Aligning Crew Scheduling Rules With Human Physiology

Release the hidden potential in your crew constraints

A collection of hard rules, based on strict cut-offs for time spent on and off duty, meant to limit fatigue risk, will always contain inefficiencies. Learn the methodology for releasing the hidden potential, benefitting both crew efficiency and flight safety.

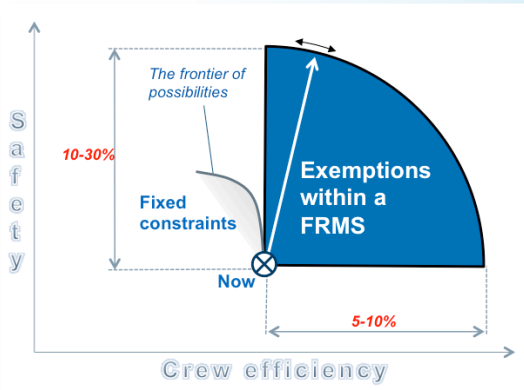
Background

A collection of hard rules, based on strict cut-offs for time spent on and off duty, meant to limit fatigue risk, will always contain inefficiencies. This due to human physiology being so much more complex than what can be captured by rules designed to limit work. Under an FRMS regime, an operator is not only expected to "patch up" the unsafe conditions in the rules, but is also allowed to open up for additional operational flexibility, and have that flexibility "pay" for the safety improvement by enabling greater efficiency, reaching a cost neutral solution. This means improving on the rules coming from a regulator, but it can also be applied to internal labor rules or scheduling practices that in their current shape and form, even though well intended, are just not up to par. It may be your current fatigue rules.

Methodology

So how can this be done in a structured way? As most airlines uses optimizers to quickly find the best possible crew planning solution (be it pairing or rostering planning) compliant with all constraints, it is actually not that difficult today with bio-mathematical fatigue models being widely available for industrial use. These are the nine steps in the methodology:

1. **Prepare.** Take your normal planning solution and use as baseline. Quantify the overall "goodness" of that solution, possibly using your optimizer's objective function, or at least parts of it. Let's call that aspect G, for "goodness". Quantify the overall fatigue risk of the baseline solution, calling it R for risk. (Good metrics to use for risk is either PA5, or, for more detail, the normalized fatigue risk NFR).
2. **Appraise.** Consider quantifying the maximum achievable potential by making a planning run (a solution) where you shut off all rules that are solely there for protecting from fatigue risk. Instead, limit fatigue risk by using an incentive for the optimizer penalizing fatiguing conditions. Quantify again G and R. (This is an optional step requiring a fatigue model that works real-time with an optimizer).
3. **Relax.** Form a hypothesis of what rule relaxations in the baseline would be the most effective for improving G. This may be done in part by activating the base line rules on the max potential solution and counting illegalities. Implement those relaxations that seem most promising from a human physiology perspective, and re-run the planning solution, calling the solution A. Measure G and R again. (If only minor improvements to G; work on your hypothesis...). Once done, it is likely you have now improved G significantly but have also made R somewhat worse.



4. **Constrain.** Use the fatigue model to find and study the cases (scheduling patterns) that you now allow in A and that the fatigue model considers really poor. Try to write rules that are preventing these cases from occurring, perhaps reformulating some of your relaxations, or adding new rules altogether, now again constraining the problem more. Use solution A to gauge that the modified rules captures (makes illegal) the bad flights with decent accuracy. Make a new run with this rule set calling the result solution B. Measure G and R again. Hopefully R is now improved, but G has most likely taken a small hit. Make sure you improve R to beat what you had in your baseline solution.
5. **Evaluate**. Unless happy with the improvement reached in G and R; go back to step 3 using solution B as the new baseline. The max potential found in step 2 can be used for measuring you level of success in step 3 and 4. Typically some 60-80% of the potential should be possible to reach by these rule re-formulations.

6. **Stress test.** Provided you have a fatigue model you also can use real-time with the optimizer; introduce an incentive for the optimizer rewarding fatiguing flights. Make new worst-case runs for a) the new rule set and b) the original rule set, now pushing the optimizer to plan as poorly as possible (while still staying within the rules). Measure R and make sure the new rules do not allow for more fatigue risk to "slip through" than the base line rules did. If they do: go back to step 3.
7. **Validate.** Make sure you also do the above steps (1-6) over bigger, or several, data sets (flight schedules) so that you verify that the rules are not in any case (e.g. during another season) resulting in making G or R worse than the baseline(s). Make planning runs for both the pairing construction and the roster construction step of your crew management process, and also consider/estimate the difference in likely impact these new rules will have on G and R during roster maintenance and day-of-ops (if any). As this is most often manual work, you will need an assessment done by a SME covering that part of the process.
8. **Apply.** Consider improving R even further by, during your regular planning runs, gently pushing the optimizer to a corner of the solution space with lower fatigue risk; by now in the proper direction, penalizing fatiguing conditions. Typically quite a lot can be achieved by this, despite fixed constraints, with almost no negative impact on G at all.

In conclusion

Clearly the above is work for a fairly skilled business analyst with insight in human physiology, and is not work that is suited for everyone. It also requires good and fast planning optimizers, as well as an easy-configurable business logic implementation allowing for creating the needed what-if's. Many of the leading airlines already have such solutions in place. And if not, there are companies such as Jeppesen that can assist with this work performed as a service. The gains on G and R may be in the range of 5-15%, sometimes higher. At Jeppesen we have seen reduction of overall fatigue risk with as much as 40% with maintained "goodness".

The methodology here described might look complex, but it is increasingly applied and has already been used for approved derogations to the EASA FTLs, complemented with verification through data collection from crew operating under the modified rules.

Read further

The methodology can also be used in a grander scale over a set of flight schedules for several operators, should a regulator wish to develop flight and duty time limits in a quantitative way, rather than rely on qualitative speculation on the effects of rule re-formulations. Please see this paper for further reasoning upon the effectiveness of flight and duty time limits.

Please consider attending the Jeppesen FRM training courses that include hands-on exercises using planning optimizers and fatigue models. Jeppesen also has several in-depth courses on modelling rules, incentives and using the built-in analytical capabilities in the Jeppesen Crew Solution suite. The full course schedule is found here.