is a separate information area for ghost information necessary (something like the stack list)?	Interaction
6	Should each label have a ghost on the other arrival routes or should a master/slave system be used?	Interaction
7	What forms/colours should be used to prevent that controllers have wrong associations with these?	Other
8	Should ghosts be clickable? How should the HMI respond to this click? Does this automatically select the associated label? What will happen with the currently selected label?	Interaction
9	Should the appearance of the ghosts be adapted to the associated IAF?	No Interaction
10	Should there be an association between the ghost and the label? How to make association between ghost and label?	No interaction
11	Should there be an option to individually show/hide ghosts? How should the HMI implement this?	Interaction

12	Should there be an option to show/hide all ghosts? How should the HMI implement this?	Interaction
13	Should there be an option in the HMI to change label size?	
14	Should there be any additional interaction that is only accessible by the supervisor?	No interaction
15	Is there a need to show only a selection of the ghosts?	No interaction
16	If the deviation from the fixed arrival route becomes too large, should the ghost be hidden? If so, should he controller be informed about this by the HMI? Should the ghost be presented differently (e.g., colour) when the flight is non-nominal or UCO at ACC?	Other
17	How should the ghost behave when the flight follows a non-nominal trajectory (e.g. it is on a heading)? When is a flight considered to be non-nominal?	Other
18	How to handle deviations in route?	Other
19	How to handle cutting corners?	Other

2.3 Setup of the NARSIM ATC simulator

The basis of the NARSIM setup was formed by the setup that was used during the SESAR 5.6.6 interval management trials run at NLR premises in January 2016. This set-up has been adapted to the needs of the simulation sessions for the merge tool development. It has the following key-features:

- Only one controller position is active: the approach position.
- The Touch Input Device (TID) functions during the simulation.
- There is a static CCIS screen for weather information.
- No STOs were used, traffic automatically responds to controller instructions.
- The default surveillance range setting of the display is 36 NM.
- The map with night transitions is displayed by default.
- Flights spawn far enough outside the TMA so that they enter the radar screen in a natural way.
- Flights are removed when on final or when transferred to tower control.
- The traffic scenarios include approximately 22 inbound flights per hour; this represents an average night for Schiphol.
- The traffic scenarios include a realistic amount of outbound traffic.
- During the trial session both a set-up for runway 06 and a set-up for runway 18R will be evaluated; switching between these two set-ups requires a restart of the scenario.
- When traffic appears on the radar screen, it is assumed to be cleared for the arrival route.
- The basic wind will be nominal (i.e. a year average); this was based on LVNL provided data.

Especially during the first simulation session, many potential HMI setting were tested. To ease this process, almost all options were available through the TID. This had the advantage that many different options could be assessed by the controllers without time consuming restarts of the simulation. These options were only for experimental purposes, in an actual implementation, these options will not exist. In particular, the following options could be switched on/off during the evaluation sessions:

- Show/hide IAF indication in ghost label.
- Show/hide ground speed indication in ghost label.
- Show/hide aircraft type in ghost label.

- Show/hide altitude indication in ghost label.
- Show/hide wake vortex category in ghost label.
- Show/hide aircraft identification in ghost label.
- Enable/disable ghost highlighting when selecting the corresponding flight.
- Enable/disable flight selection when selecting a ghost symbol or label.

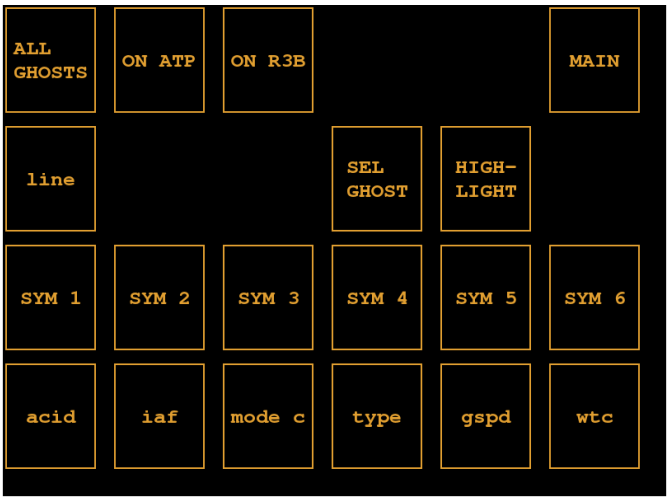

Figure 2-2: Experimental TID screen used during the first simulation session which allowed efficient assessment of many HMI options.

2.3.1 Scenarios

For the simulation sessions, several basic traffic samples[2] were created. These formed the basis for the scenarios[3] that were created in close cooperation with the OEs and other experts.

The source data used for the traffic samples was the data used during the January/February 2016 SESAR 5.6.6 Interval Management trials. The traffic samples were adapted on several parameters to ensure that during the trials as many relevant aspects of the tool as possible are demonstrated/assessed. The duration of each scenario was approximately 20 minutes. The following table provides an overview of the available traffic samples during the simulation sessions.

Table 2-4: Overview of the available traffic samples during the simulation sessions.

ID	Description	Duration
18R – ARTIP3B	General traffic sample for runway 18R during the night operation using the regular night transitions (see Figure 5-2).	20 minutes
06	General traffic sample for runway 06 during the night operation using the regular night transitions (see Figure 5-1).	20 minutes
18R – ARTIP2C (backup scenario)	General traffic sample for runway 18R during the night operation using the (currently unavailable) short night transition for ARTIP.	20 minutes

[2] A traffic sample comprises of a description of all the flights that are used during an exercise. It describes the initial states of the traffic (usually outside of the visible area of the sector that is being simulated). The flights spawn and behave according to an aircraft model, depending on the aircraft type and instructions of the controller.
[3] A scenario describes the whole set of parameters of the simulation; it defines all variables that are used. This includes the traffic sample, but also the specifics of the simulator and the merge tool, GUI settings, visuals etc.

From the traffic samples, the different scenarios were created. For the first trial session, the main focus was on the HMI aspects of the tool and on the method used to display the ghosts. This focus was reflected in the scenarios. For the second session, the focus was on requirements that describe the behaviour of the tool. Also for this purpose, several scenarios were created. The following table provides an overview of the available scenarios in both sessions and their goal.

Table 2-5: Overview of the available scenarios.

Session	Runway/transitions	Details	Goal
1	06	Ghosts projected on all transitions	Assess best way to project ghosts and experiment with several HMI aspects.
1	06	Ghosts projected on longest transition only	Assess best way to project ghosts and experiment with several HMI aspects.
1	18R	Ghosts projected on all transitions	Assess best way to project ghosts and experiment with several HMI aspects.
1	18R	Ghosts projected on longest transition only	Assess best way to project ghosts and experiment with several HMI aspects.
1	18R with ARTIP2C	Ghosts projected on all transitions	Assess best way to project ghosts and experiment with several HMI aspects.
1	18R with ARTIP2C	Ghosts projected on longest transition only	Assess best way to project ghosts and experiment with several HMI aspects.
2	18R	*Wedge* concept active (see Section 2.4.2 for more details).	Familiarization and demonstration of current results
2	06	Wedge concept active	Determine when to show/hide the ghosts.
2	18R	Strong non-nominal wind active	Assess usefulness of the tool when there is non-nominal wind

During the two simulation sessions, the controllers were briefed on the goals and the available scenarios. After some time to familiarize themselves with the simulator and the available TID options, the questionnaires (see Section 2.4) were leading to choose an appropriate scenario. As there were no performance measurements, it was not necessary to use a fixed set of scenarios. Depending on the questions, a proper scenario was chosen and executed. This led to some freedom to focus on specific aspects while still ensuring all research questions were addressed.

2.4 Simulation evaluation

As mentioned previously, two simulation sessions using the NARSIM simulator were part of this study. The setup allowed the use of several consoles simultaneously that presented different ghosting concepts, facilitating comparison between concepts. For each simulation session a separate experiment plan was created which, among others, detailed the objectives of the session, the details of the NARSIM setup and scenarios and the questionnaire. The questionnaires were created with the research questions in mind and were used to guide the sessions and provide a means to process the feedback in a structured manner. Both questionnaires (from the first and second simulation sessions) are added as annexes to this document.

During the NARSIM sessions, controllers were positioned behind a console with an HMI that closely resembled their normal HMI, but now including the presentation of ghosts. The controllers worked in parallel, but all in separate simulations (no interaction/discussion between the controllers during the simulation). They were presented with typical night-time traffic. The controllers were asked to use a think-aloud protocol to assess their first impressions and

line of thought. Sequentially, the controllers were asked about their opinions and preferences individually, and afterwards joined together in a discussion with the aim to reach consensus.
The important questions to be addressed in the trials were:

1. Does the tool support the controller in monitoring the traffic?
2. Is the tool intuitive/easily trainable?

Each controller was assigned an observer who was responsible for ensuring each question on the questionnaire was addressed. The observer asked additional questions when necessary.

2.4.1 First simulation session

In this session, controllers were initially asked about their first impression of the merge tool. This allowed controllers to provide their first thoughts and to assess how they perceive the concept in the first instances.

Table 2-6: Summary of the first simulation session.

Session location	**NLR NARSIM**
Date/time	11 October 2016, 09.00am
Duration	4 hours
Participants	**Controllers** [redacted] (controller, LVNL) [redacted] (LVNL) **Other team members/observers** [redacted] (NLR) [redacted] (LVNL) [redacted] (NLR) [redacted] (NLR)

The session then focussed on the HMI requirements listed below.

Ghost symbol
Seven options for a ghost symbol were presented one by one (by using the TID, controllers could switch between the various presentation modes). For each presentation, the controllers were asked whether it differed enough from a normal track symbol, whether a ghost could be mistaken for a flight (and vice versa), and whether it brought any (wrong) associations to mind. Controllers were asked which symbol optimally supported the controller and why. And which one, according to their opinion, was the most intuitive (require the least explanation)?

Label
Next, mini label options for the ghost were presented. The controllers were asked what they thought could optimally support them in their task. Whether they preferred no mini label or, in case a mini label was preferred, which information in the label was necessary and to which extent the presented information should be customizable.

Interaction
Interaction options with the ghost presentation or corresponding flight were discussed. The controllers were asked what they expected to happen when selecting a track symbol or the ghost.

When and where to present the ghost

Finally two options for ghost presentation were shown to the controllers:

1. All flights on each route were ghost-plotted on the other two routes;
2. Ghosts were only presented on the longest route.

And controllers were asked which they found most appropriate.

