Data-driven modelling and validation of aircraft inbound-flow at some major European airports

Carlo Lancia
Leiden University
Niels Bohr weg 1, 2333CA, Leiden
c.lancia@umail.leidenuniv.nl

Guglielmo Lulli
Lancaster University
Bailrigg, LA1 4YX Lancaster
g.lulli@lancaster.ac.uk

Starting with the pioneering work of Blumstain [1], airport operations attracted interest of the scientific community in the attempt to alleviate congestion. In particular, a lot of effort has been devoted to study the arrivals process at airports and the corresponding queues. Given the nature ofthe phenomenon, most of these studies relied on either queuing theory or simulation models. Poisson arrivals is a key assumption for the development of these models. Indeed, as point out by [2], the assumption of Poisson arrivals for airport demand has been extensively used in the transportation literature, is mathematically tractable and is consistent with the observation at major airports. Recently, [3] have shown a very good accordance between inbound traffic-data and the congestion predicted by queueing models with Pre-Scheduled Random Arrivals (PSRA) of the family PSRA/D/1. In this work, we use inbound-flights data extracted from Eurocontrol's DDR repository between June 15 and September 15, 2014 for three major airports in Europe, namely, London Heathrow, Frankfurt am Main, and Amsterdam Schiphol. The DDR was queried to extract, foreach flight, the time of the first descent below Flight Level(FL) 240, which we consider as a proxy for the time where the flight is handed over to the Terminal Control. We first validate the finding by [4] of interarrivals following a (nearly) exponential law. Next, we define in a fully data-driven manner a time-dependent Poisson process with daily periodicity by using change-point analysis under the null of Poisson arrivals [5] and averaging the intensity over clusters of identified regimes. Then, we define a data-driven PSRA process by superimposing to the last flight plan agreed with EUROCONTROL a random fluctuation sampled from the empirical distribution of delays at FL240. Through simulations we show that our data-driven PSRA is capable of describing the average daily arrival pattern much more closely than the Poisson counterpart. Further, we demonstrate that the observed arrivals in consecutive time intervals are (mostly) negatively correlated. While the simulated PSRA stream can reproduce this behavior, the family of Poisson arrivalscan not, because by definition they have independent increments. Negatively correlated consecutive arrivals is a very important feature for a model to possess, because it is linked with air-space finite capacity. Since our data-driven PSRA embeds the last flight plan that was agreed to fly, it can account out-of-the-box for airspace finiteness and other centrally regulated traffic constraints.

References

[1] A. Blumstein, *The landing capacity of a runway*, Operations Research, 7(1959), pp. 752–763.

[2] G. Hengsbach and A. Odoni, *Time dependent estimates and delay costs at major airports*, Tech. Rep. 4, MIT, Cambridge, Mass. (USA) 02139, January 1975.

[3] M. V. Caccavale, A. Iovanella, C. Lancia, G. Lulli, and B. Scoppola, *A model of inbound air traffic: The application to Heathrow airport*, Journal of Air Transport Management, 34 (2014), pp. 116–122.

[4] T. R. Willemain, H. Fan, and H. Ma, *Statistical analysis of intervals between projected airport arrivals*, tech. rep., Citeseer, 2004.

[5] R. Killick, P. Fearnhead, and I. Eckley, *Optimal detection of change-points with a linear computational cost*, Journal of the American Statistical Association, 107 (2012), pp. 1590–1598.