Probabilistic 2-Day Forecast of Runway Use

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Schiphol airport lay out
NLR, together with KNMI has performed a feasibility study to the use of meteo forecast for runway forecast

- KNMI has knowledge of meteo forecast
- NLR has knowledge of runway allocation (Runway Allocation Advisory System)

In the order for the Dutch government

Motivation: information to inhabitants around the airport (transparancy)
Runways can only be used with limited
- tailwind (e.g. 5 kts.)
- cross wind (e.g. 20 kts.)

Runways are used in configurations
- parallel (dependent, independent)
- crossing or converging
- take-off and/or departure
- segregated mode vs. mixed mode

The runway configuration determines the airport’s capacity

Agreements with environment are usually made for noise restrictions

Use of runways depends on demand – major hub airport use peak systems (arrival, departure)
Runway prediction based on meteo prediction

Meteo forecast is a probability forecast
Runway use can therefore also not be determined in absolute values
Other parameters are playing a role in the allocation of runways
• preference tables (noise preference)
• runway and taxiway availability
• ILS
• capacity of the runway combinations
• traffic demand during the day
• non-local meteorological conditions in the FIR
### Meteorological Information

#### 19 – 20 May 2011

<table>
<thead>
<tr>
<th></th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>00</th>
<th>03</th>
<th>06</th>
<th>09</th>
<th>12</th>
<th>15</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility &lt; 5 km and/or ceiling &lt; 1000 ft (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>RVR &lt; 1500 m and/or ceiling &lt; 300 ft (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RVR &lt; 550 m and/or ceiling &lt; 200 ft (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RVR &lt; 350 m (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| Winddirection (deg) | 330 | 350 | 350 | 350 | 350 | 360 | 360 | 010 | 030 | 070 | 130 | 170 | 220 | 240 | 250 | 240 |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Windspeed (kt)      | 5   | 3   | 5   | 5   | 4   | 6   | 4   | 2   | 2   | 3   | 6   | 10  | 12  | 12  | 10  | 10  | 10  |
| Gusts (kt)          |     |     |     |     | 15  |     |     |     |     |     |     |     |     |     |     |     |     |
| Standarddeviation winddirection (deg) | 40  | 60  | 40  | 40  | 50  | 30  | 35  | 60  | 80  | 70  | 40  | 35  | 20  | 20  | 20  | 20  |
| Standarddeviation windspeed (kt)               | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 3   | 3   | 3   | 3   | 3   | 3   |

**Direction may vary significantly**

**Speed may increase in short notice**

**Standard deviation changes, but does not only increase**
Preferential runway system

Preferences based on agreements with surrounding communities

Periods based on traffic demand (hub system)
Step 1: determine what combinations are available

Based on weather information only
Runway combinations and their probabilities

Chances of the meteo forecasts must be translated to chances that runway combinations are expected. Runway combinations are concrete values with probabilities.

<table>
<thead>
<tr>
<th>Runway Combination</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>06 - 36L, 36C</td>
<td>71.5%</td>
</tr>
<tr>
<td>18R - 24, 18L</td>
<td>27.0%</td>
</tr>
</tbody>
</table>
**Our approach (1/2)**

KNMI PROBABILITY FORECAST SCHIPHOL

Last update: Short term 06:52 UTC  Long term 05:10 UTC

- **Visibility < 5 km and/or ceiling < 1000 ft (%)**
  - 08: 90, 95, 75, 70, 75, 65, 60, 70, 70, 75, 70, 60
  - 09: 90, 95, 75, 70, 75, 65, 60, 70, 70, 75, 70, 60

- **RVR < 1500 m and/or ceiling < 300 ft (%)**
  - 08: 0, 5, 5, 5, 5, 5, 5, 10, 15, 20, 40, 50, 40, 20
  - 09: 0, 5, 5, 5, 5, 10, 20, 25, 25, 25, 25, 20

- **RVR < 550 m and/or ceiling< 200 ft (%)**
  - 08: 0, 0, 0, 0, 0, 0, 0, 5, 10, 0, 0
  - 09: 0, 0, 0, 0, 0, 0, 0, 5, 10, 0, 0

| Winddirection (deg) | 08  | 09  | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Windspeed (kt)      | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  |
| Gusts (kt)          |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Standarddeviation winddirection (deg) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Standarddeviation windspeed (kt) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| CB (%)              | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 5   | 0   |
| Thunderstorm (%)    | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |

These are chances and expectations
This is not the chance that the runway will be chosen, but the chance that the combination can be used, based on cross- and tailwind limits.