Additional input

In the first simulation session, only two controllers were available. To collect more input, the two other controllers involved in the study were shown videos of the prototyped ghosting tool and traffic samples of the first session. This activity was conducted in separate sessions at LVNL, using the questionnaire of the first session in a slightly adapted form.

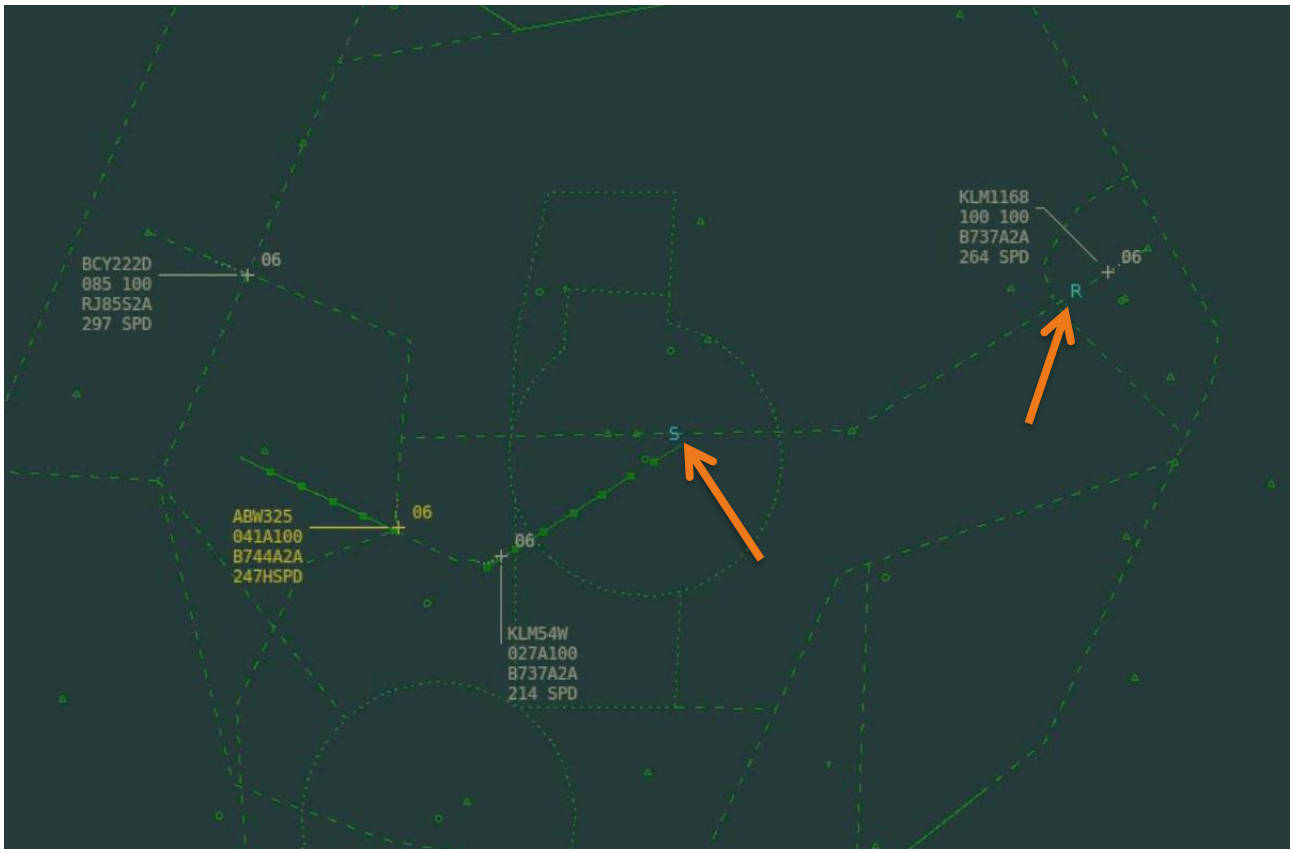

Figure 2-3: Screenshot of the radar screen that shows two ghosts as pointed to by the arrows.

2.4.2 Second simulation session

In the second session, all four participating controllers were involved in parallel simulations carried out at the same time. For this trial the emphasis was on the behaviour of the merging tool in features like filtering of flights, deviations from the normal routes (the so-called non-nominal flights) and implications of working with ghosts. The same approach as in the first simulation session was adopted: controllers were presented with a list of questionnaires with suggestions on which scenario to use, but also had a lot of freedom to experiment.

At the start of the session, the results of the first simulation session (and the other feedback collected through discussions and feedback on the movie clips) was demonstrated to verify the right choices were made. In the remainder of the session, the following topics were presented and discussed.

Table 2-7: Summary of the second simulation session.

Session location	**NLR NARSIM**
Date/time	2 November 2016, 11.00am
Duration	4 hours
Participants	**Controllers** [redacted] (LVNL) [redacted] (LVNL) [redacted] (LVNL) [redacted] (LVNL) **Other team members/observers** [redacted] (NLR) [redacted] (LVNL) [redacted] (NLR) [redacted] (NLR) [redacted] (LVNL) [redacted] (LVNL) [redacted] (LVNL)

Labels

The option to show/hide all ghost labels by means of a TID input was presented to the controllers. Also the question was raised whether the controllers preferred an alternative option to show/hide the ghost mini label items. This alternative provided the option to individually select which information was presented in the ghost mini label.

When and where to present ghosts

The logic for ghost presentation was explained to the controllers. The initial implementation used the following rules to determine ghost display:

1. Before passing the IAF, the flight should be in a wedge shaped area (see Figure 3-1) extending the first leg of the arrival route.
2. After passing the IAF, the flight should not be farther away from the route than some maximum distance.

Using the 06 traffic sample, the controllers were able to influence traffic before it reaches the IAF to test if the display rules fulfilled expectations. Controllers were asked to experiment, for example by giving flights a heading or a direct–to instruction, to evaluate (the behaviour of) the ghost plot.

Effect of wind

The effect of wind was evaluated. As the tool works distance based, the effect of wind is not reflected in the location/presentation of the ghost. Instead the effect of the wind is reflected in the behaviour (i.e. speed of motion) of the ghost. This was a deliberate choice made by controllers during the first merge project as this reflects the way of working of LVNL APP controllers (i.e. distance based, not time based). However, it was necessary to evaluate the effect of off-nominal winds on the concept to ensure the usefulness of the tool under non-nominal wind conditions.

Figure 2-4: Impression of the second simulation session at NLR premises.

3 Results and Requirements

The feedback on the movie clips, the simulation sessions and the discussions (both after the simulation sessions and during separate meetings) have provided the necessary input to answer all research questions. The answers were translated into definitions and requirements that bring the tool to TRL 6 (prototype demonstration in a relevant environment). Two issues, related to traffic using a non-nominal route, remain and are described in Section 3.3, including several potential solutions.

3.1 Definitions

Nominal flight
A nominal flight is a flight that enters the TMA via the IAF (or with a small deviation due to turn-radius of the FMS) and follows the transition. A nominal flight may receive flight delay in the ACC area of responsibility.

Non-nominal flight
A flight that is not following (parts) of the transition. This can be because of a variety of reasons including weather deviation, necessary extra spacing, etc.
It is necessary, both for the situation before reaching the IAF and the situation after passing the IAF, to define when a flight is considered to follow the standard arrival route (and is called nominal), or when it is considered *non-nominal*.
A flight is considered to be non-nominal if either:

- It has passed the IAF but is at a distance larger than 4NM from the standard arrival route, or,
- If it has not yet passed the IAF *and* it is outside a wedge shaped area in front of the IAF. For each IAF an area is defined relative to the bearing of the arrival transition starting at this IAF, by the specification of a distance, an angle at which the slice starts and an angle at which the slice stops. This area represents a (vertically unlimited) volume of airspace that the flight crosses before passing the IAF.

The above definition is clarified in the picture below.

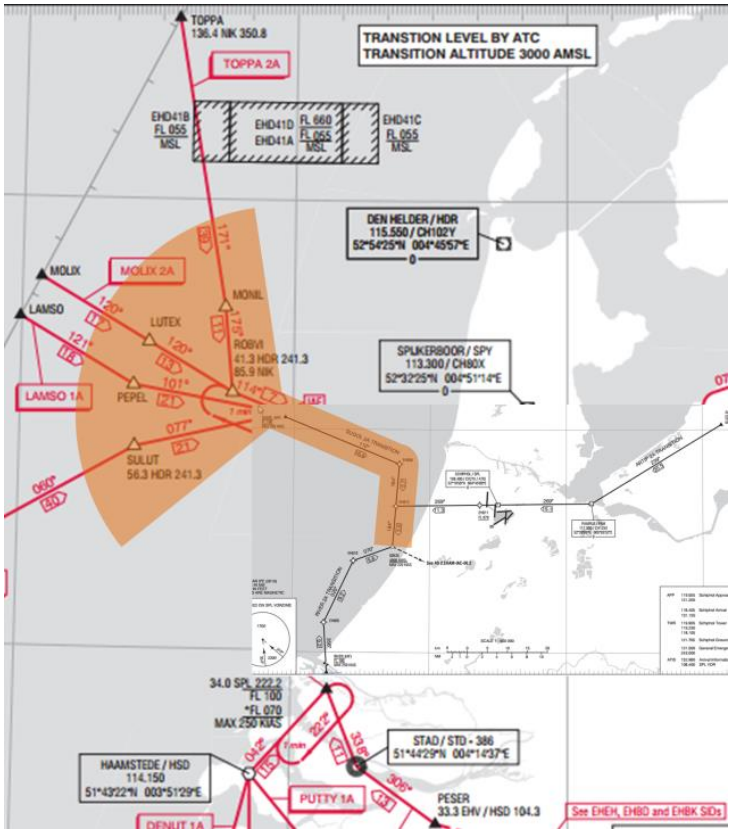

Figure 3-1: Example for runway 06 and the SUGOL arrival transition; if the aircraft is outside the shaded (wedge shaped) area, it is considered to be non-nominal.

An angle of 60 degrees on both sides of the arrival route suffices in all case except when the ARTIP2C transition is in use. In that case 80 degrees is necessary to ensure that the EELDE1A STAR is included in the wedge.

Distance-to-go

Distance-to-go is the distance that the flight still has to travel if it follows the arrival route. In case the flight is still within the wedge shaped area in front of the IAF (see Figure 3-1), the distance-to-go is calculated from the current position of the flight until the threshold by adding the straight line distance between the flight's position and the IAF to the sum of the length of all segments of the transition.

