ENVIRONMENT-AWARE RUNWAY ALLOCATION ADVICE SYSTEM

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Abstract

When selecting a runway for use, air traffic controllers must take into account technical as well as social and environmental factors. The Runway Allocation Advice System, RAAS, supports tower and approach supervisor air traffic controllers in making well-informed decisions on runway allocation and helps explaining and justifying these decisions to surrounding communities and authorities concerned. The system is currently in operation at Amsterdam Airport Schiphol (AAS) and Basel Euro Airport. Both airports operate a noise preferential runway system, which implies that the use of runways is, within the safety limits, imposed by noise regulations.

1 Introduction

The tower and approach supervisor air traffic controllers are responsible for selecting runways. Because of the complexity in making this choice, the *Runway Allocation Advice System* (RAAS) supports them in the allocation of runway combinations for arrivals and departures. RAAS considers safety, runway availability, required capacity, and environmental constraints in advising a runway (combination) for use.

Increasing traffic at airports leads to increasing noise exposure and results in protests by surrounding communities. The influence of the communities has resulted in measures and subsequent government legislation, leading to noise regulated airports. Amsterdam Airport Schiphol is such an airport that has been restricted in traffic growth by national law for a number of years now.

Schiphol has a complex configuration of six runways of which five are used for scheduled traffic. Schiphol operates its runways in segregated mode. Schiphol is the major hub airport for KLM, Royal Dutch Airlines, hence faces peak periods of traffic during which three runways are used.

Basel Airport is another airport at which RAAS is used. The airport is located on French soil, close to the Swiss and German borders (see Figure 1). Surrounding communities in three countries have a say in fair distribution of noise impacts. From the end of 2007, with the installation of a new ILS, Basel began using one of its runways more often as landing runway [1].

Fig. 1. Location of Basel Euro Airport in France (F), close to the borders of Germany (D) and Switzerland (CH).

In both situations at Schiphol and Basel, the surrounding communities were consulted and involved in the decisions on routes that will be used and on the total amount of noise that will be produced during the year. Communities as well as governments have an involvement in the actual use of the runway system, in order to reduce the number of complaints. This adds an additional constraint, on top of safety and efficiency, on the airport and on ATC to make the right decision on which runway (combination) to use at what time and also to justify the decision afterwards.

For enforcement, it is important that an independent system justifies the decision of the supervisor air traffic controllers. The RAAS system also promotes uniformity in runway allocation under similar circumstances.

This paper is organized as follows. Chapter 2 will provide background information on the use of preferential runway systems at airports. Chapter 3 gives insight in the RAAS system. Chapter 4 gives an overview of the decision parameters. Chapter 5 gives some possible scenarios for use of the RAAS system. In Chapter 6 the conclusions are given. Finally, in Chapter 7 a proposal for future work is described.

2 Preferential Runway System

To be able to meet noise restrictions, airports can bring a noise preferential runway system into use.

Because of safety, the choice for the active runway combination is limited in the first place by actual weather conditions. Secondly, when more than one runway combination satisfies all weather criteria, the one that is most preferred with respect to noise load management will be used. This preference is laid down in a predetermined ordered set of runway combinations: the preference list. The higher a runway combination is in the list, the better this combination is to stay within the noise load limit.

Preference lists are used at several airports with a more complex layout of runways. Amsterdam Airport Schiphol has evolved into a complex airport with runways in different directions that would have an uneven impact on communities in its vicinity if not for the use of a preferential runway system. Airports with similar complex layouts, such as Logan International Airport in Boston and John F. Kennedy International Airport in New York, also make use of a preference list to control noise load in its surroundings. At the US airports, noise load balancing is carried out on a voluntary basis. The Netherlands is unique in the fact that noise restrictions are enforced by law, making noise load the main steering parameter [2].

To monitor noise at Amsterdam Airport Schiphol, a distribution map (see Figure 2) is used, which consists of sixty measurement points that are defined around the airport. For each of these points, a noise limit (an accumulated amount of noise per year) is imposed. This should guarantee a fair noise distribution within a year.

