

A SYSTEMATIC APPROACH TO CREW FATIGUE ANALYSIS TO MEET EASA FRM REQUIREMENTS

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BUSINESS

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Airlines and pilots gear up for new time rules



pilot-rules.jpg

By [Keith Findlay](#)

Tags

European airlines have a year to prepare for new rules governing the amount of time pilots are on duty after a survey of more than 6,000 of them revealed shocking

Fatigue Risk



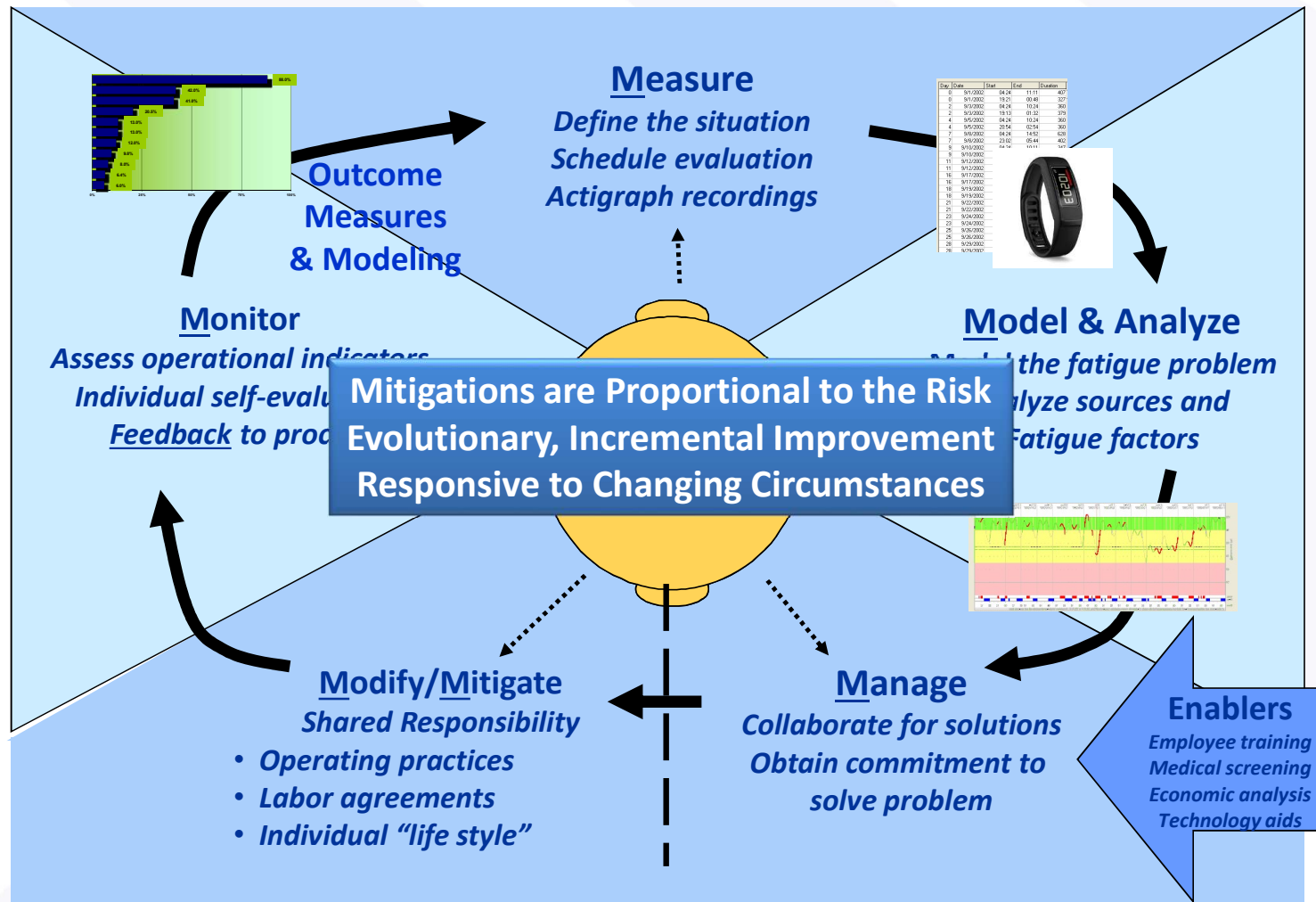
FRMS Requirements

In the EASA Standards(3.3.3), States shall require, as part of their State safety programme, that an operator implement a safety management system acceptable to the State of the Operator that, as a minimum:

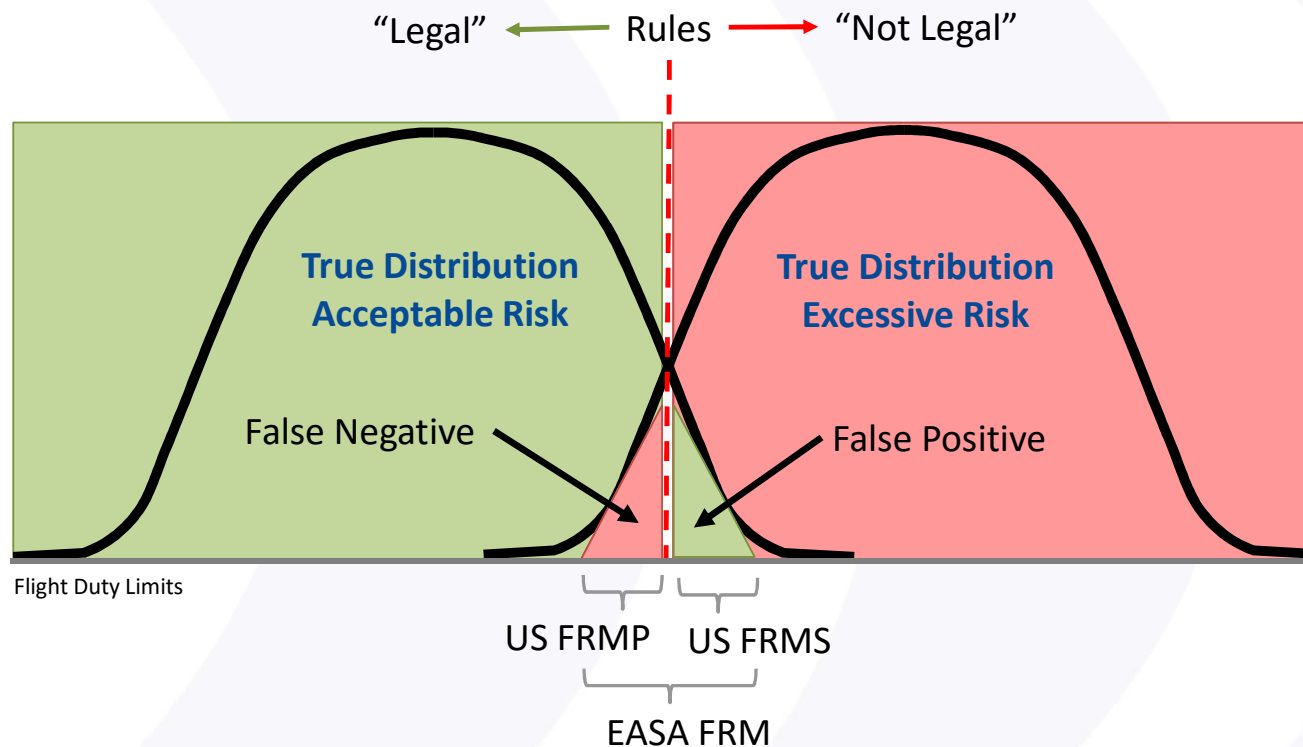
- a) identifies safety hazards;
- b) ensures the implementation of remedial action necessary to maintain agreed safety performance;
- c) provides for continuous monitoring and regular assessment of the safety performance; and
- d) aims at a continuous improvement of the overall performance of the safety management system.