If the flight has already passed the IAF, the distance-to-go computation starts by determining the route segments a flight has already completed (each pair of waypoints in a route define a route segment). To determine which segments have already been passed, a line perpendicular to the segment is used (bisector). Flights on one side of the bisector are said to have passed the segment; flights on the other sided have not (see Figure 3-2a).

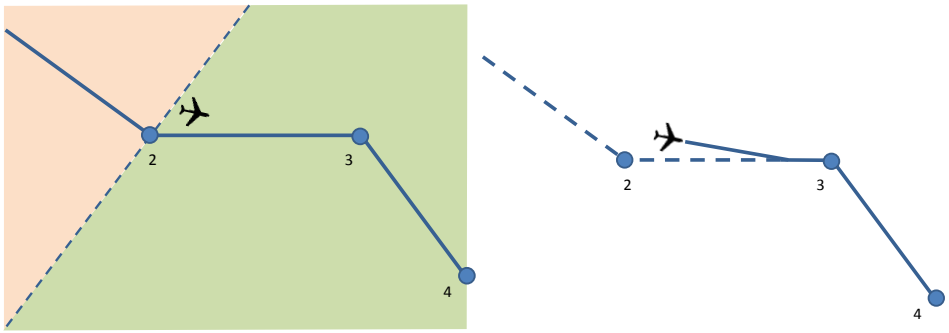

Figure 3-2: (a) Determination of which segments have been passed. (b) Extending a line from the heading of the aircraft, the solid line is used to calculate the distance-to-go.

To determine the distance to go, a line is extended from the heading of the aircraft. The aircraft is assumed to re-join the transition at the intersection point and then to follow the transition again (see Figure 3-2b). The distance-to-go calculation of the prototype does not take into account the radius of each turn in the transition, or the impact of the aircraft type on these radii.

In case of a non-nominal flight, the distance-to-go is not defined. For a discussion about this issue, see Section 3.3.

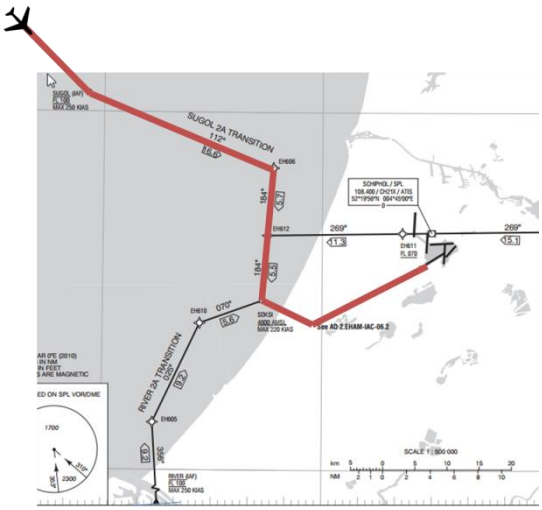

Figure 3-3: distance-to-go definition, the red line shows the distance-to-go of the aircraft in the top left corner.

Threshold distance

This is the distance from the threshold, to the location of the ghost, following the standard arrival route (on which the ghost is to be depicted) in opposite direction. The distance of the ghost is calculated based on the published transition, ignoring the radius of each turn in the transition, or the impact of the aircraft type on these radii.

Display interval

After the flight enters the display interval, a ghost is shown. If it leaves the interval, the ghost is hidden. The display interval is entered when the distance-to-go is equal to the length of the arrival route on which the ghost is displayed. The display interval ends when the flight passes the final merge point (in case of runway 06, this is SOKSI, in case of runway 18R this is NIRSI).

Ghost symbol
This is the symbol that is used to show the ghost.

Ghost mini label
This is the (optional) label that can be shown along with the ghost symbol, displaying additional information about the associated flight.

3.2 Software Requirements Specification

This section lists the software requirements for implementation of the results of the study. The requirements are acquired from the answers to the research questions. In addition, considerations that led to the requirements have been added. These considerations are included to ensure that results of discussions are saved for future reference.

A few issues remain open after this study and are therefore not covered by the requirements; these are related to non-nominal situations. The argumentation for these issues and a sketch of potential solutions can be found in Section 3.3.

REQ-1	First display of ghost
When	Flight enters display interval
What	Display a ghost symbol on the longest arrival route, with a threshold distance equal to the distance-to-go of the flight. Update this ghost each time the aircraft track is updated. If the arrival route of the aircraft *is* the longest arrival route, then no ghost is displayed. In case an aircraft deviates from the arrival route, its ghost is still projected *on* the arrival route.
Considerations	Cannot wait until aircraft reaches IAF. The ghost plot is then too late and you lose valuable time.

REQ-2	Hiding a ghost
When	Flight leaves the display interval
What	When the aircraft leaves the display interval, the ghost is automatically hidden (without an additional indication) and no longer displayed.
Considerations	

REQ-3	How to show a ghost symbol
When	For each ghost
What	A ghost is displayed as a letter that represents the arrival route of the associated flight. The letter uses the standard AAA font for track symbols and standard size. The letter can either be “A”, “R” or “S”, for arrivals via ARTIP, RIVER and SUGOL respectively. The colour of the ghost is light blue, with colour coding RGB 0, 218, 218 (Colour Id #00DADA).
Considerations	IAF indication is necessary to quickly associate the ghost with a label. Colour should not be used to distinguish between IAFs as a clear association between colour and IAF does not exist.

REQ-4	Selecting a ghost
When	The controller clicks on a ghost
What	1. The label of the associated flight is coloured light blue, no input can be made. 2. If another label was selected (yellow), then this selection is removed. 3. If the mini-label option has been turned on (see REQ-5), a mini-label is shown (below the ghost symbol). The mini-label is based on the existing SSR label and uses the same font and colour as the ghost symbol and has a comparable formatting as the SSR label. The mini-label shows the following information: • IAF indication (already covered by the ghost symbol); • Aircraft type; • Groundspeed; • Wake turbulence category (only displayed if different from “medium”).
Considerations	In this way, selecting a ghost can be used to associate it with the track. Only displaying the information when clicking on the ghost will ensure that all controllers can have the information they need when necessary.

REQ-5	Turning ghost mini label on/off
When	Controller can use TID to turn mini label on/off
What	In the TID menu, an option is present to turn the mini label option for the ghost symbol on/off. This setting is applicable to all ghost symbols. The location and working of the buttons should be in line with current AAA practice.
Considerations	

REQ-6	Intensity of ghost symbol
When	In case TAR or KNMI weather is displayed
What	TAR weather is presented as an overlay over the radar screen. This also uses blue shades to display the information. To ensure ghost symbol is not hidden by the TAR weather, the intensity of the colour of the ghost symbol should be adaptable using the TID screen.
Considerations	The colour of the ghost symbol (and ghost mini-label) has been chosen such that there is no association with other elements of the AAA system. One feature remains that could in theory cause confusion, which is the TAR weather colour.

3.2.1 Additional considerations

Inherent to an iterative design approach, in the course of the process several options, both HMI and system related have been rejected because of various reasons. Here, these options are described together with the reason of rejection. In Appendix A and Appendix C, more details can be found in the answers to the questionnaires used during the simulation sessions.

- Using “A”, “R” and “S” for the ghost symbols is the only option accepted by *all* controllers. Other options (such as arrows) were preferred by some, but rejected by others. The principle that the ghost provides an indication of the arrival route of the associated label is supported by all as this ensures a quick link between ghost and label.
- The option to individually switch ghosts on/off is considered too confusing; it makes the concept unnecessary complex.

- Influence on the appearance of ghosts (e.g. change of font) is also considered too confusing.
- Additional filtering of ghosts (e.g. show only ghosts that are on the arrival route) is unwanted as it may lead to confusion.
- There is no need for specific interaction of the supervisor with the tool.
- There are cases in which the ghost is already visible, but the corresponding label is not. Particularly in such case, additional information in the ghost mini label can be useful to provide early cues about the merging process.

In general, controllers have stated multiple times that they prefer traffic to be transferred to APP using the nominal procedures because this results in understandable behaviour of the ghost. Although it is recognized that in exceptional cases support for non-nominal traffic is necessary, the starting point should be nominal traffic.

3.3 Open issues

For the vast majority of questions related to the HMI and the behaviour of the tool, the study has resulted in clear choices that are supported by all of the involved operational experts. However, a few open issues remain. These are described below.

3.3.1 When to show the ghost

There was no consensus among the operational experts about whether *each* label should have a corresponding ghost in *all* circumstances. There are a few situations in which these issues could arise:

Non-nominal flight:

1. When an aircraft is outside the wedge shaped area and also more than 4NM away from the fixed arrival route (i.e. outside the shaded area of Figure 3-1).

Nominal-flight:

2. When an aircraft is in a holding.
3. When an aircraft gets a delaying vector in the ACC area of responsibility.

In the above cases, the added value for a ghost symbol is reduced as it is very difficult to estimate the distance to the threshold for the aircraft. This means that it is also very difficult to estimate where the ghost should be displayed. On the other hand, if a label has no corresponding ghost, this may confuse a controller because it may be difficult to see when this occurs. There was no consensus among the involved operational experts on how to resolve this issue.
An additional development iteration with movie clips may be sufficient to resolve this issue, however, this could not be done within this study. Potential solutions include:

- Hide the ghost but provide a cue (e.g. a symbol in the label) that this has been done.
- Show the ghost in a different shape or colour to provide an indication that “strange” behaviour can be expected.

3.3.2 Glitches

Even when a flight follows a nominal path, there may be glitches in the behaviour of the ghost. An example is the situation in which the flight passes the IAF within a distance of a few NM, for example because of turn-radius (this is acceptable behaviour). At some point, the algorithm will decide that the aircraft passed the IAF and the distance to go will make a small jump which will lead to a small jump forward of the ghost.

Potential solution
A straightforward solution could be to use a weighted average of the distance-to-go via the next waypoint and the distance-to-go when the next waypoint is skipped. This should lead to a smooth motion of the ghost while still showing the ghost on a realistic position.

3.3.3 Conflicting requirements

One other issue that has not yet been resolved involves two conflicting requirements that are explained below. Three movie clips have been made to illustrate some of the open issues discussed in this section. These movie clips can be found on the project's SharePoint site at LVNL, in the section "Specialistische documenten | Animaties". They can also be found on the following (unlisted) YouTube channel:
https://www.youtube.com/playlist?list=PLBdoQI7oTLUMY2uVm6Yy4AC2He0UHXvgp

Requirement 1: Already from an early start of the study, it has been clear that the tool should be as simple as possible for several reasons. Firstly, the tool should be intuitive because controllers only work night-shifts once or twice every six weeks. In case the tool is more complex, it will be more difficult for controllers to work with the tool and the chance increases that they will not use it at all. Secondly, because of training issues, the tool should not be complex. If the tool requires additional training, then it will be much more difficult to implement it in the operation.

