Slot Swapping Applications for CDM

P.R. de Waal*, M.H.L. van den Briel**, J.M. van den Akker ***

Summary

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* National Aerospace Laboratory NLR, P.O. Box 90502, 1006 BM Amsterdam, The Netherlands.

** Department of Industrial Engineering, College of Engineering and Applied Sciences, Arizona State University, PO Box 875906, Tempe, AZ 85287-5906.
The research for this paper was performed while the author was at NLR.

*** Institute of Information and Computing Sciences, Utrecht University, P.O. Box 80.089, 3508 TB Utrecht, The Netherlands.
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Summary

In this presentation, we present a study on slot swapping, an important CDM application for slot allocation. Slot swapping allows airlines to prioritise flights by exchanging the (departure) slot of a flight with the slot of another flight. This can for example be advantageous when there is a commercially sensitive flight (e.g. with many transfer passengers) with a long delay and there is a possibility to advance this flight by simultaneously delaying another flight. Slot swapping is one of the CDM applications that have been proposed for Air Traffic Flow Management (see [2]). Slot swapping is also part of the Ground Delay Program Enhancements in the USA (see [1] and [5] for an overview of this program).

The development of slot swapping in Europe is still in its initial phase. Report [2] contains a preliminary description of the slot swapping application. In this paper we address a more general way of slot swapping. We present the following three applications for slot swapping:
Swap at departure time: Two flights are swapped by interchanging their departure times.
Swap at sector arrival time: Two flights get different departure times, such that their arrival times at a common ATC sector are interchanged.
Swap by load contribution: Two flights get different departure times, such that their respective contributions to the traffic load in regulated ATC sectors are interchanged.

For all three applications checks have to be performed on the validity of the interchanging of flights. Most importantly it has to be checked that the change in departure times for two flights does not lead to higher workload in the ATC centers that the flights travel through. By this we guarantee that slot swapping does not compromise required safety levels. For all three applications swapping is not restricted to two flights leaving from the same airport.

We have implemented prototypes of efficient search algorithms to find all possible swaps. These prototypes have been tested on a number of testcases taken from [4]. As a basis for the experiments in our study on slot swapping, we have used the Optislot algorithm (see [3]). Still, the slot swapping methods that have been developed are applicable to any type of slot allocation scheme. The numerical results are promising, since a significant percentage of the delayed flights can be swapped.

In the presentation we shall describe the three algorithms and the numerical results from the prototype study. We also pay attention to the impact of swapping on safety, efficiency and on environmental regulations.

References

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Author biographies

P.R. de Waal received his M.Sc. degree in Mathematics from Eindhoven University and his Ph.D. degree from Tilburg University. He has held several positions as a researcher at the Centre for Mathematics and Computer Science in Amsterdam, working on problems in queueing theory, reliability theory and control theory. Since 1997 he has been working for NLR in the department of Mathematical Models and Methods. His current activities and interests lie in the area of modelling, simulation, and optimisation problems for Air Traffic Management.

M.H.L. van den Briel received his M.Sc. degree in Econometrics with a major in Operations Research from the University of Maastricht (Netherlands, May 2000). He performed the research for his M.Sc. at the National Aerospace Laboratory (NLR), resulting in the thesis 'Algorithms for CDM on slot allocation: slot swapping and slot shifting'. Until August 2001 he worked at ORTEC Systems. His work concentrated around SHORTREC Distriplanner, a vehicle routing software package designed by ORTEC. Since August 2001 he is a research assistant at the Department of Industrial Engineering of Arizona State University, Tempe.

J.M. van den Akker has a M.Sc. (1990) and Ph.D. (1994) degree in Mathematics from Eindhoven University of Technology, the Netherlands. Her Ph.D. thesis is in the area of combinatorial optimisation and concerns machine scheduling. In 1995, she started as technology consultant in the ICT Division of the National Aerospace Laboratory NLR, the Netherlands. For more than 5 years, she has worked on modelling, optimisation, and simulation in Air Traffic Management and Road Pricing. In december 2000, she started as assistant professor at the Institute of Information and Computing Sciences at Utrecht University.