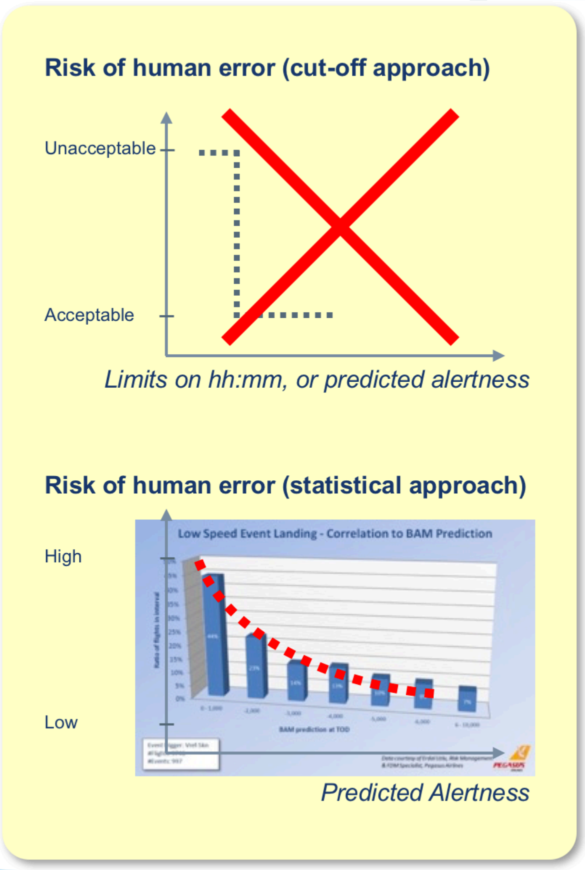
Are Your Crew Processes for FRM *in Control*?

Using Statistical Process Control techniques to detect ***true*** trend changes in risk exposure

Are you attempting to 'correct' or improve your crew management process in order to reduce fatigue risk for your crew? Please find below some thoughts to get you started, using a sound statistical approach in order to reduce the risk that you overreact to common causes of variation - which may even make things worse.

Background

To produce the daily roster content for thousands of airline crew, month after month and year after year, is in many ways very similar to large-scale manufacturing of any other product. The final 'product' will contain *variation* as a result of disparities in the material used (the flight schedule), the skill and motivation of the operators (the crew planners) and the capability and shape of the machinery (the crew planning solution/process). The product is further governed by the constructional drawing (duty time rules) and other limitations present (bidding concept, base establishment etc) as well as a need for keeping costs as low as practically possible in order to stay in business over time.



Cut-off approach (top) compared to a statistical address of risk, recognising that risk accelerates as the prediction falls, here overlaid with operational FDM data.

In former times, producing a product with high quality was to a large extent connected to using *final inspection*; removing products at the end of the line which fell beyond tolerances as an effect of variation in the process. This was found to be an expensive way of ensuring quality. This is why already in the 1930s, a technique called Statistical Process Control (SPC) evolved. With SPC, the quality control is applied to the process itself; identifying and eliminating special causes for variation. The technique, originally developed and advocated by Shewart and Deming [1], is today the dominating one in all of manufacturing and part of the basic 'tool box' in Lean, Six Sigma and Quality Management in general.

It turns out, not surprisingly, that detailed knowledge of a production process and a systematic approach for reducing process variation and increasing process capability, is *crucial* for improving any process output in a cost efficient manner. One such output is the level of *fatigue risk* present in produced crew rosters. Using a bio-mathematical model to only gauge rosters at the 'end of the line', sending some back for costly and time consuming re-work, resembles the approach abandoned by the manufacturing industry many decades ago.

So what *should* then a fit-for-purpose, systematic approach to controlling and reducing risk, entail?