Requirement 2: To ensure that the APP controller gets information about the merge process as early as possible, the ghosts are projected on the longest arrival route. A direct consequence is that when the ghost is displayed for the first time, the corresponding flight is still under control of ACC. As the future trajectory of the flight is not always clear (the flight can experience delay imposed by ACC in the ACC area of responsibility), the motion of the ghost will be influenced by the delay, and can result in a slow, frozen, or backward moving ghost.

In the first simulation session, it was clear that it is a strong wish of the controllers that ghosts are displayed as soon as practicable. Therefore, as soon as a flight enters the display interval, a ghost is displayed on the longest route. This means that at first display, the flight has not passed the IAF and is not yet under control of the TMA controller. In such cases, the algorithm needs to estimate the distance-to-go which leads to several challenges. To make the estimation, an assumption is needed about the future trajectory. However, if this assumption is not correct, then the ghost may show "strange" behaviour. This is illustrated by several examples below:

1. **Non-nominal-flight:** The aircraft is on a heading (e.g. weather deviation) when inside the wedge. The algorithm will need to make an assumption about the distance-to-go and will first assume that, at some point, the aircraft will continue on the fixed arrival route. If this assumption is incorrect, an update of the distance-to-go calculation is necessary. This will lead to a corresponding jump forward of the ghost.
   Example: movie clip "merge_app_week8_1" ("moapp S8 E1" on YouTube) illustrates this example. Flight KLM686, on a direct to NIRSI, passes SUGOL at a distance of about 3 NM. While inside the wedge, the

distance-to-go calculation is based on the assumed flight path direct to SUGOL, continuing via EH606 to NIRSI. On leaving the wedge, the distance-to-go calculation becomes based on the actual flight path direct to NIRSI. This event triggers a jump in the ghost symbol displayed on the RIVER3B transition of about 10 NM.

2. **Nominal-flight:** The aircraft is on a direct IAF (or already on the arrival route) and the distance-to-go seems clear. The flight has to be delayed because the ETO differs from the EAT. The controller decides to add delay to the flight by using some vectors. The algorithm will need to make an estimate on the distance-to-go and will assume that the aircraft will at some point turn back to the IAF. However, the vectoring before the IAF may increase the distance-to-go and in such case the ghost will move backwards.
   Example: movie clip "merge_app_week8_2b" ("moapp S8 E2b" on YouTube) shows the impact of ACC delaying flight KLM16P before handover. While the aircraft is still out of range for the APP controller, it is vectored off the direct route to RIVER, causing the ghost already displayed on the ARTIP2A transition to first slow down and then move backwards (in the direction of ARTIP) on the PAMPUS – ARTIP segment of the ARTIP2A transition. When the flight is turned on a direct to RIVER the ghost continues its expected movement.
3. **Nominal-flight:** The aircraft is put in the holding. This will lead to a cycle of increasing and decreasing distance-to-go and corresponding "strange" behaviour of the ghost.
   Example: movie clip "merge_app_week8_3" ("moapp S8 E3" on YouTube) demonstrates a similar situation as described above; in this case flight KLM16P is instructed to hold at RIVER. The ghost displayed on the ARTIP2A transition continues to move forward and backward between EH611 and PAMPUS with different speeds.

A ghost that shows potentially confusing behaviour jumps forwards or moves backwards on the arrival route. Although being correctly displayed, given the distance-to-go calculations, such behaviour requires more insight of the controllers into the details of the algorithm and as such contradicts with Requirement 1. If this insight is not present, such behaviour of the tool may create confusion, which is highly undesirable. In addition, controllers may lose confidence in the tool.

Potential solutions

For the solution of this issue, the project team has identified several potential solutions:

a. Accept that the tool requires more complex algorithms which lead to more complex behaviour of the ghosts and explain them to the controllers. This solution will also require more attention to training. There are many ideas to improve the behaviour of the ghost. Several examples are summarized below:
   - For the glitch issue, a more sophisticated method of distance-to-go calculation may be able to provide a solution.
   - If, in the future, a *direct-to* is entered into the system, this input could be used for the distance-to-go calculation.
   - Instead of moving the ghost backwards, freeze it at its current position (maybe also provide an indication for this).
   - Do not jump forwards but temporarily increase the speed of the ghost.
   - In case the standard arrival route is not followed properly, add more intelligence to the distance-to-go calculation.

b. Hide or mark ghosts for which their distance-to-go cannot be properly estimated. This will need to be reflected in the tool. Some initial ideas include:
   - Give ghosts for which the aircraft is not under control of the APP controller a different colour.
   - Give ghosts that do not show nominal behaviour an indication (e.g. a "*").
   - Blink a ghost that shows non nominal behaviour.
   - Add a specific indication for specific behaviour (e.g. "H" for holding).

- Add an additional field in the ghost mini label with an indication of the reason for the non-nominal behaviour.

c. Only show the ghost when the flight has passed the IAF. To ensure there are no issues with flights in a holding, a ghost should only be displayed when its control has been transferred to APP.
d. Simply accept (as an air traffic controller) that, sometimes, there is “strange” behaviour and provide an explanation for this in the training for the tool.
e. Do not present a ghost, or cancel a ghost, for non-nominal flights.

4 Discussion of the results

In this chapter the results of the previous chapter are discussed and the potential implementation impact on AAA/iCAS is described.

4.1 Usability of the tool

The reason to initiate the first KDC merge project was that it was expected that support for merging traffic on arrival routes would be useful for approach controllers to verify that the merge operation progressed as expected. This idea was further refined by the results of that project which stated that it should be a *distance-based* merge tool like the RPI of MITRE or NLR's CORADA tool.
The assumption that such a tool could be useful has been fully confirmed by the results of this study. The initial reactions on the tool by the controllers were very positive and confirm that a merge support tool for the Schiphol TMA can be very useful.

4.2 Effects of strong wind

In the second trial, one of the scenarios focussed on the effects of strong wind on the usability of the tool. As the tool is distance based, a stronger wind will influence the behaviour (i.e. speed) of the ghosts. As the controllers are fully used to aircraft with lower groundspeed due to strong wind, this was not seen as a disadvantage. In contrast: the controllers indicated that this is the behaviour they would naturally expect from the ghosts in strong wind conditions. Some comments from the controllers on this subject:

- "Behaviour of the ghost is predictable."
- "The support of the tool is just as good as in nominal conditions."
- "I do not expect a lot of familiarization to work with the tool in these conditions".

More comments can be found in Appendix C (questions 20-24 of the second simulation session).

4.3 Complexity and trainability

As controllers only work during the night once or twice every 6 weeks, it is very important that the learning curve is not too steep. Many design decisions have been taken with that fact into account. There is, however, a balance between usability and simplicity of the tool. The more functions the tool gets (this includes more intelligent algorithms), the less simple it becomes. Finding the right balance is therefore a challenge. If all traffic is assumed to fly on a direct course towards the IAF (without delay), then no major issues are identified. In case the (nominal) flights are delayed (by a given heading, or a holding) before reaching the IAF, or (non-nominal flights) are off the transition route (e.g. extra delay or weather deviation), more complex issues arise which are directly reflected in the behaviour of the ghost. These have been discussed in detail in Section 3.3. To ensure that there are no issues with trainability it has been suggested that trainers get involved in the assessment of the tool. However, this will only be useful if the open issues are resolved first as the solutions to those issues may introduce more complex tool behaviour.

4.4 Implementation issues

In this section the impact of an implementation of the requirements in the LVNL IT system is discussed. An important challenge for this study was to specify a tool that can be implemented within AAA and later iCAS.

In the Architecture Decision Document (ADD) "Merge Operations Tool"[4] a target implementation architecture in the AAA timeframe (the pre-iCAS timeframe) is proposed. It is advised that the implementation shall be done in AAA and the core functions shall be part of the System Design Document (SDD) CSCI.

The core "Merge Operations Tool" Machine Functions are identified and mapped on the AAA CSCI's. The core Machine Functions identified are:

- Configuration;
- Activate;
- Select;
- Compute;
- Present.

Special attention is paid to the Next Position (NXTPOS) calculations that are part of the core Flight Path handling of the FDP and are input for the Compute process.
This implementation is favoured because:

- It requires low effort of AAA team;
- Provides sufficient flexibility for the foreseen Merge Advisory Tool functions.

High Level implementation issues:

- iCAS is insufficiently investigated in the current activity. Before implementation in AAA is decided, the impact on iCAS must be evaluated. Implementation in iCAS must also be planned and agreed. This is not yet considered.
- In case complex algorithms using wind or complex trajectory calculations functions are required, the proposed architecture does not suffice. Such developments are not foreseen.
- Little is known about future developments in the Merge Tool Operations. Therefore the flexibility of this architecture to support future developments cannot be evaluated.
- Support for DCT operations, especially direct-to instructions in the TMA are badly supported by AAA. In case such support is wanted, AAA must be closely involved to propose feasible solutions.

In the following tables, the system requirements are repeated and the system requirements are mapped onto the Machine Functions. Then for each Machine Function a list of AAA requirements is provided. For each function a proposed implementation in AAA is provided identifying re-use of existing or the need for new functionality. Finally the effort to implement the requested functionality is provided.