Continuous Improvement Process



Fatigue Risk Management Systems



- Apply a scientific and data driven approach to minimize fatigue risk.
- Eliminate false negatives and false positives created by imperfect rules.



FRMS Methods to Better Manage Fatigue

- Goals:

1. avoid situations that pose excessive fatigue, even when permitted
2. identify certain prohibited situations that do not pose excessive risk and could be flown under controlled circumstances.

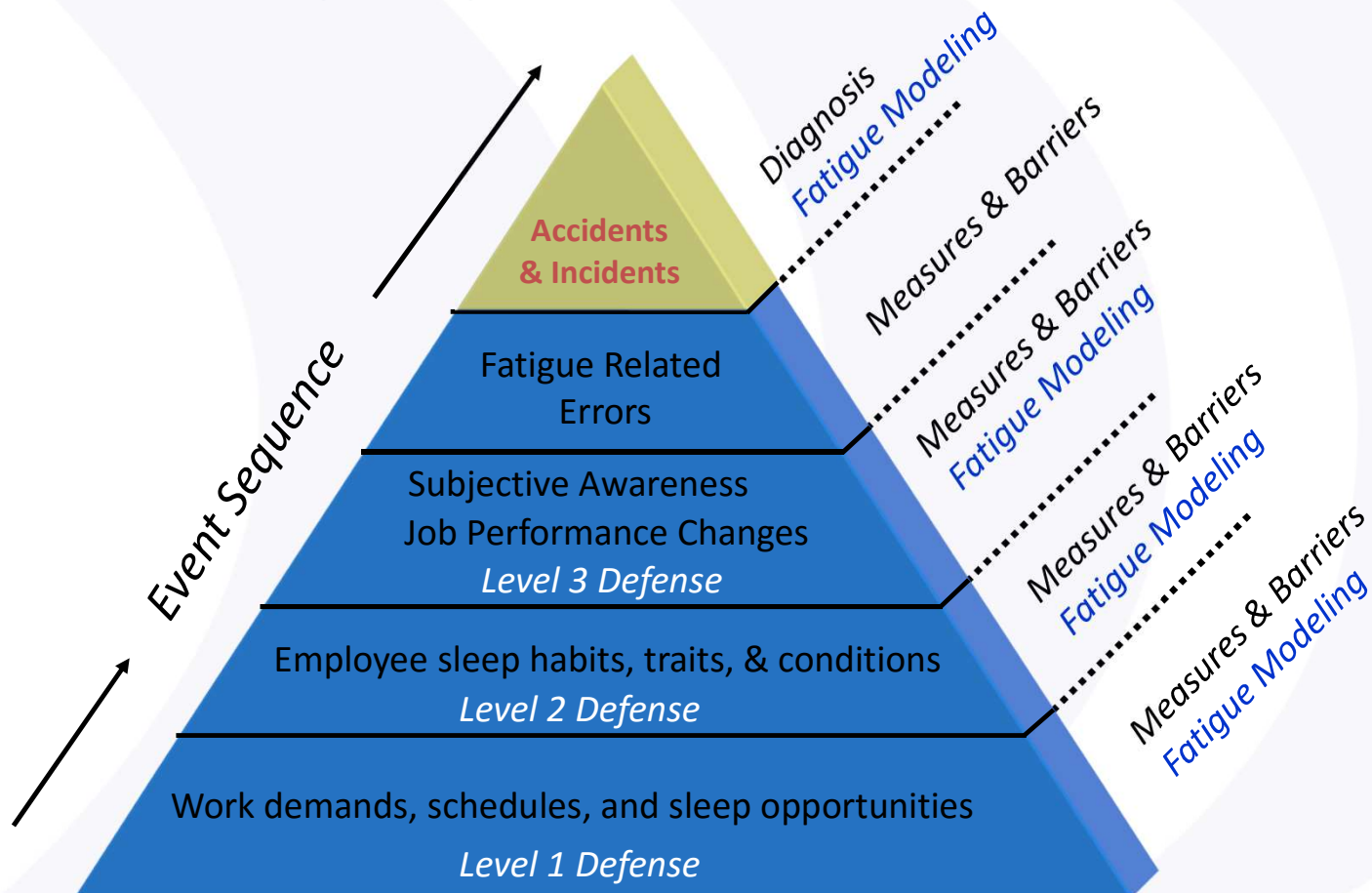
- Methods:

- ◆ Additional duty and rest policies
- ◆ Fatigue reports and root cause analysis
- ◆ Fatigue training
- ◆ Sleep disorder screening and treatment
- ◆ Fatigue related events and root cause analysis
- ◆ Policies for non-punitive “fatigue declaration”
- ◆ Studies of actual sleep and performance
- ◆ Proactive biomathematical modeling of schedules



Fatigue Risk Pyramid

Reducing Fatigue is a Shared Responsibility



Based on James Reason, "Managing the Risks of Organizational Accidents",
Figure 1.6, Stages in the development and investigation of an organizational accident.



Implementation of FRMS



Explicit Fatigue Modeling:
Identify Hazards & Audit Results

Tools must identify increases in fatigue at each stage of planning and operations.

Prospective fatigue identification requires a fatigue model.



Key Modeling Considerations

- **FRM requires fatigue evaluation at every stage in scheduling process**
 - Should be “universal”, pulling data at each stage and providing fatigue hazard assessment against a single standard.
- **Fatigue models in aviation should use realistic sleep assumptions**
 - Sleep assumptions are just as important as the underlying physiological model.
 - Models should realistically reflect how flight crew manage sleep across multiple time zones with irregular start times and variable commute times.
 - The sleep pattern should be reported for evaluation against actual data.
- **Fatigue models should give you more than a single score**
 - Model ought to display and document the fatigue factors that cause the hazard and display the verifiable benefits of mitigations.



Key Modeling Considerations (cont.)