The air traffic controller still has a choice:
18 – 24
27 – 24
27 – 24
Configuration selection
From the list of possible runway combinations

- from weather prediction
- preferential runway system
- peak periods

we have to select the runway that most probably will be used

Evaluation over 2009:

- all weather predictions are available
- all preference tables and peak periods
- all aircraft movements for actual runway use

We evaluated several algorithms for configuration selection
Algorithms for predicting the choice

Highest score only is too simple and has not been considered a serious algorithm

Algorithm 1:

- Determine the highest in the list above a given threshold (e.g. 80%)
- If none found then determine the highest in the list if none of the possible combinations is above the threshold

<table>
<thead>
<tr>
<th>PIEK</th>
<th>&gt;90%</th>
<th>&gt;80%</th>
<th>&gt;70%</th>
<th>&gt;60%</th>
<th>&gt;50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>46%</td>
<td>50%</td>
<td>52%</td>
<td>52%</td>
<td>50%</td>
</tr>
<tr>
<td>N</td>
<td>66%</td>
<td>68%</td>
<td>67%</td>
<td>65%</td>
<td>64%</td>
</tr>
<tr>
<td>O</td>
<td>54%</td>
<td>58%</td>
<td>59%</td>
<td>58%</td>
<td>57%</td>
</tr>
<tr>
<td>S</td>
<td>52%</td>
<td>54%</td>
<td>54%</td>
<td>54%</td>
<td>53%</td>
</tr>
<tr>
<td>Totaal</td>
<td>56%</td>
<td>59%</td>
<td>60%</td>
<td>58%</td>
<td>57%</td>
</tr>
</tbody>
</table>
Algorithm 2:

- Determine the highest in the list above a given threshold (e.g. 80%)
- Select this, only if the difference with another higher combination is below a given value (e.g. 20%)
- To avoid a combination of 79% to be rejected over a slightly lower combination with 81%

<table>
<thead>
<tr>
<th>PIEK</th>
<th>0/50</th>
<th>10/50</th>
<th>20/50</th>
<th>30/50</th>
<th>40/50</th>
<th>20/60</th>
<th>20/70</th>
<th>30/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>36%</td>
<td>49%</td>
<td>52%</td>
<td>53%</td>
<td>52%</td>
<td>52%</td>
<td>52%</td>
<td>53%</td>
</tr>
<tr>
<td>N</td>
<td>51%</td>
<td>68%</td>
<td>69%</td>
<td>67%</td>
<td>64%</td>
<td>69%</td>
<td>68%</td>
<td>67%</td>
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<tr>
<td>O</td>
<td>41%</td>
<td>58%</td>
<td>60%</td>
<td>60%</td>
<td>58%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>S</td>
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<td>56%</td>
<td>55%</td>
<td>54%</td>
</tr>
<tr>
<td>Totaal</td>
<td>43%</td>
<td>59%</td>
<td>61%</td>
<td>60%</td>
<td>58%</td>
<td>61%</td>
<td>60%</td>
<td>60%</td>
</tr>
</tbody>
</table>
Surprisingly, this introduction of the second threshold does not improve the results significantly.

- It appears that many improvements in runway selection were found
- Per period (land, start, off-peak, night) things improve or get worse
- However, many other factors influence the result leading to initially “good choices” now going “wrong”

We need more:

- The current method is taken as a basis
  
  + (a good analysis)

- Combinations 1 and 2 are chosen more often
- Some combinations are more sensitive for low visibility (e.g. parallel departures)
- The trend in expected runway use (history or forward trend) is used
Algorithm 3

- Consider combination 1 and 2 first with algorithm 1
- If (1 or 2) then use algorithm 2
- If not (1 or 2) then evaluate the other combinations
  - evaluate the low visibility case
  - use historical runway use

<table>
<thead>
<tr>
<th>1st hour</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>73%</td>
</tr>
<tr>
<td>N</td>
<td>83%</td>
</tr>
<tr>
<td>O</td>
<td>68%</td>
</tr>
<tr>
<td>S</td>
<td>61%</td>
</tr>
<tr>
<td>Total</td>
<td>73%</td>
</tr>
</tbody>
</table>
Conclusions
Results

We have evaluated runway used, based on
  • meteorological conditions (1 to 30 hours)
  • preferential runway system
  • static traffic demand (peak periods)
A 100% score cannot be achieved
  • currently, the operation can be predicted with 70% – 75% accuracy (based only on weather prediction)

Improvements possible
  • include runway/ILS availability
  • include traffic demand (from e.g the CDM process)
  • include capacity
  • include reliability
Other considerations

Present alternatives
- not only the “best fit” combination, but also the second
  => score will significantly increase

Use of
- air traffic controller – support the decision process
- people living near the airport – prediction on expected noise
- airline & airport – prediction on expected capacity
- improved planning for AMAN/DMAN and CDM
QUESTIONS?