REQ-1	First display of ghost
When	Flight enters display interval
What	Display a ghost symbol on the longest arrival route, with a threshold distance equal to the distance-to-go of the flight. Update this ghost each time the aircraft track is updated. If the arrival route of the aircraft *is* the longest arrival route, then no ghost is displayed. In case an aircraft

[4] ADD – Merge Operations Schiphol – Jan Westland, F018-2016-07-01.

	deviates from the arrival route, its ghost is still projected on the arrival route.
Considerations	Cannot wait until aircraft reaches IAF. The ghost plot is then too late and you lose valuable time.
Mapping MRD functions	Configure, Select, Compute, Presentation
Configure	Description: The transition routes that are used to present the ghost tracks shall be statically defined for each runway transition combination. Implementation: Standard adaptation in AAA can be extended. Standard: Solution fits in the architecture. Effort: Low.
Select	The flight to be used for presentation must fit a number of conditions: Flight Plan Related: Inbound EHAM, following a transition, Next Route Point on the Fixed Arrival Route (Dutch: VNR). All these items are available in the SDD. Position related: Flight must be within a predefined area. Distance based: Projection of the flight must be within the TMA on the projection route. Implementation: In the AAA flight database the necessary items are available. Furthermore a geographical area can be defined using standard polygons as available in AAA to select a flight viable for presentation. In case more complex distance calculations algorithms are used, the distance selection shall be based on two steps: pre-filtering and post compute filtering. Standard: Solutions fit AAA standards. Effort: Low.
Compute	The distance for a flight to the threshold must be calculated. And the position on the projection route must be calculated. This requires: • Knowledge of the NXTPOS, the next waypoint of the flown route. • Depending on the algorithm: Special handling in turns, special handling in positional deviations. Special handling for non-standard manoeuvres. • Special handling when passing waypoints not exactly. The NXTPOS in AAA is not available for the TMA routes. Furthermore in AAA it is not possible to specify a DCT to a waypoint in the TMA. NXTPOS should be determined at one place: the FDP. For these calculations the FDP must/shall be updated. In case DCT are involved the algorithm should change calculations. It has not yet been determined how. It must be possible to distinguish cleared DCT to a waypoint versus automatically updated NXTPOS. Knowledge about the calculation along a route shall be re-used. In TPs some basic aircraft performance modelling is used to calculate these distances. In case re-use of these algorithms is required it must be decided whether FDP calculations are re-used or whether the calculations are that simple that they can be programmed in the SDD (HMI) as presentation logic. As long as very basic algorithms can be used then: Implementation: NXTPOS in the TMA must be implemented in the FDP; Simple distance calculations based on position of the flight and following the route starting from the actual NXTPOS to the threshold can be implemented in the presentation logic. Standard: Not yet; NXTPOS in TMA not available; route distance calculations not available in presentation logic. Effort: High.
Display	The display of a ghost label requires the position where the ghost label shall be presented. The presentation of a label is a standard feature of AAA presentation logic. The position is provided by the compute function.

	Implementation: Re-use of presentation logic of AAA. Standard: Yes, re-use of CRDA prepared functions. Effort: Low.

REQ-2	Hiding a ghost
When	Flight leaves the display interval
What	When the aircraft leaves the display interval, the ghost is automatically hidden (without an additional indication) and no longer displayed.
Mapping MRD functions	Select
Select	Implementation: Only flights within the merge-contour are selected for presentation. Standard: Re-use of standard AAA contours. Effort: Low.

REQ-3	How to show a ghost symbol
When	For each ghost
What	A ghost is displayed as a letter that represents the arrival route of the associated flight. The letter uses the standard AAA font for track symbols and standard size. The letter can either be “A”, “R” or “S”, for arrivals via ARTIP, RIVER and SUGOL respectively. The colour of the ghost is light blue, with colour coding RGB 0, 218, 218 (Colour Id #00DADA).
Considerations	IAF indication is necessary to quickly associate the ghost with a track. Colour should not be used to distinguish between IAFs as a clear association between colour and IAF does not exist.
Mapping MRD functions	Present
Present	Implementation: Configure label. Standard: Yes. Effort: Low.

REQ-4	Selecting a ghost
When	The controller clicks on a ghost
What	1. The label of the associated flight is coloured light blue, no input can be made. 2. If another label was selected (yellow), then this selection is removed. 3. If the mini-label option has been turned on (see REQ-5), a mini-label is shown (below the ghost symbol). The mini-label is based on the existing SSR label and uses the same font and colour as the ghost symbol and has a comparable formatting as the SSR label. The mini-label shows the following information: • IAF indication (already covered by the ghost symbol); • Aircraft type; • Groundspeed; • Wake turbulence category (only displayed if different from “medium”).
Considerations	In this way, selecting a ghost can be used to associate it with the track. Only displaying the information when clicking on the ghost will ensure that all controllers have the information they need when necessary.
Mapping MRD functions	Present

Present	Implementation: The link between track and ghost track is known to presentation logic. The colouring in AAA can be adapted for ghost tracks. The presentation of the mini-label conforms to the standard in AAA. Selection of a ghost-track with different behaviour than selection of a normal track is not available in AAA and requires considerable engineering. For radar labels in AAA there are already different algorithms for ACC and APP for appearance and display. When this functionality is implemented, the selection of these flights shall be re-evaluated and brought in line. Selection Logic: Complex, provided new behaviour of HMI, creates knock-on requirements, such as where to stop highlighting, where to provide flight information. Effort: High.

REQ-5	**Turning ghost mini label on/off**
When	Controller can use TID to turn mini label on/off
What	In the TID menu, an option is present to turn the mini label option for the ghost symbol on/off. This setting is applicable to all ghost symbols. The location and working of the buttons should be in line with current AAA practice.
Mapping MRD functions	Present
Present	Implementation: This shall be conform label content selection for normal tracks in AAA. It must be noted here that the position of information in a mini label is fixed. This deviates from the implementation in NARSIM. Standard: Yes. Effort: Low.

REQ-6	**Intensity of ghost symbol**
When	In case TAR or KNMI weather is displayed
What	TAR weather is presented as an overlay over the radar screen. This also uses blue shades to display the information. To ensure ghost symbol is not hidden by the TAR weather, the intensity of the colour of the ghost symbol should be adaptable using the TID screen.
Mapping MRD functions	Present
Present	Implementation: The final colouring of the ghost labels shall be determined and evaluated in the SIM environment. The NARSIM environment is not suited for this task. It is not advised to implement change of intensity of the ghost label in AAA since this complicates the operational use of the tool.

5 Conclusions and next steps

Starting from the results of a previous study that sketched the main characteristics of a merge support tool, within the present study the requirements elicitation process for such a tool has been executed. This ensures that the tool is brought to a pre-implementation level. As it was clear from the beginning what the objectives were, the approach of the study was straightforward and goal oriented. A set of research questions was created which, when answered, would provide the necessary input to create both the HMI and system requirements. To answer all research questions, three methods were used:

1. Use movie clips with radar screen images to show various considerations.
2. Use a controller-in-the-loop exercise.
3. Use discussions with controllers and other experts.

An iterative development process was adopted in which a prototype of the tool was continuously improved by using feedback from the three above methods. The development process and the final version of the tool provided sufficient details to answer all research questions.

5.1 Conclusions

The conclusions about the usability of the tool are clear: controllers see value in such a tool. An important principle that was adopted in this study and appreciated by the project team was to keep the support tool as simple as possible. This is important for two reasons. First, controllers only work during the night once or twice every six weeks. A tool with a steep learning curve is therefore difficult to use. Second, a more complex tool will need additional training, which would make the introduction of the tool more complex.
The requirements of the tool are perfectly in line with this principle as long as aircraft are not delayed and enter the TMA on a direct heading towards the IAF, and stay on the transition route. In that case, there are few open issues left before implementation can potentially start.

Of the identified issues in Section 3.3, the glitch issue has a relatively simple solution that, with some additional effort, can be resolved. This is also true for the issue about whether each label should always have a ghost or that in some circumstances a ghost can be absent. The third issue, however, is more difficult to resolve as it is the result of two conflicting requirements. If ghosts are already displayed before a flight reaches the IAF, this may, in some cases, lead to non-standard/non-expected behaviour of the ghost. Several solutions have been suggested and a brief follow up study is necessary. This study will also need to show whether and how an off-route flight should be supported by the merge tool. A part of the solution to this last issue lies outside of this study and should be solved by an agreement between area control and approach control. Approach controllers have stated multiple times that they prefer traffic to be transferred to APP using the nominal procedures because this results in better understandable behaviour of the ghost.

Throughout this study, several interesting paradigms have been used that are supposed to have contributed to the success of the simulation sessions. These may be of value for future studies as well:

1. Especially the HMI requirements definition process required that controllers had the ability to quickly see several different options (e.g. several different symbols to represent the ghost). In a simulation, this often requires a lot of time as for each option the simulation has to be restarted which is a time consuming process. Creating the possibility for the controllers to use the TID to switch between several options during

the execution of a simulation ensured that the best possible comparison could be made between the various options. Different combinations of options could be tested in different circumstances at any time in the simulation.

2. The questionnaires used for the evaluation ensured that the controllers had sufficient time to familiarize themselves with the tool while still ensuring all questions could be answered. In other words, the controllers had the freedom to “play” with the simulation instead of following a prescribed script.
3. By creating some additional scenarios that were available during the simulation sessions, controllers had the ability to experiment a little more when time permitted.

5.2 Next steps

The requirements listed in Section 3.2 provide sufficient detail for a brief follow-up study of the merge support tool. Within this study, the focus should be to find the answer to two different questions:

1. Nominal flights: How should the merge tool support delay within the ACC area of responsibility?
2. Non-nominal flights: (How) should the merge tool support deviation of the transition route?

It is expected that with one additional simulation session, a choice can be made between the potential solutions sketched in Section 3.3. Trainers and less experienced controllers should be involved to draw definitive conclusions about trainability of the tool.

In addition to the above points, a decision should be made about how strict the procedures should be followed when traffic is transferred from ACC to APP as this influences the behaviour of the ghost. With these issues resolved, the implementation process, on either AAA or iCAS, can quickly start based on the requirements and considerations provided in Section 4.4.

