to divide the error by the actual capacity to give more emphasis to the error of 5 out of 10. For this reason, we will compute the Mean Absolute Percent Error (MAPE), which is the mean of these values (|actual-forecasted| / actual).

We have the following values:

MAPE (arrival) = 12.88 %

MAPE (departure) = 15.32 %

C. Discussion

This section will discuss the results of the runway configuration forecast and the capacity forecast.

Score of the forecast for runway configuration is 0.758, while the MAPE for the forecast for runway capacity is 12.88% for the arrival and 15.32% for the departure capacity. These figures are considered sufficiently accurate to use in operation.

Surprisingly, capacity scores are higher than those for the runway configuration, while the capacity forecast is based on the configuration figures. This seems contradictory. The reason is that some different runway configurations provide (almost) the same capacity, so that a small error in the determination of the runway configuration may have no effect on the capacity figure.

Just as well, we can note that an erroneous forecast of the runway configuration does not mean that all runways in the configuration have been forecasted wrongly. Some runway configurations have overlapping runways, e.g. the inbound configuration 18R 18C / 18L uses two landing runways: 18R and 18C and one runway for take-off: 18L. A similar configuration is 18R 18C / 24, with the same arrival configuration but another departure runway; in the situation where one of the configurations has been forecasted, but the other was actually used, we have considered the runway configuration to be forecasted wrongly, even though two of the three runways have been forecasted correctly and all inbound runways have been forecasted correctly. The resulting capacity for both runway configurations shows indeed the same inbound capacity (68 movements per hour) and almost similar outbound capacity (40 for the three parallel runways and 35 when using runway 24, because of the slight dependency between the runways).

This motivates why the runway configuration forecast can be off, while capacity forecast can be correct, after all.

Several reasons for erroneous runway configuration forecasts have been examined:

- Weather forecast accuracy.
- Methodological issue.
- ATC makes another decision.

Weather forecast: From [7], it can be seen that specifically visibility is difficult to forecast and about 10% of visibility forecast does not classify the forecast in the correct category. Through use of our probabilistic approach, the margin in error reduces but still exists. Analysis has shown that the impact of weather forecast is in the magnitude of 5%.

Methodology: The method used can be improved and the analysis given above will help to further understand where changes to the method can be made. It must be noted again here that in many cases the arrival configuration has been forecasted correctly, while the departure is not, in which case the runway configuration has been considered to be forecasted incorrectly. Analysis has shown that some wind directions show better results, specifically a northern or southern wind will demonstrate a highly accurate runway configuration forecast, while a north-eastern or south-western wind performs significantly worse. The night period at Schiphol is more restrictive, leading to very accurate forecasts.

ATC: The air traffic control supervisor eventually will decide on what runway configuration to use. He will consider more aspects than is possible in our forecast, like local phenomena in the weather (rain or thunderstorms) and incidents on runways or taxiways. Just as well, when reconfiguring the airport from northern to southern runway use, sometimes some intermediate configurations are used for a brief period of time. These cannot be forecasted.

Further work towards runway capacity forecast will focus on the elements described above to improve quality of the forecasts.

One element already mentioned to be further studied, is the presentation of the information. Operators will either have to get acquainted to the probabilistic presentation of forecast data or will have to be presented with figures they can apply directly. In the latter case, the figures will have to be rounded off to the nearest integer value that represents one possible runway configuration with a corresponding capacity figure. Obviously, information will get lost but this will better fit to the operation.

The presentation will largely depend on the environment in which the forecasting will be integrated. In a larger operating environment, such as Total Airport Management (TAM), the forecasting element will become part of the cooperation and planning systems. Methods and presentation will have to connect to that of TAM.

In a larger context, the runway capacity forecast may become part of a larger airport capacity forecast system. Although at most airports, the runway system mostly represents the capacity of the airport as a whole as well, other elements may become bottlenecks in specific situations. For example, at some airports, the taxiway system becomes the capacity bottleneck in low visibility operations. Other major factors in airport capacity are de-icing operations and snow removal. At landside, the passenger’s security passage is a capacity issue that will benefit from good forecast information. In fact, de-icing and security passage are already under investigation by the consortium.

IV. Related Work

Most work on runway capacity is concerned with more efficient use of existing infrastructure, while enhancing capacity. Examples of studies concern those for Arrival Management, Departure Management, and A-CDM. When *forecasted* runway capacity is studied, this is mostly for airport expansions or for periods in which maintenance is scheduled. Examples of studies concern those with fast time simulation studies. As the scope of these studies is different from the capacity forecast that we present in this project, their relevance to the work described is considered limited.

The "other side" of capacity forecasting is considered by us to be demand forecasting. This type of forecasting takes the current situation as basis and will extend the situation through prediction or simulation towards a moment in the future, either long term (months or years) or short term (minutes to hours). Contrary to capacity forecasting, demand forecasting does not consider resource availability to be the basis. When both are put together, Airport Capacity and Demand Balancing, is considered a powerful mechanism, where future capacity is matched with future demand in an optimum manner. Cooperation on planning systems is one of the topics in Total Airport Management and preparation of planning, e.g. through capacity forecast will be one element in the complete chain of processes [4].

Runway configuration advice is given to controllers amongst others at Amsterdam Airport Schiphol, Basle Euro Airport and Brussels Zaventem airport [2][3], through systems that present the air traffic control supervisor the most appropriate runway configuration to use or show what runways cannot be used, because of exceeding wind limits.

Runway configuration forecasting is performed at Frankfurt airport, where the environment is informed on expected eastern or western runway use for the following days [8].

V. Conclusion

We have presented a runway configuration forecasting model, based on meteorological information, and evaluated the model with recorded data over 2012 and 2013. Based on the forecasted runway configuration, a capacity forecast has been made and evaluated as well. Runway capacity is at most airport the main factor in airport capacity.

The runway configuration forecast has been proven to be possible with high accuracy, whereas the capacity forecast can be modelled with even higher accuracy. Although capacity is based on the runway configuration, the fact that different configurations allow the same capacity causes this to have higher accuracy. Just as well, some runway configurations consist of partly the same runways and where the configurations could be forecasted wrongly, the capacity of the runways will yield a reasonably correct figure.

The work described here will be beneficial to airports and airspace users, who will be able to better plan their resources. It will bring automation of airport operations to a higher level and enable further automated planning of the operations, where stakeholders will get a role to oversee the operations at a higher level than is currently the case. A higher predictability of the operations can be expected as the adherence levels to target times will lead to increased predictability for runway planning functions in AMAN, CPDS, A-DCB and A-CDM.

Further work is ongoing to improve quality of the runway configuration forecasting and to apply the methodology of capacity forecasting to other airport planning processes, such as planning for de-icing and in-terminal planning of passenger processes. The human machine interface will need to be designed and integrated in a larger set of related functions such as for A-DCB and A-CDM.

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