- The modeling process should be “transparent” to the user
 - Each assumption made, hazard identified, and mitigation required – should be exposed so it can be audited and verified against an independent standard.
- Fatigue models should be implemented so the entire performance distribution is moved to the right – to higher levels of alertness
 - Not just elimination of outliers.
- Fatigue modeling should be part of a continuous improvement process
 - Process should include evaluation of performance at each stage and time point.
 - Modeling should support all the other elements of the FRM.
- There is no “Easy Button” – modeling is an imperfect “reality”
 - Multiple metrics, sliding criteria
 - Judgment by the user should be applied appropriately.



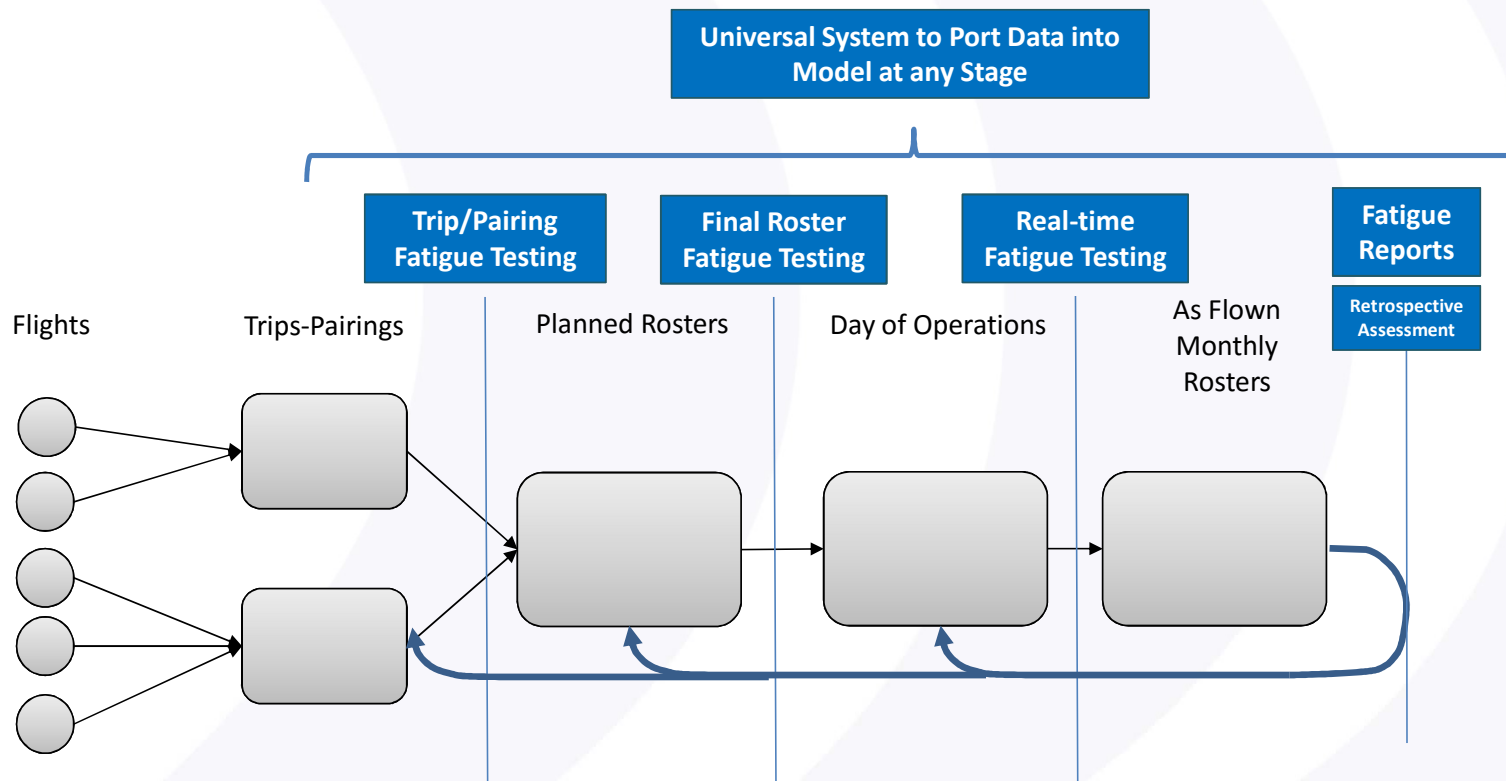
Identify Explicit and Verifiable Fatigue Factors

- **Time of Day:** between midnight and 0600 hrs.
- **Recent Sleep:** less than eight hours in last 24 hrs.
- **Continuous Hours Awake:** more than 17 hours since last major sleep period.
- **Cumulative Sleep Debt:** more than eight hours accumulation since last full night of sleep (*includes disrupted sleep*).
- **Time on Task/Work Load:** continuous work time without a break or intensity of work demands.
- All five factors **interact simultaneously** in non-linear relationships
- The model can estimate the level of degradation in performance and provide an estimate of ***schedule induced fatigue risk***.