Appendix A Night transitions

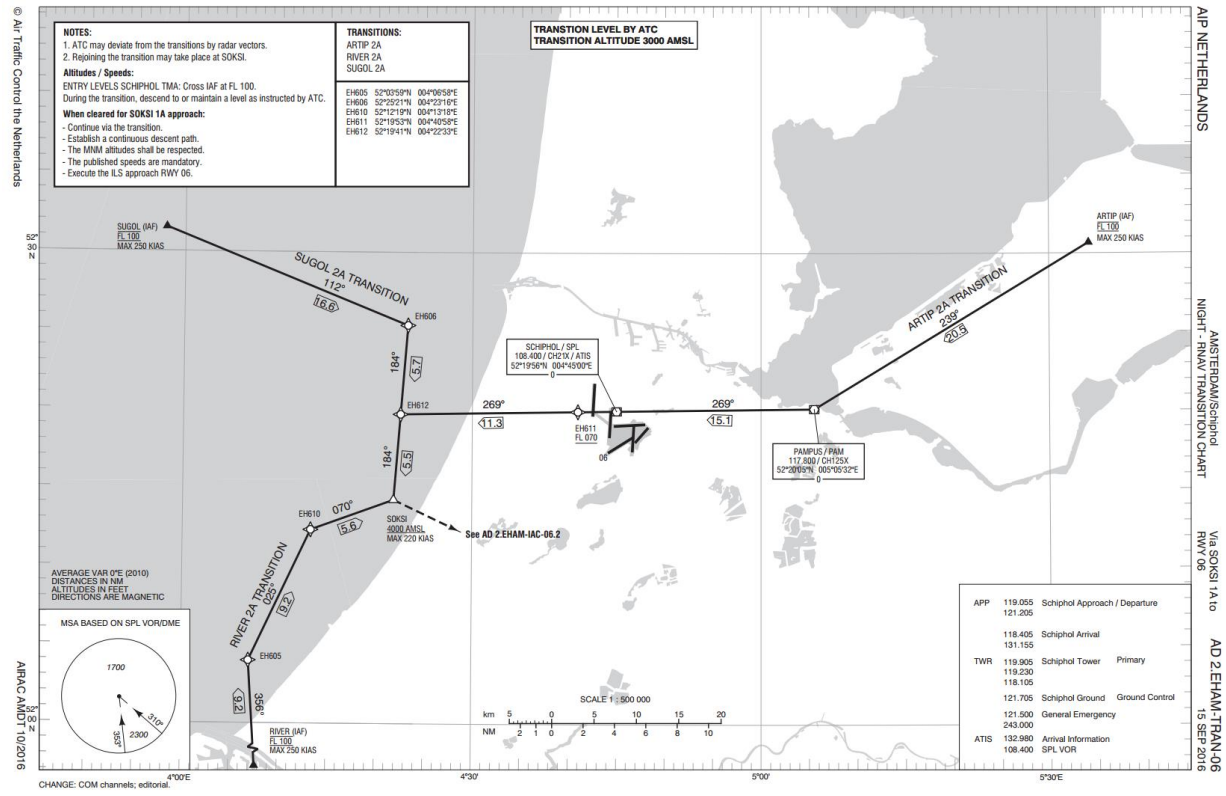

Figure 5-1: Night transitions for runway 06

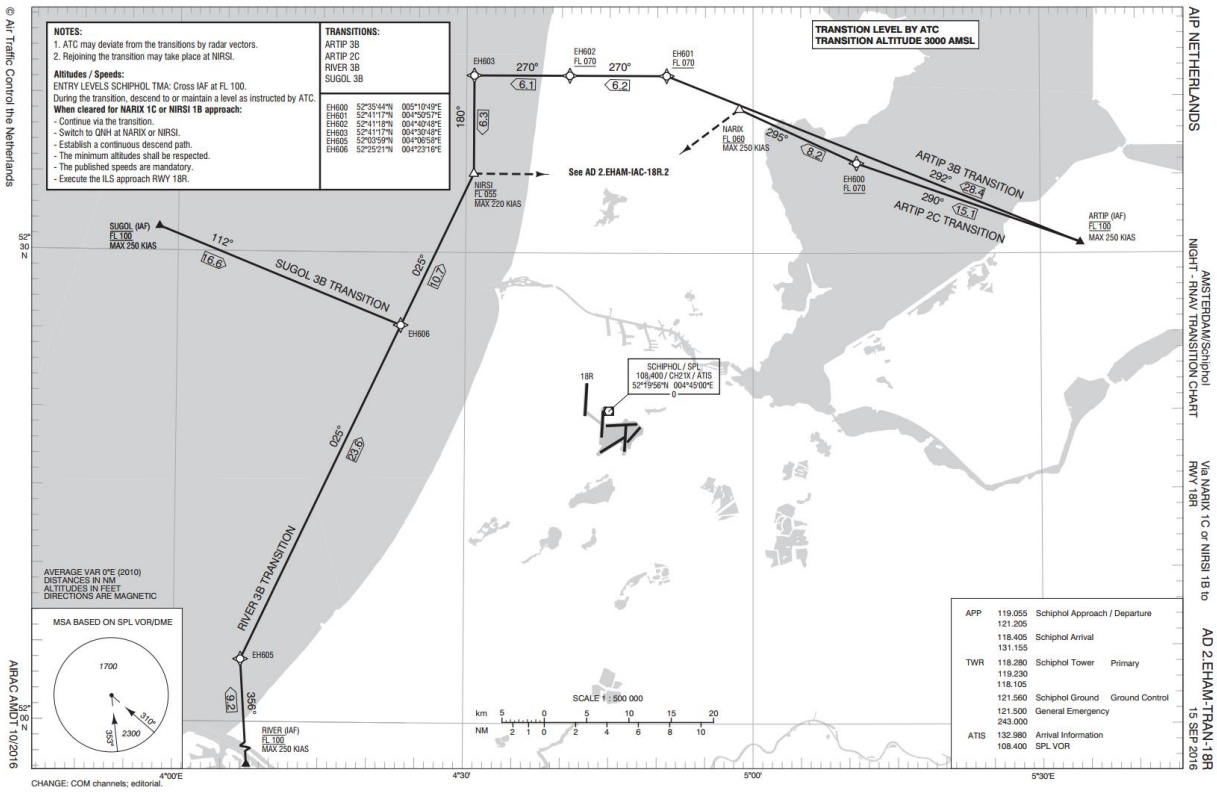

Figure 5-2: Night transitions for runway 18R

Appendix B Questionnaire and answers 1st session

Onderstaande vragen worden gesteld tijdens de simulatie. Doorvragen om de verkeerleiders hun mening te laten onderbouwen.

Neem de tijd om te laten wennen aan het concept, zonder instellingen te veranderen.

Controller 2, Controller 3

0. Wat is de eerste indruk? Simulatie set-up is goed en bruikbaar voor beantwoording vragen. (Gebruik scherm: alle projecties, symbool: G) Duidelijk welke ghost bij welke vlucht hoort Ik zou iets met de snelheid van het achterste vliegtuig doen, dat kan ik goed zien aan de ghost. Je kunt hier wel wat mee. Het geeft geruststelling. Je ziet wel meteen of je iets moet doen. Je ziet vrijwel meteen dat er één veel te kort op zijn voorganger zit. SA opbouwen gaat sneller dan zonder ghosts.

Ghost symbool

Verschillende symbolen voor de ghosts worden getoond.

Per optie de volgende vragen: a) Kun je eenvoudig afleiden welke ghost bij welk tracksymbool hoort? b) Duidelijk leesbaar? c) Eenduidig te interpreteren? d) Symbool voldoende onderscheidend van track symbol? e) Roept het symbool associaties op?
1. G (Sym 1) Relatie ghost – label lastig af te leiden. Niet in een oogopslag, geen negatieve associaties. A. Nu wel, maar als het drukker wordt wil ik weten uit welke stack dit zou komen. B. Ja, kleur valt op. C. Ja D. Ja E. Maakt duidelijk of je wel of niets meer moet doen en of je moet handelen.
2. A, R, S (Sym 2) Nadeel: A is AAA symbool, dan zou het anders moeten zijn. Relatie ghost – label wel duidelijk. R associeert met Rotterdam. Scherm alle projecties: Hier word ik niet vrolijk van, want ik weet niet waar het over gaat. (observatie: toen hij wist wat de letters betekenen vond hij dit verreweg de fijnste representatie van de ghost). Het wordt heel druk, met 5 vliegtuigen lijkt het of ik er 10 heb. Andere schermen: Als het op 1 route geprojecteerd wordt is het beter omdat je dan minder clutter hebt. Wel makkelijker dan vorige. B. Ja C. Ja D. Ja E. Ja, waar je op mikt.
3. ↙ARTIP, ↗ RIVER, ↘ SUGOL (Sym3) Ja, duidelijk. Geen verwarring. A. Ja, maar lastiger dan sym 2. B. Ja

C. Nee. Ziet er grappig uit, maar moeilijk te interpreteren. D. Ja E. Ja
4. ↗ ARTIP, ↙RIVER, ↖ SUGOL (Sym4) Idem, maar minder intuïtief. Helemaal niet handig. Nog minder intuïtief, erg verwarrend. A. Na wennen wel. Als je het eenmaal weet. B. Ja. C. Niet bepaald eenvoudig. D. Ja. E. Weet nog niet welke.
5. A, R, S omcirkeld (Sym 5) Beter dan sym2, maar verder dezelfde bezwaren. Met cirkel verwarrender welke vliegtuig welke is, meer dan bij sym 2. Cirkels zijn storen, waarom is moeilijk om aan te geven. B. Nee, R lijkt veel op A.
6. A, R, S omcirkeld en inverse (Sym 6) Minder duidelijk, ghost erg prominent aanwezig. Zelfde als sym 5.
7. Streepje loodrecht op de route (line) Relatie label-ghost lastig. Deze gaat ook nog. A. Als het rustig is makkelijk, als het drukker wordt dan wordt het lastiger. C. Redelijk. Minder duidelijk dan andere.
8. Welke van de getoonde opties geeft de optimale ondersteuning? Pijl, sym 5 zou ook een optie kunnen zijn. Sym 2 (letters).
9. Welke vergt het minste uitleg? Is meest intuïtief? Pijl en sym 5. 2
10. Vind je de kleur blauw een logische keuze? Blauw goede keuze, brightness zou instelbaar moeten zijn. Prima, geen verkeerde associaties. TAR-weer is ook blauw. Ja, maar TAR weer is ook blauw, dus misschien niet genoeg onderscheid hiermee.
11. Vind je de kleur blauw voldoende onderscheidend? Ja, wel instelbaar qua intensiteit. Ja
12. Denk aan de range and bearing line, voorzie je verwarring als die geselecteerd is? Nee, die is wit in AAA en ziet er heel anders uit. Nee, want kleur in NARSIM is niet de juiste.
13. Zou je kleurcodering willen voor onderscheid tussen routes? Dennis: nee, wellicht anderen wel, wellicht waard om te onderzoeken. Zou ik moeten zien, maar denk het niet.
14. Vind je het onderscheid naar route belangrijk? Ja, ghost moet indicatie geven waar hij vandaan komt. Ja, al gezegd.
15. Alternatieve suggesties voor een symbool? Ghosts hebben nu geen history dots. Zou wellicht een optie zijn. Niet echt, sym 2 is goed.