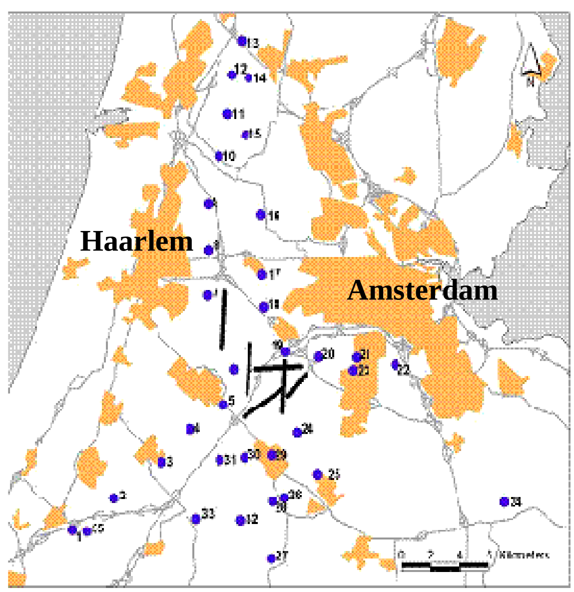

Fig. 2. Noise Management points around airports

This means that the choice for using a runway depends on the accumulated noise throughout the year, of course within safety limits determined by weather conditions. Due to actual noise accumulation, the sequence of runway combinations in the preference list can be changed during the year, to avoid exceeding noise limits [3].

3 RAAS description

When the Netherlands government established a noise zone around the airport to control aircraft noise exposure, runway allocation became more and more complex. The noise zone effectively constraints the operational use of runways.

To aid the supervisor air traffic controller in making optimum use of the runway configuration within the noise regulations while preserving safety, computer-based support for the supervisor Air Traffic Control was desired.

In close co-operation with Air Traffic Control The Netherlands (LVNL), the National Aerospace Laboratory NLR has developed RAAS, a decision support system for allocating runways to inbound and outbound traffic at Amsterdam Airport Schiphol. The system became operational at Approach and Tower ATC in 1998 [4].

RAAS is connected to a meteorological data server which continuously provides the system with the most actual weather information (see figure 3), such as wind and visibility. Other factors in selecting safe runways are the runway availability, ILS category, and ILS availability. These data are provided by the Runway panel.

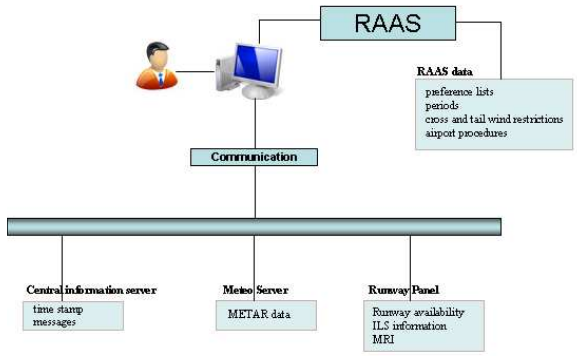

Fig. 3. RAAS Architecture

RAAS operates under normal conditions in advice mode (see figure 4).

In the left upper corner of the advice window the used preference list is shown. Traffic density is indicative for the applicable peak period and the accompanying preference list. Below this data panel, the current data are shown: the actual weather, runway availability, and ILS category and availability

Every minute RAAS updates the recommended advice runway combination, based on all these data. Starting point for RAAS are the noise preference lists with all runway combinations in a preferred sequence. After eliminating combinations because of present weather conditions, runway availability, and ILS conditions, the combination at the top of the remaining list is the advice.