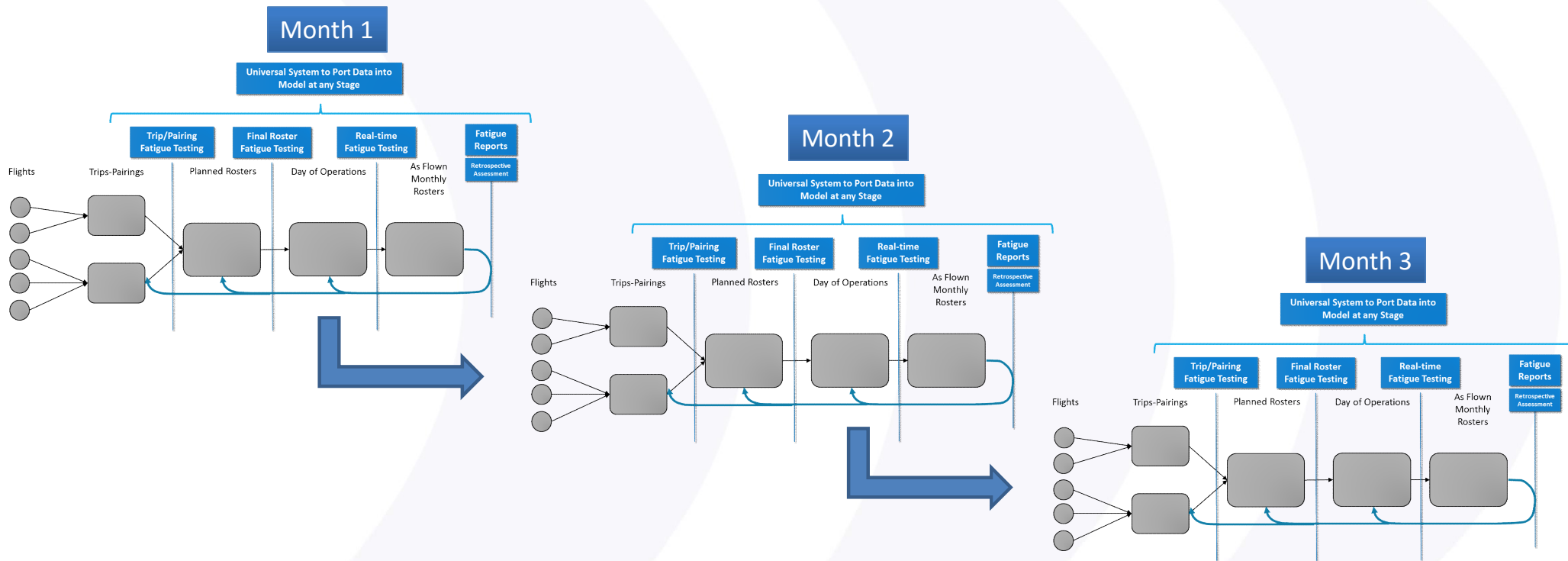


Concept of Mature Fatigue Modeling Approach

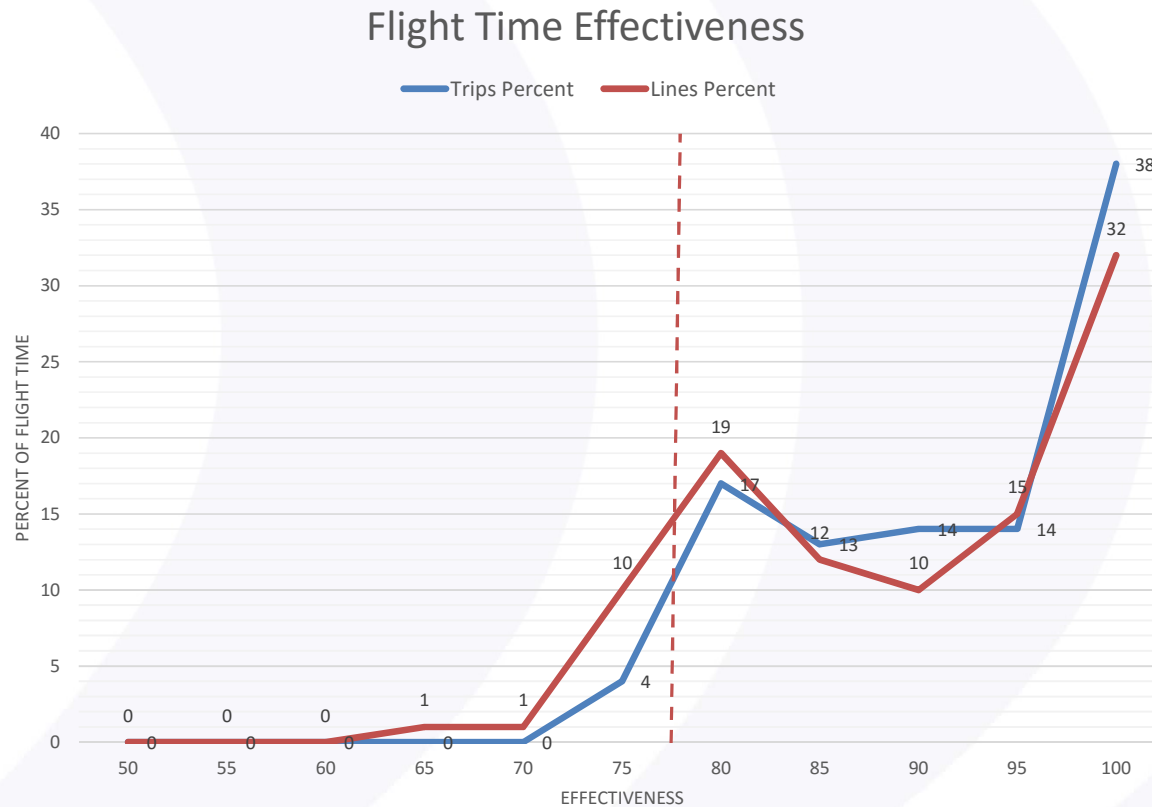
Flight Schedule Assessment - Critical Control Points in Life-cycle of Flight Operations



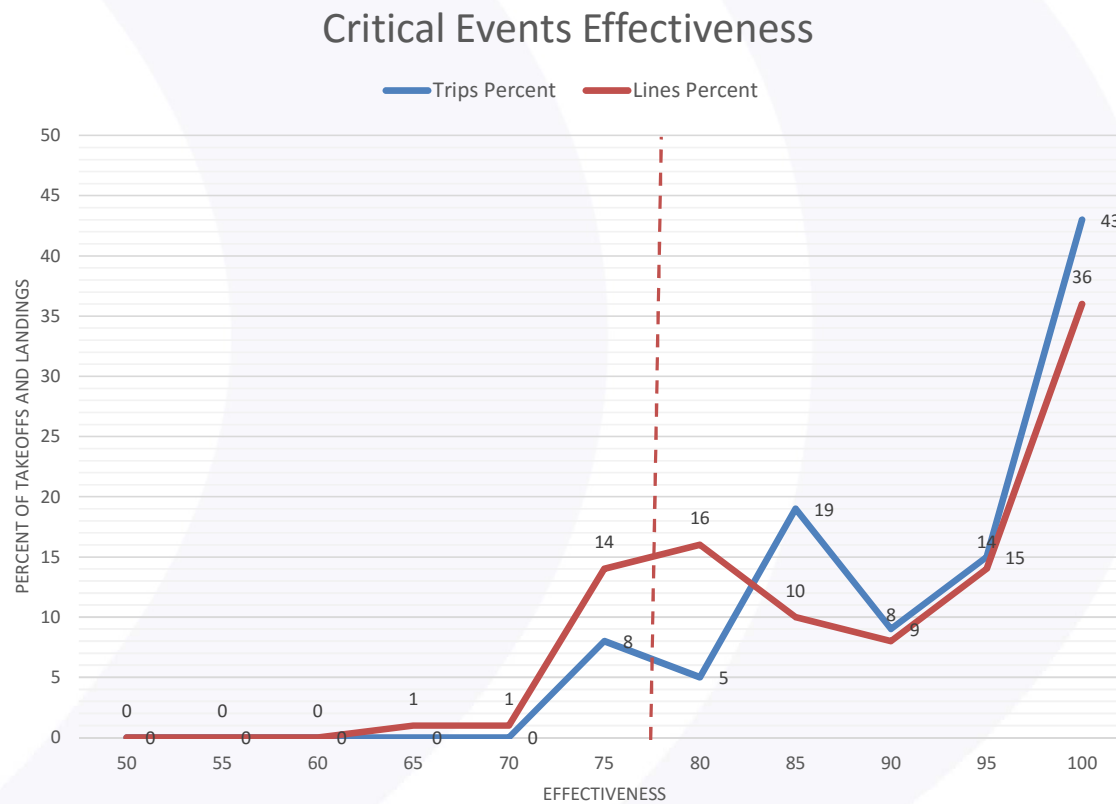
Evolution of Improved Performance over Time



