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The Wake Vortex Prediction and Monitoring System WSVBS

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Design and performance of the Wake Vortex Prediction and Monitoring System WSVBS are described. The WSVBS has been developed to tactically increase airport capacity for approach and landing on closely-spaced parallel runways. It is thought to dynamically adjust aircraft separations dependent on weather conditions and the resulting wake vortex behaviour without compromising safety. The WSVBS consists of components that consider meteorological conditions, aircraft glide path adherence, aircraft parameter combinations representing aircraft weight categories, the resulting wake-vortex behaviour, the surrounding safety areas, wake vortex monitoring, and the integration of the predictions into the arrival manager. The WSVBS has been designed and applied to Frankfurt Airport. However, its components are generic and can well be adjusted to any runway system and or airport location. The prediction horizon is larger than 45 min (as required by air traffic control) and updated every 10 minutes. It predicts the concepts of operations and procedures established by DFS and it further predicts additional temporal separations for in-trail traffic.

A specific feature of the WSVBS is the usage of both measured and predicted meteorological quantities as input to wake vortex prediction. In ground proximity where the probability to encounter wake vortices is highest, the wake predictor employs measured environmental parameters that yield superior prediction results. For the less critical part aloft, which can not be monitored completely by instrumentation, the meteorological parameters are taken from dedicated numerical terminal weather predictions. The wake vortex model predicts envelopes for vortex position and strength which implicitly consider the quality of the meteorological input data. This feature is achieved by a training procedure which employs statistics of measured and predicted meteorological parameters and the resulting wake vortex behaviour.

The WSVBS combines various conservative elements that presumably lead to a very high overall safety level of the WSVBS. The combination of these conservative measures certainly leads to a very high but currently unknown overall safety. Once the methodology of a comprehensive risk analysis will be established, it is planned to adjust all components to appropriate and consistent confidence levels.

The WSVBS has demonstrated its functionality at Frankfurt airport during 66 days in the period from 18/12/06 until 28/02/07. The performance test indicates that

(i) the system ran stable - no forecast breakdowns occurred,

(ii) aircraft separations could have been reduced in 75% of the time compared to ICAO standards,

(iii) reduced separation procedures could have been continuously applied for at least several tens of minutes and up to several hours occasionally,

(iv) the predictions were correct as for about 1100 landings observed during 16 days no warnings occurred from the LIDAR.

Fast-time simulations reveal that adapted concepts of operation yield significant reductions in delay and/or an increase in capacity to 3% taking into account the real traffic mix and operational constraints in the period of one month. Before the WSVBS can be handed over for final adaptations to become a customized fully operational system some further steps are planned. A risk analysis needs to be pursued to convince all stakeholders of the usefulness and capabilities of the system.