Solving the Airline Pilot Manpower Planning Problem

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1 Abstract

Jeppesen builds planning products with specialized optimizers in use by major airlines all over the world. Among these is the Manpower Planning product which handles the long term planning of recruitment and promotion to meet the forecasted crew need. The planning horizon is typically a three-year period to ensure that the promotion and recruitment decisions made in the following months are feasible in a long term perspective. Transitioning a pilot between aircraft types is costly both in terms of equipment used and production lost during the training that may span across several months up to half a year. Thus, avoiding unnecessary promotions and recruitments is just as crucial as doing the necessary ones in order to have a cost-effective resource plan.

An airline usually has several different aircraft types, all requiring their own unique qualification. In most cases, these qualifications are mutually exclusive, meaning you may only be qualified for one aircraft type at the time. These different positions, generally two for each aircraft type due to different requirements for captains and co-pilots, all need to be balanced with respect to the forecasted crew need. For a large airline with 4000 pilots these different positions easily generate over one million different legal promotions, or rosters, over the planning period.

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The order in which crew are granted promotions is governed by strict seniority rules. Meaning, a pilot who has worked longer at the airline should always be promoted before a more junior pilot. These strict seniority rules can force multiple transitions between fleets due to vacancies created by senior crew moving to even more senior positions. Due to the lack of a predefined career path, crew are moved depending on bids, which further complicates the structure of the model. For each given time period, simulators, instructors and other training resources need constraints to avoid overuse. Distribution of vacation, recurrent trainings, part-time, temporary moves between bases and leave is also part of the manpower planning problem, and has been incorporated into our model of the problem.

The model has been formulated as a mixed integer program. The main decision variables are deciding which, if any, promotion a crew member receives. Additional variables make decisions such as how much vacation or overtime should be used in a given time period. The constraints consist mostly of seniority constraints, one for each pair of rosters, resource balancing constraints and constraints balancing how much crew is needed in the different positions over time.

Naturally the problem is too large to solve directly, even as an LP relaxation, with columns counted in millions and rows counted in billions. The solution approach uses a sequence of different methods in a neighbourhood of varying size around the incumbent solution, limiting which promotions are available for crew. These methods include LP-based construction heuristics, very large-scale neighbourhood search methods and time sweep methods. The methods formulate smaller versions of the full MIP which are typically solved using a third-party optimizer such as CPLEX or Xpress.

Substantial savings have been seen by airlines using our manpower planning optimizer. The savings come from e.g. reducing the required number of new hires, decreasing usage of simulators and reducing the need for additional instructors. In the talk we will give a more detailed description of the problem as well as present a high-level description of the mixed integer model, the heuristic solution process and successful applications.