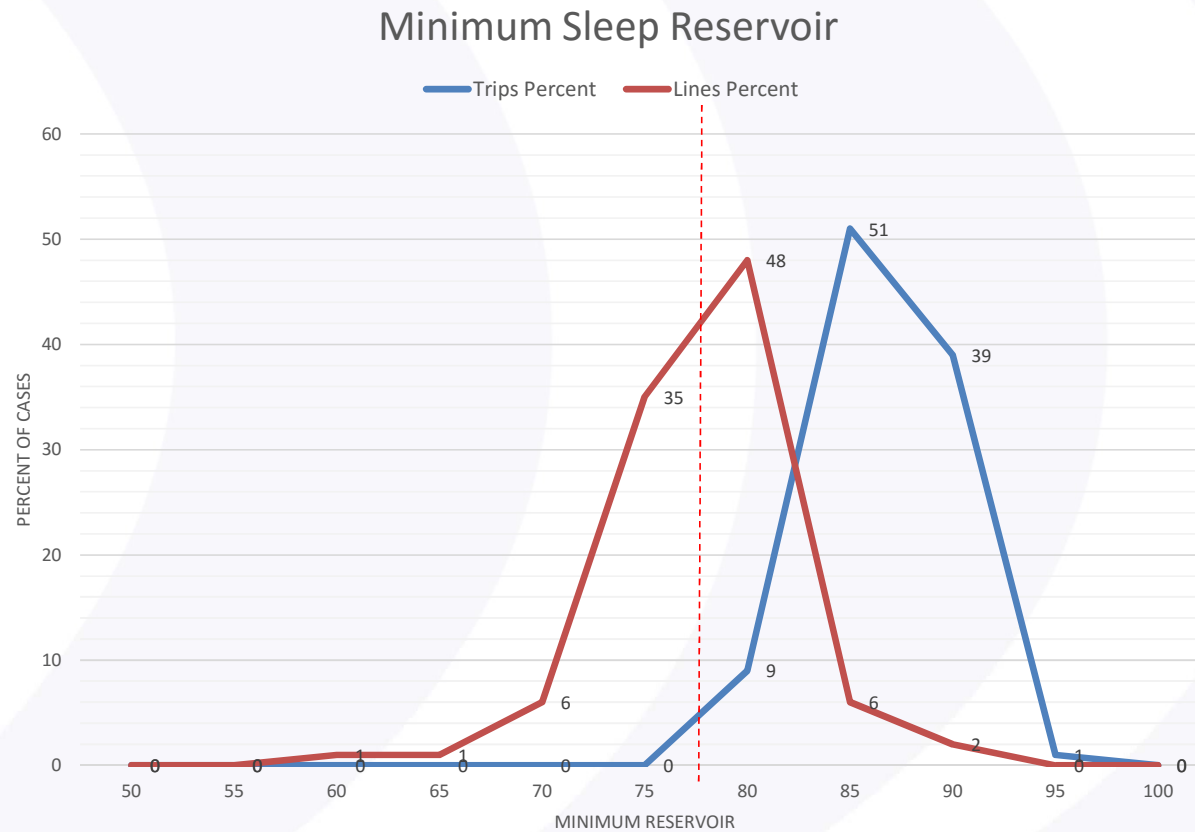
Shift in Flight Time Effectiveness



Shift in Critical Events Effectiveness



Shift in Sleep Reservoir Minimum

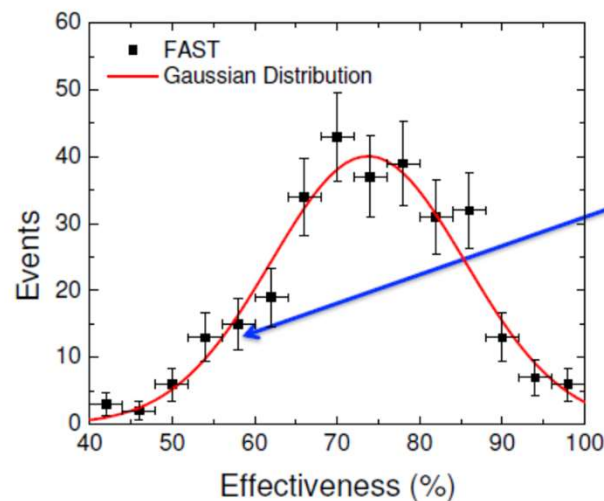


Correlation between Fatigue Model Prognostics and Fatigue Reports of Pilots of Brazilian Civil Aviation

P. Licati, T.E. Rodrigues, D. Wey, F.M. Fischer, and L. Menna-Barreto

Pilot Effectiveness

Hystogram of Pilot Effectiveness (301 fatigue reports)



