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A Wider Perspective on Reducing Fatigue Risk in Aviation

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Problem

The traditional method of containing fatigue risk when planning airline pilots has been to apply a collection of strict cut-off rules, for example for the duration of duty time. Today, when having bio-mathematical models (BMMs) available which more accurately predict fatigue risk, many organisations are still limiting their risk reduction approach to only focus on the flights beyond a cut-off limit from a BMM. This leaves a significant amount of untapped improvement potential, as risk is also present below the cut-off limit. This paper proposes metrics for quantification of overall fatigue risk and a method for improved risk reduction in a crew planning process.

Method

Fatigue risk in aviation is, in simple terms, equal to the risk of a crew member performing a lapse, slip, mistake or violation with a potentially negative impact on flight safety, as an effect of low levels of alertness (high sleepiness or fatigue). Bio-mathematical fatigue models (BMM's), predict, on various scales, the performance degradation of crew on future rosters. These outputs are continuous and with a significant variance around the output value that typically is a prediction for the median of the population of crew operating the sequence of activities. The variance stems from the models being imperfect, the models being under-informed (e.g. individual commute times and actual sleep not being available) and from inter-individual and individual differences in crew. This leaves the BMM, in individual cases, with a rather low accuracy - particularly for predictions that are high in alertness.

For these reasons, it becomes important to look not only at the "few worst flights" but to attempt to address the overall risk which is reflected by the sum over all flights. In this paper we have a) proposed definitions for this aggregated fatigue risk, and b) quantified the difference in overall fatigue risk level obtained between a few crew planning problems solved (i) using the traditional cut-off approach, and (ii) using a BMM that, via a metric on overall fatigue risk, in real-time, guides the solution away from risk. Measurements were made using crew planning tools and optimisers common for many of the larger airlines. Both crew efficiency aspects as well as the overall fatigue risk were quantified in a sensitivity analysis.

Results

Building on the correlation between sleepiness levels and the fatigue risk of an individual, and the known variance of BMM's, this paper proposes a definition of two metrics for <u>overall fatigue risk</u>; Absolute Fatigue Risk (AFR) reflecting the overall risk for a fatigue related incident or accident taking both severity and frequency into account, and Normalised Fatigue Risk (NFR) reflecting the <u>risk profile</u>; average risk per flight. Using these two metrics for quantification of overall risk, the results clearly show that fatigue risk, in the studied planning problems, can be reduced 4-9 times more effectively with a holistic proactive approach and without a drop in crew efficiency, , compared to a more traditional approach using only a strict cut-off.

It is further shown, when keeping all constraints intact, that there is a point after which the return diminishes and costs are increasing much faster than fatigue risk is being reduced. We also demonstrate that an even higher improvement, at a lower cost, can be achieved if a few rules are allowed to be re-aligned with human physiology - something a BMM can be used for in a series of iterative what-if simulations.

This study is done using just a few network structures for two pilot operations and it should be noted that results are highly dependent on the flight schedule, the crew base establishment and additional constraints present.

[Picture over the results when solving a planning problem without (left), and with (to the right), the assistance of a BMM. Crew efficiency here represented by the number of duty days.]

Discussion

There is no doubt that flight and duty time limits, using hours and minutes of work/rest in various combinations, will remain the main constraints governing the design of crew pairing and rosters. It is also clear that only complementing them with an additional rule, stating that crew should not be planned beyond a certain threshold on an output from a BMM, is not an effective approach compared to the alternative investigated here. This alternative is to quantify overall fatigue risk and allow such a metric guide the basic design of crew schedules, while naturally still respecting all of the traditional constraints. Even if we are unlikely, in the industry, to arrive at defining rules for overall risk, it is clear that it is these metrics we should place a higher focus on in the future as they much closer reflect the actual risk for a fatigue related incident or accident. Verifying that a definition of overall fatigue risk is the best possible one, should not be taken as an excuse for not using one, as we know the overall risk is what will produce the undesirable outcomes.

BMM's will hopefully be used increasingly in a proactive way rather than only being applied after the planning results are ready, changing only a few flights. BMM's may also be used in this way to improve the rules through iterative what-if's, alternatively relaxing them to achieve efficiency, and alternatively making them stricter to better capture problematic flight combinations.

Summary

This study clearly illustrates how fatigue risk can be more effectively reduced in crew planning by guiding the construction of crew pairings and rosters with bio-mathematical modelling, ensuring risk contribution is taken into account from a much wider set of flights than typically done today. It would be highly valuable if the airline industry could agree on a definition for the aggregation of overall risk, and shift the focus away somewhat from only the absolute value of an individual flight - using a wider perspective for fatigue risk reduction.