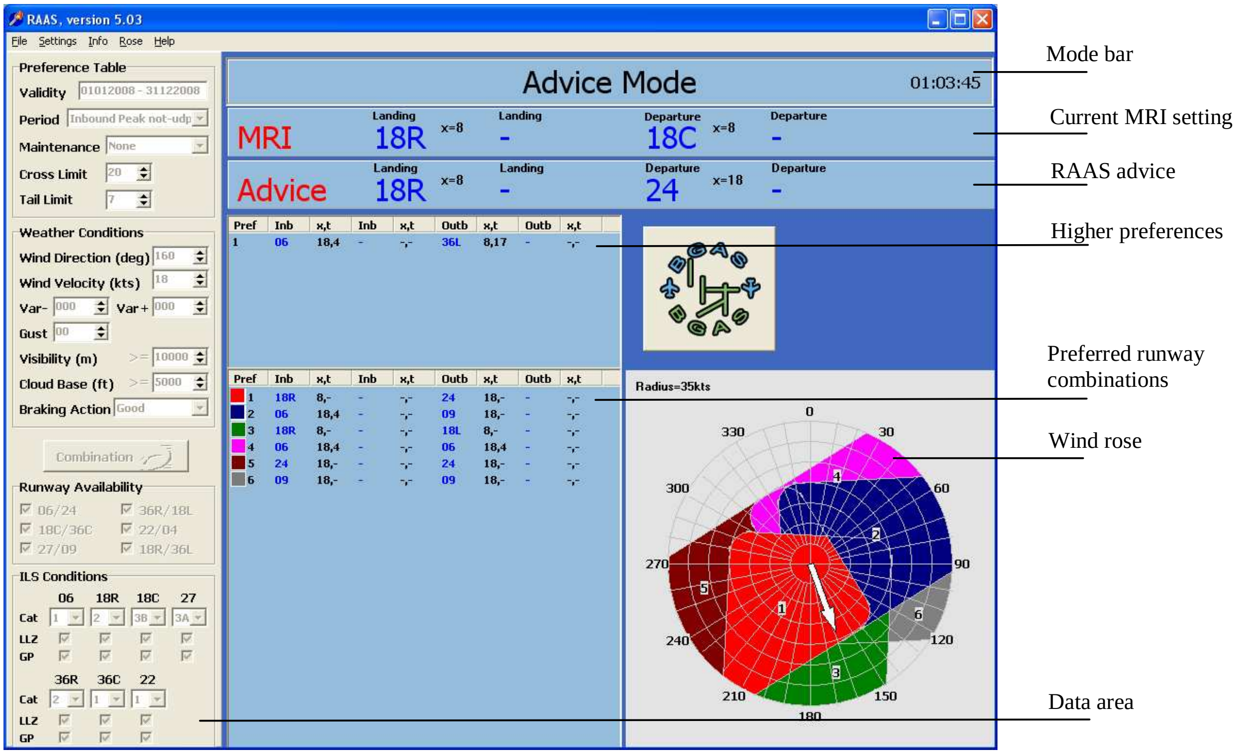

Fig. 4. RAAS Advice Mode

At the Main Runway Indicator (MRI) the actual runway combination choice is shown. This choice is manually entered by the supervisor air traffic controller in the Runway panel and becomes available for RAAS through the data interface. If the supervisor air traffic controller decides to ignore the system's recommendation, the supervisor will be asked to motivate this decision. The advice combination, the actual chosen runways and reason for deviation are logged, as well as the weather and runway circumstances at that moment. These loggings are used for analysis afterwards and for justification to authorities and neighbours of the airport.

In the panel “Preferred runway combinations”, valid combinations are shown in order of preference. The system also shows the “higher preferences”: the runway combinations that can't be used under the current weather conditions.

RAAS graphically presents the preferred runway combination and other valid combinations with lower preferences in a compass rose. The compass rose consists of wind velocity circles spaced at 5 kts and radial lines spaced at 10 degrees. On this background the runway combinations are presented in sequence of preference, with the preferred combination shown on top.

A forecast (what-if) mode is also available within RAAS. In this mode the supervisor air traffic controller manually enters weather data, runway availability, and ILS information on which RAAS determines an advice. The supervisor uses this functionality to anticipate upcoming weather changes. Also gust and wind variation can be given in forecast mode. This can be seen in figure 5 as the “rounded” area.