Average value:
 $\mu = 73.8 \pm 0.8 (\%)$

04/06/2012 06:00

Effectiveness

59





Recent Sleep

Chronic Debt

Hours Awake

Time of Day

Out of Phase

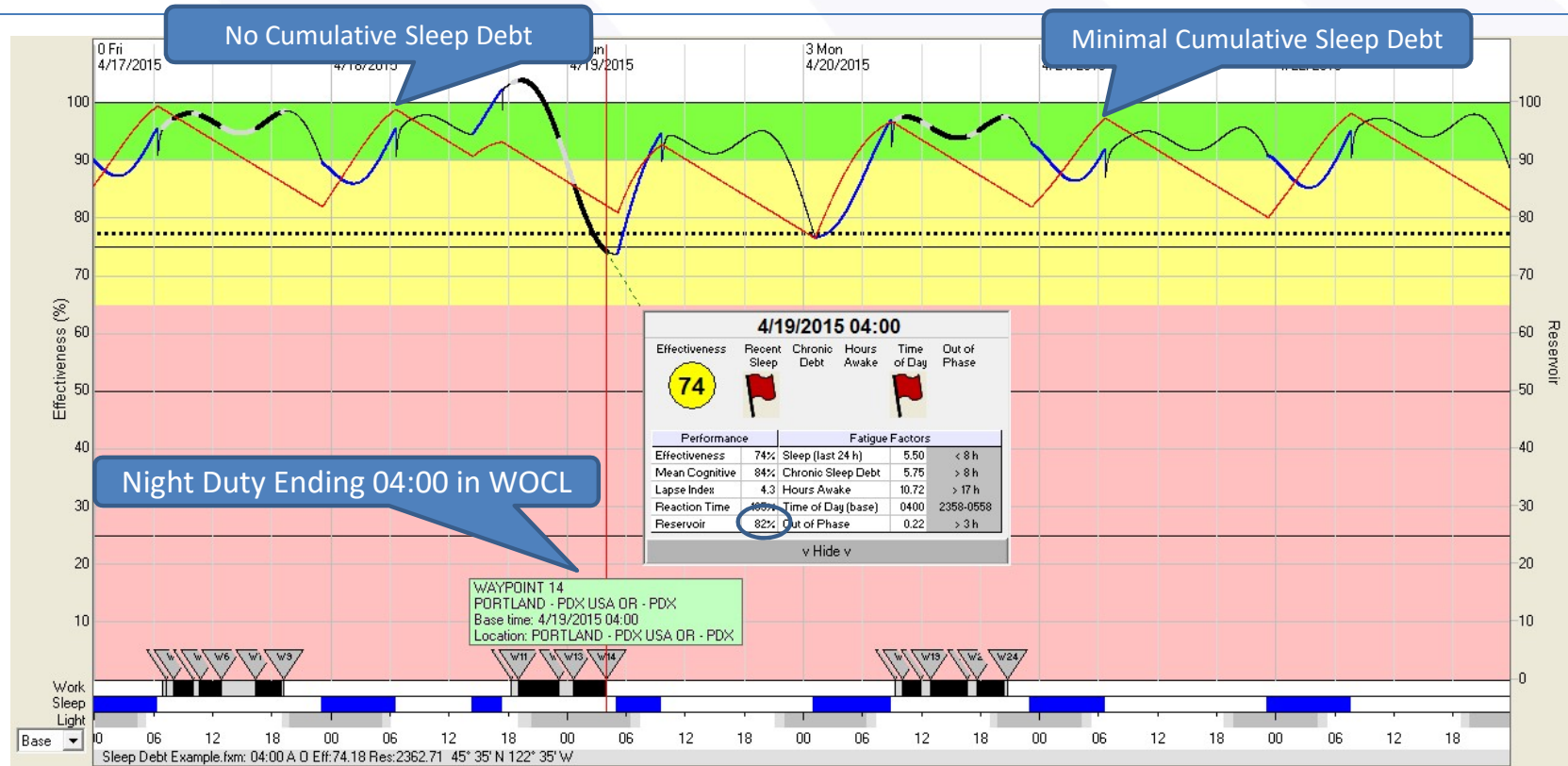


Performance		Fatigue Factors		
Effectiveness	59%	Sleep (last 24 h)	5,50	< 8 h
Mean Cognitive	74%	Chronic Sleep Debt	10,60	> 8 h
Lapse Index	8,1	Hours Awake	12,52	> 17 h
Reaction Time	168%	Time of Day (base)	0600	0019-0619
Reservoir	67%	Out of Phase	9,68	> 3 h



Alertness Score (Effectiveness) Is Not The Whole Story

Night Duty Ending in the WOCL Below Threshold



Value of Sleep Debt as a Risk Metric

- In many cases, the requirement to work at night, either doing shift work or conducting flight operations, cannot be changed.
- Hence, the circadian penalty reflected in effectiveness is unavoidable.
- What is manageable is the sleep debt that is carried into night operations.
- Hence, by focusing on reducing sleep debt during all shifts or duty periods, we are taking the most direct path to minimizing risk.



Explicit Modeling Supports Fatigue Hazard Management

a) identifies safety hazards

- ◆ Modeling Transparency: the specific causes and 'mitigations' of fatigue must be explicitly reported and transparent to the company, pilots, and the regulator.
- ◆ Verifiable Results: An external and transparent model isolates specific sequences as fatiguing, which can be verified by an expert, and fatigue is mitigated by explicit rules, which also can be verified by an expert

b) ensures the implementation of remedial action necessary to maintain agreed safety performance

- ◆ Audit Trail: The problems and mitigations are based on a validated model that can be audited. The effectiveness of the FRMS approach and the modeling can be externally evaluated.
- ◆ Performance Standards: Each solution is evaluated for excessive fatigue relative to a standard. Outliers are identified and user inserts explicit mitigations (rules) in scheduling system that can be audited by the regulator to demonstrate the validity and effectiveness of the FRMS.



Explicit Modeling Supports Fatigue Hazard Management

c) provides for continuous monitoring and regular assessment of the safety performance

d) aims at a continuous improvement of the overall performance of the safety management system

- ◆ Independent Standard: The model identifies specific fatigue factors at any point in a schedule that can be independently verified. Mitigations can be evaluated against these same fatigue factors.
- ◆ Progressive and Continuous Improvement: Only cases of excessive fatigue are mitigated, leaving most other pairings and rosters unaltered. This minimizes cost and operational disruption. Performance improves progressively over time.
- ◆ Multiple Control Points: Modeling can be applied at any stage in the scheduling process to minimize fatigue at each step: pairings, lines, and operations.



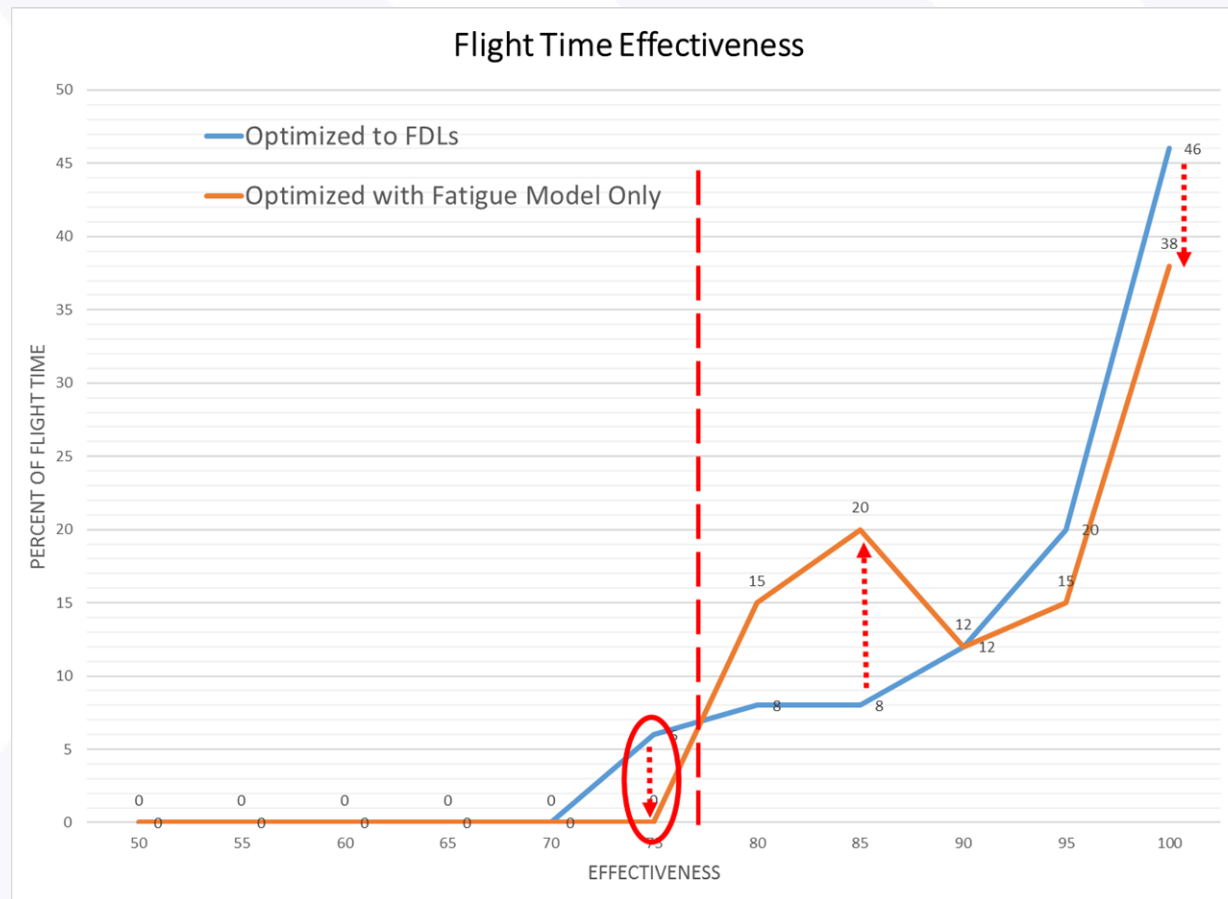
Why not just put the Fatigue Model in the Optimizer?