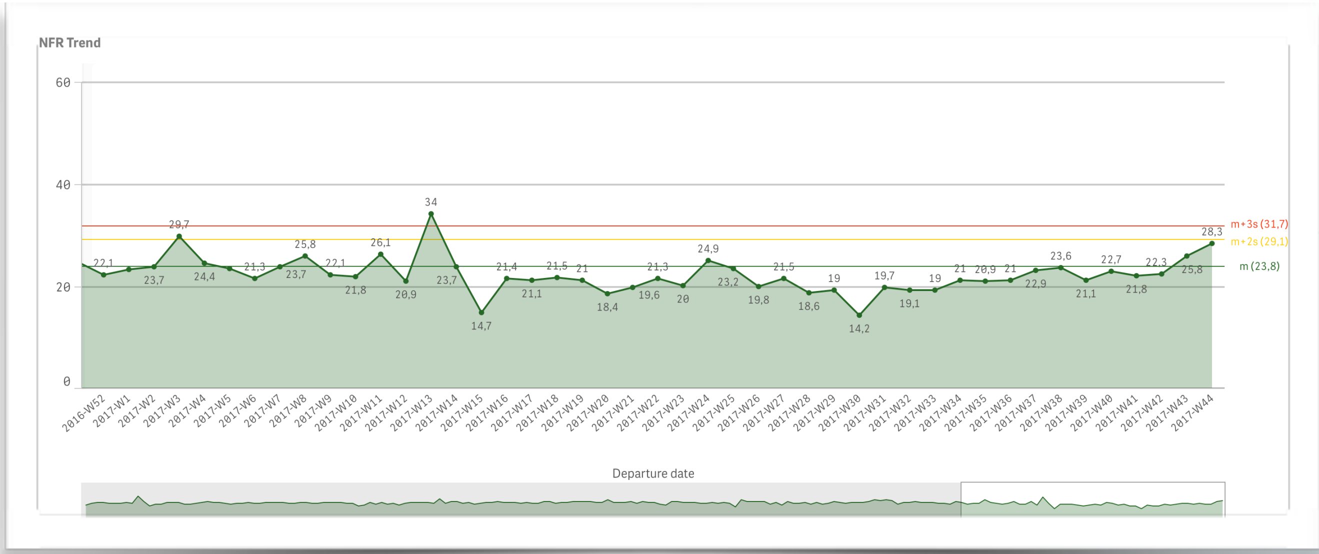
Metrics Reflecting Risk Exposure

To start off with, there is a need for a metric that gauges the output of the crew planning process in a relevant way, but also one used at all intermediate process steps. What will need to be reflected is the *overall* fatigue risk for the operation (or part of the operation). The metric should reflect the risk of a *lapse*, *slip*, *mistake* or *violation* by the crew with potentially negative impact on flight safety, as an effect of low levels of alertness. This risk has been shown to *accelerate* as the predicted level of alertness from a fatigue model approaches zero.

Furthermore, in order to be able to track the risk development over time, it is good if the metric reflects the risk *profile*, for example expressing risk per flight or flight hour. (This should not exclude tracking overall risk development, but that risk may obviously also shift with the overall production volume.)

A suitable metric fulfilling the above is **NFR**, the Normalised Fatigue Risk. This metric is using the predicted level of alertness at top of descent for the pilots (and the average level during the flight for the cabin crew), and then applies a weighted sum over all flights, reflecting the accelerated fatigue risk in humans, computing an average risk per flight. With this number, it is possible to compare different fleets, ranks, crew bases or even airlines to each other - even though they differ in size. NFR is also suitable for tracking the fatigue risk development *over time*; for example looking at the variation in weekly NFR in a part of the operation. Looking at a calendar week is a good “chunk” of the production as there is typically a natural weekly periodicity in the flight schedule.

The picture below illustrates an example of tracking the weekly NFR over a few years.



A control chart for NFR, derived from 1.5M flight assignments, out of Jeppesen Concert. UCL is marked in red. (The data point in week 13, going beyond UCL, is caused by the DST change shortening night sleep for all crew with one hour.)

Process Improvement

Improving upon the crew management process is *one* obvious objective of a fatigue risk management system. It is highly desirable to implement changes that reduce, or at least better constrain, the overall level of crew fatigue risk. But implementing changes and attempting to improve a process that is not in *statistical control* is futile; first we need to ensure that the process is stable and produce repeatable and reproducible results. We would not want to overreact on common causes for variation, but rather improve a process that is in control and focuses on the special and systematic causes for variation. So how can we detect that we have special causes present and that we should take action? Here we can lean upon the approach used in the manufacturing industry for decades: control limits.

Implementing Control Limits

Control limits can be seen as the *voice of the process* and is typically placed so that they surround the mean process output with +/- 3 standard deviations. There will be an upper control limit (UCL) serving as an indicator for increased risk, and a lower one (LCL) indicating that there is a decrease in risk level that is not just occurring by chance. Assuming a normal distribution of the variation, 99.7% of the data points are expected in the interval between UCL and LCL. A data point *outside* the control limits, serves as a very good indicator of a systematic change to the risk level induced by special causes of variation; so called non-random variation.

Examples could be that we have a crew deficit on a base leading into higher risk (going beyond UCL), or that we have managed to improve our process; seeing the risk fall below LCL which serves as a receipt of the effectiveness of our FRMS.

Commonly used indicators for a“signal” of special cause of variation are:

- Any point outside the control limits
- A run of 7 points, all above or below the central line
- A run of 7 points going up or going down

When one or more of these criteria are met, we can be fairly sure we are looking at a trend change that is not only due to common causes of variation. We should now investigate and consider taking action. Or celebrate our success.

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Further reading:

- More on Control Charts
- Aligning Rules With Human Physiology
- Jeppesen Concert
- Assignment-centric Performance Indicators
- The secret behind pro-active risk reduction
- Your opinion is interesting, but…

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[1] SPC was pioneered by Walter A. Shewhart at Bell Laboratories in the early 1920s. Shewhart developed the control chart in 1924 and the concept of a state of statistical control. Statistical control is equivalent to the concept of exchangeability developed by logician William Ernest Johnson also in 1924 in his book *Logic, Part III: The Logical Foundations of Science*. W. Edwards Deming was an important architect of the quality control short courses that trained American industry in the new techniques during WWII. Deming also traveled to Japan during the Allied Occupation and met with the Union of Japanese Scientists and Engineers (JUSE) in an effort to introduce SPC methods to Japanese industry.