Label

Verschillende label opties worden getoond, dmv *"SSR" label. De inhoud vertoont eerst alleen het vliegtuig type, waarna de toevoeging van ground speed, en vervolgens de hoogte zal worden getoond. Ook een aanvulling 'h' van*

heavy zal aan het type worden toegevoegd indien de vlucht in die wake vortex categorie valt. Speel eens met de verschillende instellingen

16. Welke informatie heeft toegevoegde waarde om in het ghost label te tonen? Of is het label overbodig? IAF indicatie Dennis: verder geen info nodig. Soms: wake-cat nodig + ground speed. Wellicht bij aanklikken, hier zouden meer OEs iets over moeten zeggen. Aanklikbaar: callsign, type, ground speed. Dit zorgt ervoor dat meer mensen hun voorkeur terugzien. IAF = overbodig, want ik gebruik sym 2 (dat is dus dubbelop). ACID = niet handig, want lijkt te veel op track label. Als deze aan staat lijkt het of er extra vliegtuigen zijn. Allemaal niet, want het is te verwarrend. Ik ga ze aanzien voor vliegtuigen. De hele rij is overbodig.
17. Welke label instelling vraagt de minste uitleg/ is het meest intuïtief? VBC was onduidelijk, want moet WTC zijn. Op zich wel duidelijk verder.
18. Is een ghost plot met label nog voldoende onderscheidend van een normale track symbol? Ja, niet hetzelfde formaat als label. Aanklikbaar helpt hierbij. Nee.
19. Wat is jouw voorkeur betreffende de instelbaarheid van de labels (aan/uit/instellingen)? Moet passen in huidige systeem. Alleen aanklikbaar. Niet aanzetten. Sommige collega's misschien wel. Toch, hoe minder hoe beter.
20. Leiden deze labels de aandacht af? Bij te veel informatie wel, lijkt drukker dan het is. Ja
21. Zouden de labels kunnen leiden tot clutter (bij drukker verkeer)? Ja, zeker als ze te dicht bij elkaar zitten. Vooral verwarring.
22. Heb je suggesties voor een alternatief formaat van het ghost label? Als informatie presenteren dan dezelfde kleur blauw label weergeven bij aanklikken label. Nee

Interactie

Vier opties worden getoond:

- Geen interactie
- Ghost clickable waardoor de bijbehorende vlucht wordt geselecteerd
- Bij selectie van vlucht licht de ghost op.
- Ghost is selecteerbaar net zoals bij een normale vlucht

23. Welke interactievorm heeft toegevoegde waarde voor het mergen? Ghost selecteren → selecteert ook label. Ghost selecteren, dan ook geel kleuren. Gevaar: je kunt dan invoer maken bij ghost, dan wil je niet. Ik denk het niet, misschien als het wat drukker wordt. Overbodig om op te lichten/highlighten. Geen nadelen als het wel aan staat. Er is geen risico dat ik de ghost voor een vliegtuig aanzie wanneer deze geel wordt.
24. Welke interactievorm is het meest intuïtief? Niet nodig, als ik een moet kiezen 2-zijdig (laatste optie) het meest intuïtief.
25. Andere suggesties voor interactie met ghosts? Suggestie: ghost aanklikken, dan label blauw en geen invoer mogelijk! Bij label klikken ghost niet highlighten. Nee

Ghosts - waar en wanneer?

Twee verschillende varianten van het ghosting concept worden getoond:

1. Ghosts van alle 3 routes op alle andere routes
2. Ghosts worden alleen geplot op de langste route

26. Welke optie biedt de beste ondersteuning tijdens de nachttransities? Alles op alles geeft verwarring en haalt je uit je primaire proces. Optie 1: te druk Optie 2: Bij voorkeur om te kunnen kiezen, mits dat geen problemen oplevert voor de overdracht.
27. Welke optie vergt het minste training/uitleg? Projectie op langste transitie. Bij 18R heeft RIVER de voorkeur. Volgende sessie extra onderzoeksvraag: 06: ARTIP, 18R: RIVER met keuze voor ARTIP. Bij aanzetten bijv. nachtmodus moet de instelling standaard zijn of dit moet aangeven welke instelling aan staat om te voorkomen dat je verkeerd kijkt. Dit hoeft niet op het grote scherm, maar op de TID.

Scenario met baan 06 wordt getoond

28. Bij projectie alleen op de langste route: vind je het verwarrend dat de ghosts nu op een andere route worden geprojecteerd? Vormt dit een risico? Niet verwarrend → langste transitie is intuïtief. Nee, wat meteen duidelijk. Alle mogelijkheden die er in zitten moeten ook altijd geselecteerd kunnen worden. Interessant om bij sim sessie te kijken wat er geselecteerd wordt na een baanwisseling. Altijd langste route of de route die het meest recent gebruikt is?
29. Vanaf welk moment zou je een ghost plot van een vlucht willen zien? (Goed uit laten leggen... vanaf de IAF op de langste route: dat betekent dat van vluchten op de kortere routes al voor het bereiken van de IAF op de lange route moeten worden geplot...? of niet?) In geval van 06 te laat! Altijd binnen een bepaalde range, bijv. 30 NM. Ghost laten zien dan aanname direct RIVER of SUGOL als niet binnen trechter dan niet weergeven. Misschien 10 mijl voor IAF? In ieder geval eerder dan dat ze op de route zitten. Liefst vanaf het begin van de

langste route.
30. Op welk moment moet een ghost verdwijnen? Meest logisch lijkt het moment van samensmelten. Zoals nu is prima
31. Zijn er situaties denkbaar waarin je de ghosts uit zou willen zetten? Samen met transities gaan ze aan en uit. Misschien bij heel rustig verkeer. Ik zou hem in principe niet uit willen zetten.

Trainbaarheid

32. Zie je ook situaties waarbij de ghosts verwarrend zijn? Geen issues voor training. Als je hem gebruikt zoals nu niet. Met meer informatie wel verwarrend, verder niet.
33. Leiden de ghosts je aandacht af? Alleen bij te veel informatie. Nee
34. Snapte je direct wat de ghost was, voelde dit intuïtief? Ja, bij 06 informatie te laat! Ja, zie 1e indruk.

Algemeen

35. Heb je nog zaken gemist in deze eerste HMI sessie? Wat moet zeker in de volgende sessie worden geëvalueerd? – Moment projecteren – Meer outbounds – Non-nominals, hoe omgaan Eerder projectie Simulatie met baanverandering en kijken wat er gebeurt met de instellingen. HF afdeling uitnodigen voor volgende keer en hun mening vragen. Overdraagbaarheid, kleurtjes/labels.
36. Heb je verder nog suggesties of opmerkingen? Ghost altijd op transitie, ook als kist off-track is. Wel beetje bekend vanwege CRDA.
37. Hoe zou het aanbieden van ghosts nog beter kunnen? History dots, blauw? Misschien betere planningstool aan de voorkant. In combinatie met ghost ben je eigenlijk al.

Overige op- en aanmerkingen

2e sessie: nog geen STO's, wel HDG en SPP instructies. Hoe andere 2 VKL op hetzelfde niveau krijgen? Gedrag bij harde wind Direct naar andere punten dan IAFs Eigenlijk wil ik vluchten die op de route gaan komen al zien (eerder dus). Fijn als je zelf kunt switchen tussen routes.

Appendix C Questionnaire and answers 2nd session

Onderstaande vragen worden gesteld tijdens de simulatie. Doorvragen om de verkeersleiders hun mening te laten onderbouwen.

Tijdens de tweede evaluatie zijn er 3 basis scenario's beschikbaar:

1. Dit scenario is voor gewenning en toont de resultaten van de eerste trial sessie. Er wordt ook één nieuw HMI aspect getoond.
2. Dit scenario is om te evalueren wanneer een ghost wel en wanneer niet getoond dient te worden.
3. Dit scenario is om het gedrag van de merge tool te evalueren met niet-nominale wind.

Start met scenario 1 op basis van 18R
Het doel van dit scenario is om te wennen aan de simulatie en om de resultaten van de eerste trial te laten zien. Alle elementen kunnen rustig worden nagelopen om zeker te zijn dat de keuzes gedragen worden door de controllers.

Controller 1, Controller 2, Controller 3, Controller 4

Labels kunnen aan en uitgezet worden via de TID. Hierbij gaan ze óf allemaal tegelijk aan, óf allemaal tegelijk uit.

1. Wat vind je hiervan? Prettig Voorkeur voor extra informatie bij aanklikken, maar kan leven met deze keuze Kleur is goed. Labelinformatie bij ghost is niet nodig, je kunt eerder een cleared APP geven. Uit is beter, want het label is storen als het drukker wordt. Ik kan ook gewoon naar de labels van de vliegtuigen kijken. Aan de ghost is al te zien waar hij vandaan komt, dus ik kan snel het juiste vliegtuig vinden.
2. Wat heb je liever betreffende de instelbaarheid van de labels van ghosts: • de optie dat je het label kan instellen zoals het label van een vliegtuig in AAA, dus instelbaar per informatie-element of • een on/off knop ? (dit bestaat nu niet in AAA) Waarom? Beide acceptabel. Bij unanimiteit on/off, anders instelbare labels. Het is een hulpmiddel → wil zo min mogelijk informatie Je haalt je informatie uit het normale tracklabel. Je neemt eerder een beslissing op basis van de ghost. Aan/uit geeft minder poespas. Het menu voor selectie is zoals we gewend zijn.
3. Hoe vaak denk je dat je dit zult gebruiken/ het label zult wijzigen? Eén keer aan het begin van de nachtdienst. Gaat label (ghost function) automatisch aan als transities aan gaan? Alle informatie staat al in het label, dus niet nodig. Label van de ghost nooit wijzigen. Goed om op de RIVER … te lopen. Als het drukker is, dan zou ik er wel een keertje naar kijken, dus even aan en uit zetten. Niet standaard aan, want ik wil hem niet verwarren met een echt vliegtuig. De informatie waar ik naar zou kijken is snelheid, als ik het label al aan zet.
4. Welke van beide opties is het makkelijkst aan te leren/ vergt het minste uitleg? Pagina op TID? Leerbaarheid prima. Alleen de letter leren is makkelijker aan te leren. Maakt niet veel uit, want labels instellen kunnen we al.
5. Wat vind je van de bruikbaarheid van de in het label getoonde informatie? WTC – dan zit je zowiezo krap. C/S + g.s. Niet nodig.

Niet bruikbaar, geen toegevoegde waarde. Rustig beeld. Het voelt heel natuurlijk, omdat het je timmermansoog ondersteunt is de letter voldoende!
Goed. Type en snelheid is relevant, dus dit is prima. Dit is informatie die ik zou zoeken. Ik zou het label uit zetten, maar anderen misschien niet.

Selecteer een ghost -> een eventuele selectie van een label wordt nu automatisch ongedaan gemaakt. Tevens kan voor het blauwe label nu geen informatie ingevoerd worden.

(In AAA kun je een track selecteren zonder vluchtplan. Ook dan kun je geen invoer maken voor deze vlucht).