Downside of an optimized solution:

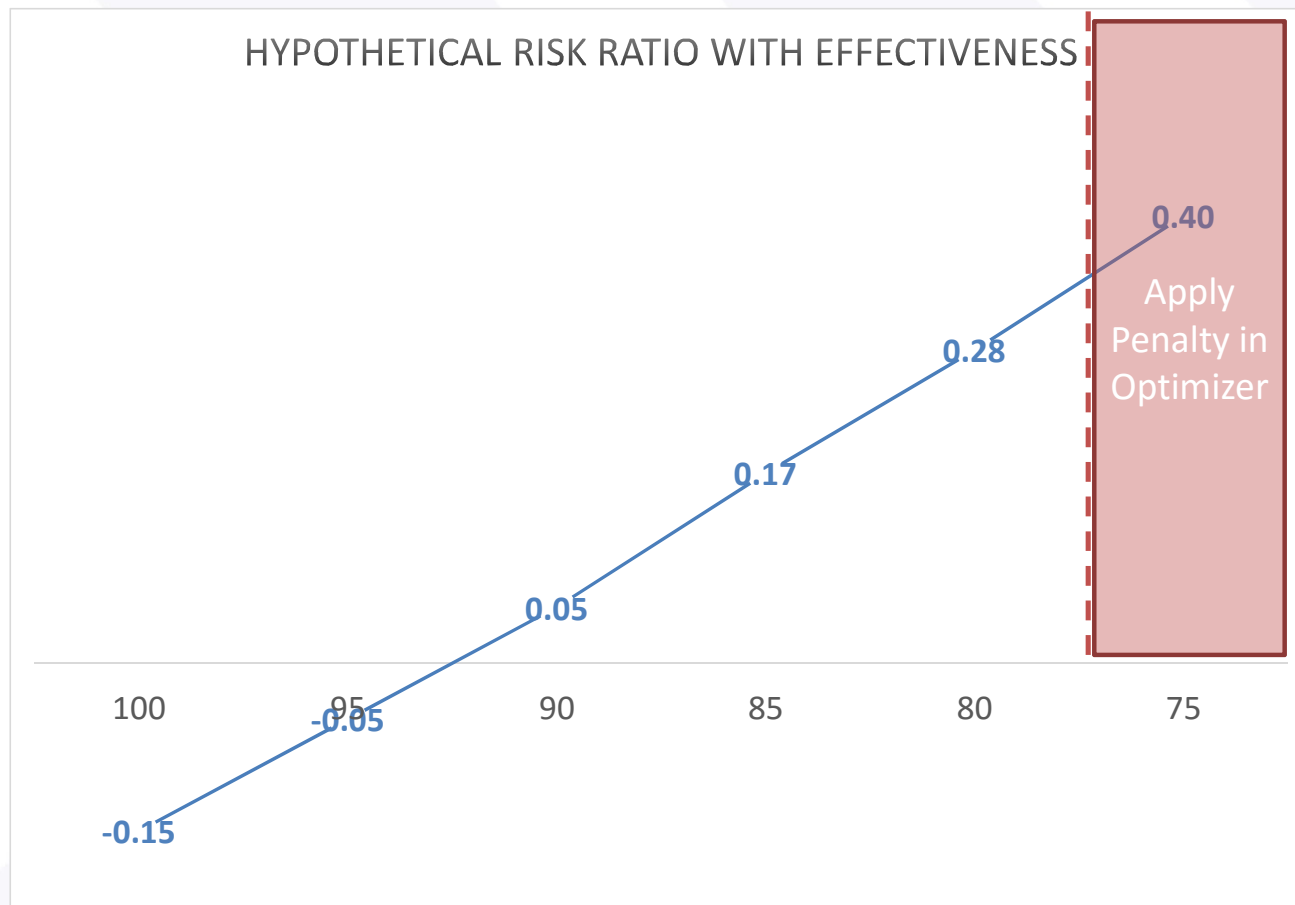
- A simple model is used to run quickly within a pairing/rostering optimizer
- Little to no transparency into the solution process:
 - What caused the fatigue?
 - How was the fatigue mitigated?
- Optimization may move the solution to an overall lower alertness level if FTLs are relaxed
 - ◆ Eliminates (by the model) extreme cases
 - ◆ Moves other cases up to the boundary defined by the fatigue cost penalty
- Overall higher cost solution by introducing another global constraint (minimal fatigue score) to the optimizer in addition to company and regulatory restrictions