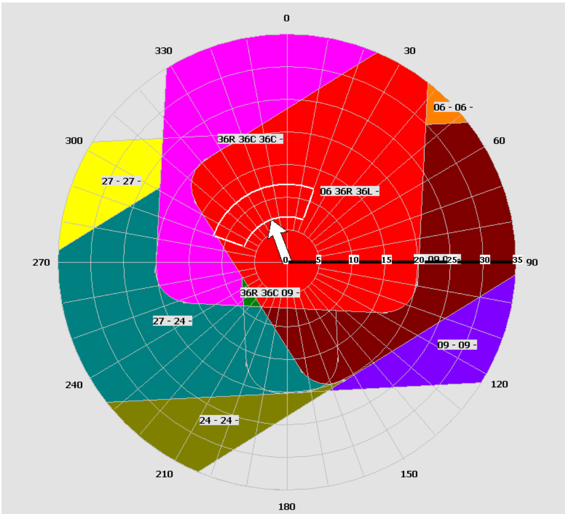

Fig. 5. Wind rose with gust and variation

4 Decision parameters

Wind

The wind vector is given in the wind rose as an arrow, pointing from the origin of the rose. Depending on the use of wind roses at an airport, the wind vector may point away from or towards the wind direction. The direction of the arrow can be reversed when necessary.

Wind direction and velocity are used to determine the crosswind and tailwind component for each runway. A maximum cross- and tailwind will be applied and when exceeded, the runway will not appear in any of the combinations advised. Usually, in good conditions, a cross wind limit of 15 knots and a tail wind limit of 5 knots are allowed. Furthermore, if both the crosswind and tailwind are at their limit, the runway will not be advised either. For this, in the compass rose, the corners of the combinations are rounded off.

Depending on the condition of the runway, which can be either dry or wet, the cross- and tail wind limits differ, i.e. in wet weather conditions tailwind is not allowed and the cross wind limit will be reduced.

More diversion can be made by actually measuring the runway friction coefficient.

Gust has two components: the wind velocity and the variation. Gust will always exceed the “normal” wind velocity. Gust is also important for determining the cross- and tailwind components of a runway, be it that this will be variable. Gust is indicated in the compass rose as an area on top of the wind vector, see figure 5.

Depending on how the airport wants to implement the RAAS system, gust can be taken into consideration to determine the preferential runway combination or it can be presented as advice to the supervisor who can make an assessment of the gust and may decide to use a certain runway or not. The RAAS system will always indicate gust, so that the supervisor can determine the best course of action.

Visibility conditions

Visibility conditions are important decision parameters in allocation of landing and take-off runways. Visibility consists of two parameters: horizontal visibility and cloud base.

At the moment that visibility or cloud base is at or below the level of LVC (Low Visibility Conditions), the system will indicate this and no advice will be given. Supervisor controllers will use local rules for runway assignment.

Extra restrictive visibility and cloud base limits can be set for each of the runway combinations. Should for any runway of the combination the visibility conditions drop below a given threshold, the runway combination will not be selected as the advised combination.

Visibility conditions are also related to ILS. Below certain visibility values landing runways can only be used if they are equipped with ILS.

ILS

Status of the ILS is important for advising a runway to be used for arrival. The ILS status consists of a category, glide path indicator, and localizer. Through and interface with the ILS system, the RAAS system is informed on the status of the ILS.

Depending on the ILS category, the runway can be used for landing within restricted visibility conditions. Per landing runway, the ILS category can vary, so that the runways can be used under different visibility conditions.

Runway panel

Runways may be unavailable for short periods (runway check, friction test, snow sweep, etc.) or for a longer time, e.g. for maintenance.

In case runways will be out of service for a longer period of time, the runway can be excluded from the list of available runways, so that it is considered a non-existing runway to the RAAS system.

Alternatively, runways can be regarded unavailable for a brief period of time. These data can be entered in the RAAS system via the runway panel.

Runways which are not available for a short or long period of time will not be included in the advice of the RAAS system.

Time

The system operates with periods. A time period is a fixed period of the day for which a certain kind of operation applies. Most airports have night restrictions, so during night time, different preferences apply, ergo a different preference list needs to be used.

At a hub airport like Schiphol, a day is divided into inbound and outbound peak periods. During an inbound peak, two runways are selected for arrivals and one for departures, during an outbound peak two for departures and one for arrivals. For brief periods of time, an inter peak period applies, where four runways are used simultaneously. Just as well, during day time, an off peak period may apply, where only one departure and one landing runway are in use.

5 Using RAAS

The RAAS application can be used for many different purposes, mostly related to the impact of the airport on its environment, i.e., the surrounding communities. How to use the application throughout the operational year for these purposes will be discussed in this section by means of two typical scenarios. The first scenario uses the application in isolation for reporting deviation statistics at the end of the operational year. The second, more advanced, scenario uses the application in combination with other applications for actively managing the operations or environmental impact of the airport.