6. Wat vind je hiervan?
Goed.
Goed.
Ja, is acceptabel.

7. Wat verwachtte je dat er zou gebeuren bij selectie van een ghost?

8. Wat vind je ervan dat een eerder geselecteerde vlucht nu niet meer geel is?
Acceptabel.
Is acceptabel.
“snap de vraag niet”

9. Wat vind je ervan dat bij een blauw label de informatiebalk leeg is?
Goed.
Geen probleem.
Geen probleem, je wilt toch geen invoer maken.

10. Hoe intuïtief vind je deze manier van selectie?
Geen nadelen.
Ik zie geen nadelen.
Ik zie geen nadelen.

11. Welke eventuele nadelen zie je aan deze manier van interactie?

TAR meteo informatie tonen

12. Wat valt je hierbij op? Welke eventuele suggesties ter verbetering zie jij?
Zoals nu gepresenteerd geen kans op verwarring. Je kan de intensiteit nog inregelen als je er wel “last” van hebt.

Door verschil in intensiteit zie ik geen probleem.

Als er veel buien zijn wordt er niet op de Transitie gevlogen, we hebben het hier in het verleden over gehad en besloten dat dit acceptabel is.

Tweede scenario met 06. Het gaat er nu om te bepalen wanneer een ghost wel en wanneer deze niet getoond dient te worden. Er wordt gebruik gemaakt van trechters rondom de IAF om dit te bepalen. Als een vlucht in deze trechter zit, wordt een direct IAF aangenomen door het systeem en wordt de ghost getoond. De trechters kunnen zichtbaar gemaakt worden. Er kan met de hand ge-vectored worden om te zorgen voor niet-nominale tracks.
Ná de IAF wordt een ghost alleen getoond als de vlucht binnen 2NM van de VNR route zit.

13. Wat vind je van het moment (locatie) waarop de ghosts voor het eerst worden getoond? Scenario 1: Het is fijn om alvast te zien, omdat je dan kennis hebt als er 1 van andere stack komt. Is nu goed! Moment is goed, je hebt ruim de tijd om te reduceren. Prima, zou er graag zelf mee oefenen (met pseudopilot).
14. Welke situaties vallen je op (bijvoorbeeld waarin de ghost niet getoond wordt, terwijl je deze wel zou willen zien of vice versa)? Presentatie is vroeg én goed, onduidelijk hoe werkbaar het is bij bijvoorbeeld hold. Geen presentatie bij bijvoorbeeld vertraging. SUGOL → HDG150 → Ghost gaat achteruit, maakt sprong BAW438 DCT gegeven dan loopt de ghost de verkeerder kant op. ICE 502 DTC CH → Je zou verwachten dat ghost inloopt op RIVER, maar loopt terug = onbetrouwbaar. Je moet 100% van de ghosts zien, dus ook als ze buiten de trechter vliegen. Andersom (een ghost wordt getoond, maar er is geen vliegtuig) is niet mogelijk. Alleen vliegtuigen met bestemming SPL moeten te zien zijn.
15. Wat valt eventueel op aan het gedrag van de ghosts? De ghost RIVER versus ARTIP vlucht loopt uit (zoals verwacht). Achteruit = no go! In het geval van DCT was gedrag niet logisch. Achter = prima mits het logisch is. Nee.
16. Heb je verder nog opmerkingen hierover? De ghost moet een logische beweging maken, als je maar kunt blijven beoordelen of de separatie gewaarborgd blijft. Nee.

Geef een vlucht een heading zodat deze langs de IAF gaat vliegen/de trechter uitvliegt

17. Wat valt je op aan het gedrag van de ghost? RIVER 340. Ghost achteruit. Breder dan 2 NM. SUGOL inb bij DCT toch achteruit. Onacceptabel. Als er niet over IAF gevlogen wordt verkeerde presentatie. Blijft zichtbaar → fout! Wedge lijkt goed idee. Het valt op de ghost lang gepresenteerd wordt. Grotere bandbreedte rond de UNR 2 NM is te klein. Gedrag niet altijd logisch. Blijft stil staan en zelfs achteruit. Dit moet niet, want dit is onlogisch gedrag. Hij moet weg.
18. Op welke manier zou je geattendeerd willen worden op het feit dat een vlucht geen ghost heeft? Of is een dergelijke indicatie niet nodig? Discussie Zou door ACC gemeld moeten worden. Je wilt altijd een ghost zien. Als de ghost wegvalt ga je deze zoeken en dat kost tijd. Je bent aan het sturen op de ghost. Dus laat staan! Misschien eerst knipperen en dan weg. Zeker niet achteruit lopen. Geen verdere ideeën hierover. [Idee voorgelegd van stacklist] → Zou kunnen, moet kunnen zonder ghost.
19. Hoe beoordeel je de betrouwbaarheid van het ghost concept? Betrouwbaar zolang de route netjes wordt gevolgd. De ghost doet niet wat je verwacht als je DCT geeft. Daarom onbetrouwbaar. Als je alleen de IAF als referentiepunt neemt, klopt de berekening niet altijd. Je moet vaak van de transitie afwijken om het kloppend te maken. Daarom een grotere trechter nodig. Andere punten overwegen. Goed, maar zou graag validatie willen doen en in werking willen zien. Betrouwbaarheidsschatting: 90%.

Start het derde scenario op basis van 18R. Er woedt nu een niet-nominale (hardere) wind zodat het gedrag van de tool in deze situatie geëvalueerd kan worden.

20. Wat vind je van het gedrag van de ghosts in deze situatie? Gedrag van ghost is voorspelbaar. Logisch, doet wat je verwacht De ghost geeft wel aan wat de afstand is. Je ziet dat je actie moet ondernemen. Zie niet echt iets anders. Wind is ook niet echt hard. ARTIP 2C gestart, omdat hier ghosts meer last van de wind hebben/het duidelijker zichtbaar is.
21. Hoe beoordeel je de ondersteuning door ghosts bij deze wind? In combinatie met groundspeed bruikbaar, maar…. Net zo goed Je ziet dat je iets moet doen. Er wordt nog wel een groot beroep gedaan op je ervaring. Geen nieuwe inzichten, wel controle. Zowiezo goed, wind maakt niet uit. Bij wind weet je al dat het lastiger wordt, dan helpt de ghost.
22. Heb je in deze omstandigheden behoefte aan andere informatie in het label? Welke? Nee Nee, alles wat je nodig hebt wordt gegeven. Nee, staat uit. Gebruik ghost niet als label.
23. Is het voorgekomen dat ghosts tracks binnen de separatieafstand van de echte tracks zijn geweest? En zo ja, hoe heb je dit ervaren? Ja, wordt niet als erg ervaren omdat je ziet dat het goed komt. Ja, nuttig. Geen probleem, je moet je er wel bewust van zijn dat het een ghost is. Komt vaker voor, maar is niet erg. Als het op het laatste stuk is, is het wel erg, want dit had voorkomen moeten worden. Maar op begin van RIVER geen probleem.
24. Denk je dat er veel gewenning nodig is om te leren werken met de ghosts in verschillende windcondities? Nee, zelfde principe. Niet veel gewenning voor nodig. Het werken met de ghost is het probleem niet. Bij wind is de ghost weinig ondersteunend. Geen nieuwe inzichten dan zonder ghost. Wind maakt niet uit.

Trainbaarheid

25. Vind je deze tool intuïtief? Ja, het lijkt op wat we altijd doen. Ja, simpel houden. Zonder wind werkt de tool beter. Tot op zekere hoogte geeft het inzicht Je hebt wel een controlemechanisme. Ja.
26. Denk je dat je vakbekwaam kunt blijven op dit tool als je dit alleen tijdens nachtdiensten gebruikt? Jazeker. Ja, want het is heel duidelijk. Ja, zou geen probleem moeten zijn.
27. In welke situaties zou je de ghosts uit willen zetten? Bij DCT vliegen. Als het goed is zou de wens er niet moeten zijn. Bij vectoren, individueel. Bij transitie, ghost altijd. Niet uitzetten mits de tool goed werkt. Moet ervaring laten blijken. Eigenlijk nooit. [Suggestie: holding pattern] Zou eigenlijk niet gepresenteerd moeten worden, anders uitzetbaar zijn.
28. In welke situaties vond je de ghosts verwarrend? DCT/IAF/achteruit Achteruit → dodelijk. Bij DCT. Ghost die achteruit vloog. Toen hij achteruit vloog. Anders niet. Bij raar gedrag zou ik ze uit willen zetten. Idee dat er dan iemand naar moet kijken.

Algemeen

29. Welke zaken heb je gemist in deze HMI sessie? ACC Sample niet goed. Wat doen bij holden? Niets gemist. Hands-on ervaring oefening. Uurtje 18R en een uurtje 06.
30. Heb je verder nog suggesties of opmerkingen? Iemand die blanco is. Hangt of staat bij discipline ACC afspraken. Is het doel om de ARTIP2C weer in te voeren?

Overige opmerkingen:

- correlatie ghostvlucht
- voorkomen dat je invoeren kunt maken
- ghost op verschillende tr presenteren bij andere baan? Nee, makkelijker bij hetzelfde
- wanneer presenteren? In verband met holding draaien.
- vluchten via SUGOL werkt niet bij berekening, dan rekenen tot IAF andere keer route…
- na overvliegen IAF → DCT teruggerekend naar IAF…
- Scenario 1: 44.00 mooi voorbeeld
- Algemeen: band rondom route lijkt wat krap
- Als kist nog niet in beeld, maar ghost wel → dan toch nu voor ghost label.
- Als direct, dan wellicht geen ghost weergeven
- Nabespreking:
    - Details bij vectoring/direct → nader bepalen. Voorkeur: elke vlucht altijd een ghost, is dat mogelijk= Mits raar ghostgedrag voorkomen kan worden.
    - Eisen klikken ghost: geen invoer
    - Requirement: er moet groundspeed informatie getoontd kunnen worden bij ?
- Liever vanaf begin kortere routes dan achteruit vliegende ghosts
- Scenario 2: de ARTIP kisten komen nog wel eens anders binnen. SUGOL en RIVER eigenlijk nooit.
- ’s nachts geen holdings, maar in de toekomst misschien wel. Hoe hiermee omgaan? Want dan vliegen ze in de trechters.
- Ghost vna ARTIP maakt sprong op het begin van RIVER.

NLR

Anthony Fokkerweg 2
1059 CM Amsterdam, The Netherlands
p) +31 88 511 3113 f) +31 88 511 3210
e) info@nlr.nl i) www.nlr.nl