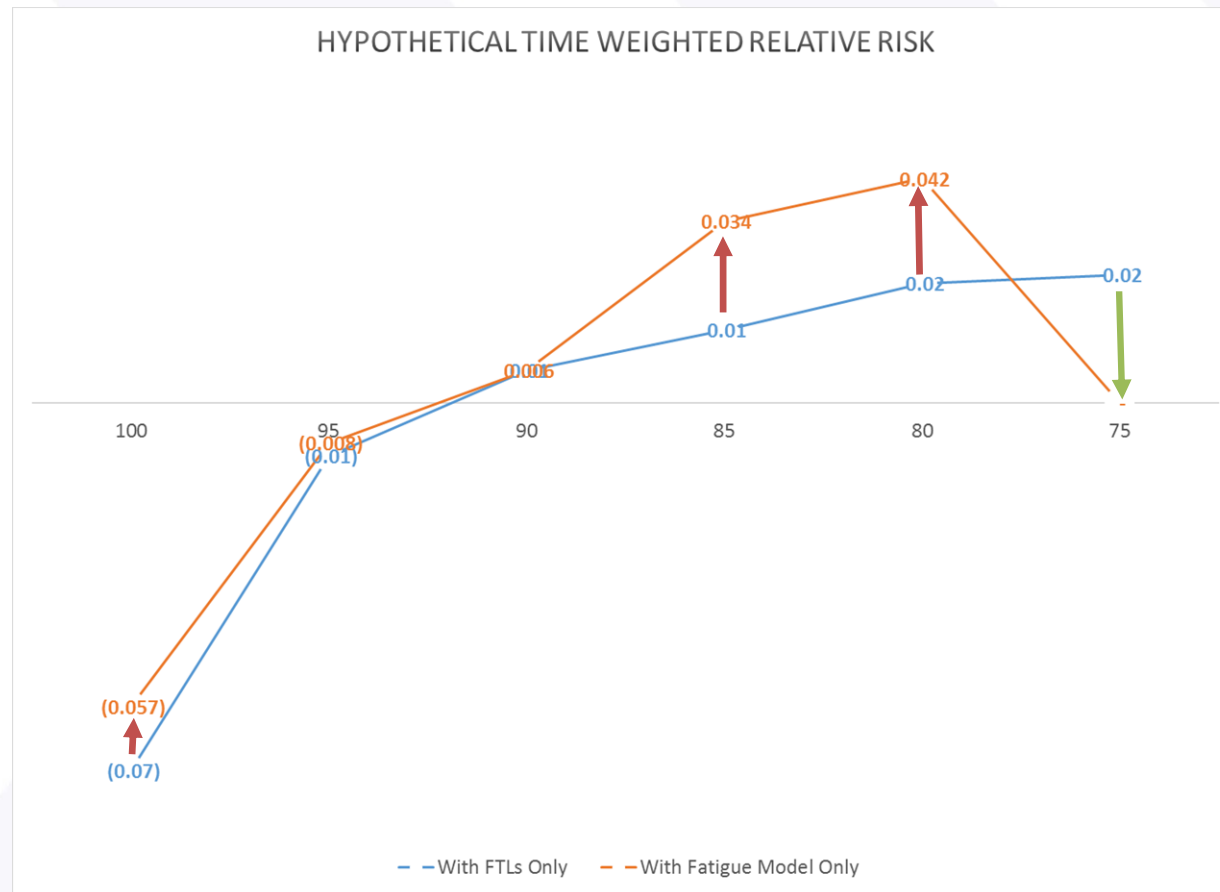
Excessive Focus on the “Bright Line” can Shift Performance to the Middle, Instead of Improving Overall Performance



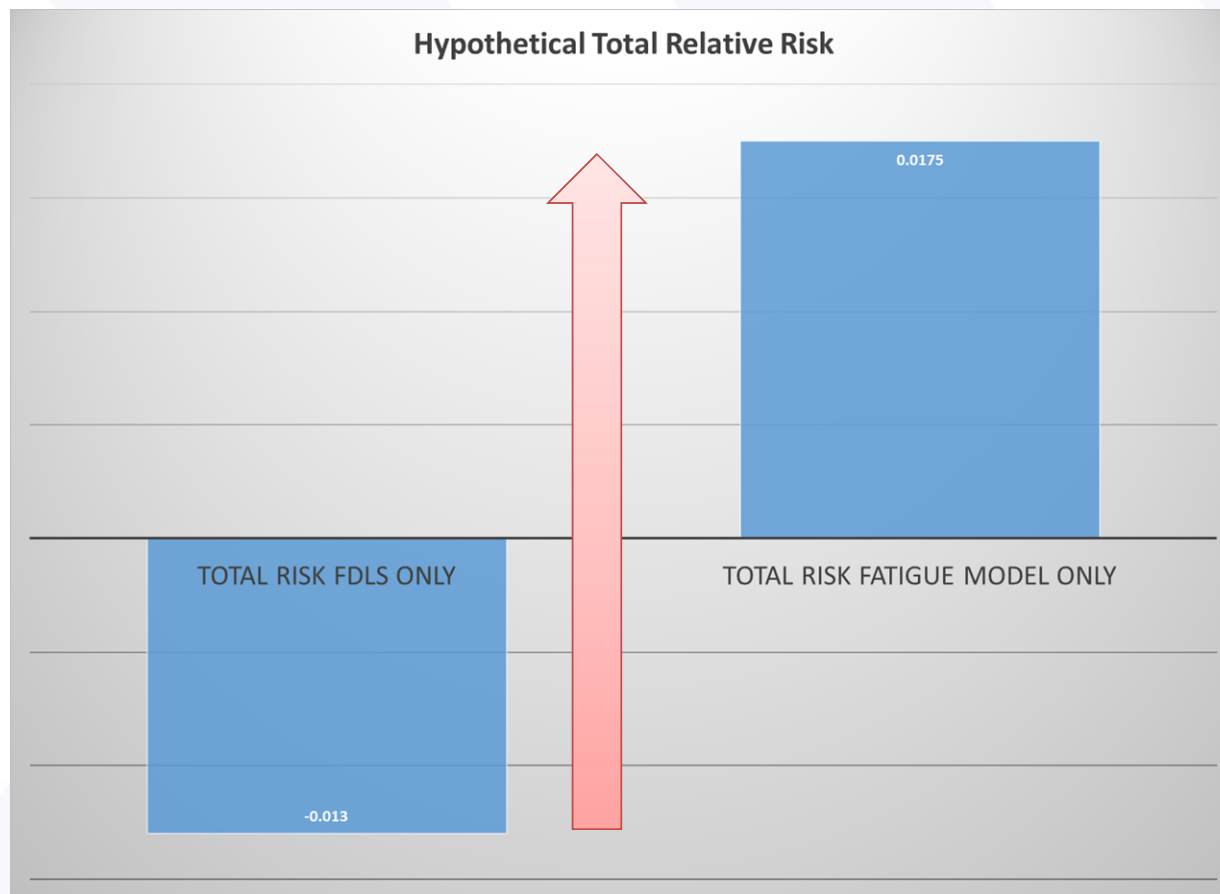
Hypothetical Risk Ratio Function



Time Weighted Relative Risk



Hypothetical Total Relative Risk



Iterative Fatigue Analysis Process

Benefits of an Iterative Fatigue Analysis Process:

- Outliers are identified along with the cause of fatigue
- Schedules that produce high levels of performance are preserved
- Knowing the cause will help guide the mitigation strategies:
 - Adjust scheduling practices
 - Educate affected Crews on cause of fatigue and ways to minimize the risk
- Full transparency, since fatigue is identified and mitigated at each step of the planning and scheduling process
- Auditing, by regulator/labor/management: fatigue is identified along with mitigation from a risk and a cost perspective
- Support to derogation: explicit fatigue analysis with a model can be used to establish a temporary basis for an alternative means of compliance, to be validated by sleep and performance data.



If fatigue is present, what do you do about it?

- An explicit fatigue model should give more than a fatigue score:
 - ◆ Estimates fatigue risk
 - ◆ Shows detail of each schedule
 - ◆ Calculates fatigue factors
 - ◆ Isolates conditions that lead to fatigue so mitigations can be implemented by an FRMS



Questions and Discussion:

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Backup Charts



Crew Fatigue Identification

- Fatigue Reports
- Fatigue Related Incidents
- Root Cause Analysis: a systematic process to identify the organizational, personal, and environmental conditions that led to fatigue so that those conditions can be avoided in the future to improve safety.
- Fatigue modeling can be a useful tool to assist root cause analysis, supplemented by crew reports of environmental conditions and expert knowledge.