5.1 Scenario 1: RAAS as a stand-alone reporting tool

In this scenario, RAAS is used in isolation from other tools. At the beginning of the operational year, the preference lists to be used by the application are fixed. During the operational year, any deviations from the preferred runway usage will be logged by the application. At the end of the operational year, the number or percentage of deviations, possibly detailed per reason of deviation, is reported and analyzed.

Although the usage of the application is simple, the possible reasons for using the application in this way are numerous:

- Transparency to the surrounding communities: the reporting can be used to show that the airport operates differently from the preferred usage in only x % of the time, and for good reasons. Especially when the preferred usage has been agreed upon with the communities, RAAS can help to improve understanding between the airport and surrounding communities.

- Reduction of complaints: by correlating complaints to deviations from the preferred usage, the airport may analyze which complaints could have been avoided and subsequently take measures to avoid these complaints in the future.
- Law abiding: in situations where the airport is restricted by law in some sort of way (e.g., maximum noise load), and preference lists have been designed to meet these restrictions, the reporting of RAAS may be used to prove conformation to the preference lists.

This way, the system is in use at Basel Euro Airport.

5.2 Scenario 2: RAAS as part of a larger management system

In this scenario, the airport has a larger environmental management system in which RAAS is one of the applications used. Other applications are dealing with registration, calculation, and analysis of environmental impacts, resulting in changes in preferences lists, which are then fed into RAAS to actively manage the airport environment.

The usage of RAAS together with other applications in this scenario could be the following. At the start of the operational year, environmental targets are defined (or enforced by law). Analysis tools are used to determine the preference lists that will have the highest probability of meeting these targets at the end of the year. At certain points during the year, for instance each quarter of the year, the actual environmental impact of the part of the operational year already performed is determined, and a predicted impact for the remainder of the year is calculated. Based on the results of this intermediate analysis, new preference lists are determined, again with the aim to maximize the probability of meeting the targets at the end of the year. RAAS then uses these new preference lists for its advice. In the extreme case, this analysis and update of preference lists could be performed continuously. Together with the deviation reporting functionality of RAAS, this airport environment management system could be used towards surrounding communities and government to show that the airport is continuously working towards reducing its impact on the environment.

This way, the system is in use at Amsterdam Airport Schiphol.

6 Conclusions

When selecting a runway for use, air traffic controllers must take into account technical as well as social and environmental factors. The Runway Allocation Advice System RAAS has been developed to assist the supervisor air traffic controller in making a well-informed decision which runways to use and to help explaining and justifying these decisions to surrounding communities and authorities concerned.

In this paper, the backgrounds of the noise preferential runway system at Amsterdam Airport Schiphol, and the specific situation at Basel Euro Airport have been introduced. The noise preferential runway system has been discussed in some more detail in Chapter 2. At the heart of a preferential runway system lie the preference lists. These preference lists are the main input to the RAAS application, which is discussed in detail in Chapter 3 and 4 based on the different screens in the graphical user interface and the input used by the application to select the preferred runway combination. Finally, in Chapter 5, some scenarios have been described on how RAAS can be used by air traffic control to maximize the chance of meeting targets or constraints agreed upon with surrounding communities and/or regulating authorities.

7 Future work

RAAS is currently used at two airports, Amsterdam Airport Schiphol and Basel Euro Airport. At the latter, the application is used in isolation (conform Scenario 1 in Chapter 5). At the former, preference lists are updated (manually) at several moments during the operational year to take actual use of runways into account. At both airports, the preference lists are based on noise regulation.

There are two potential directions for further developing the application. One direction is to tightly integrate RAAS with noise monitoring systems to identify a potential noise limit violation early, and prevent this violation by changing the order of combinations in the runway preference lists automatically (as in Scenario 2 in Chapter 5). Another direction is to base the preference lists on another rationale, for instance shortest taxi routes, minimum fuel consumption, minimum CO_2 and/or NO_x emissions, maximum peak hour capacity, avoidance of densely populated areas, or availability of equipment (e.g. ILS) on runways.

In addition to these two directions toward expanding the area of application of RAAS, future work will also include research into a more detailed decision model which will also take the route system (in addition to the runway system) into account.

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