

FTL Effectiveness

How much lower risk? At what cost?
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The problem...



- FTLs are primarily there to limit fatigue risk
- FTLs spring from rules designed to limit physical (not cognitive) fatigue
- The FTL updates in ≈2010-2020 have been done mostly in a <u>qualitative</u> way:
- "12 h of rest before a flight should be better than just 9 h" (...but we know rest may force crew out of bed)
- "A shorter night duty should be more safe than a longer one" (...but more night duties, disrupting good sleep?)
- We lack a <u>quantification</u> of the effects of rules, on overall fatigue risk, when applied to (complex) crew management processes

Qualitative	Quantitative
'I bought the ice cream be- cause I saw it when I was in the checkout line - I wanted	'20% of survey respondents bought ice cream today'
to treat myself.' 'I like a lot of toppings on my pizza - cheese, sauce.	'The average amount spent on ice cream by 500 respondents was \$5'
pepperoni, olives.'	'50% of people in New York strongly enjoy pizza'
'The grocery store has good options in general but the lines can be long and they are often out of stock of my favorite brands.'	'On average, respondents rate their grocery store a 3.5 out of 5'



- Phase 1 published in March 2019. Found 'an increased probability of high fatigue levels during nights and duty periods with late finishes, among both pilots and cabin crew'
- Phase 2 ongoing. NLR/DLR/scientists. Collecting data to further quantify 'FTL Effectiveness'. At all possible?

The platform



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Crew	Plans	to	produce:

4 * 3 * 400 = **4800**

(8,900,000 flights planned into context, using >15k CPU hours...)



'Roll out' and

load into a BI-

solution

Jeppesen Crew Planning (29.0.58181) - ipa2_2019_user IPA2_20210503/AA/32... File Edit Planning Tools Admin Tools Options Jobs Window Special Help 🖿 🖬 C 🗠 🚈 🏦 🖬 🐼 庙 Opt 📊 🕅 = Z U D X II Area 1 Mon Tue Wed Thu Fri Sat Sun 1 Trips Mon Wed Thu Fri 1/1/0//0/0/0/0/0//0 A... JFK JFK A... LAS LAS LGALGA A... LAX <no name> LAX 1/1/0//0/0/0/0/0//0 ... CLT CLT A... SMF SMF "CLT <no name> CLT 1/1/0//0/0/0/0/0//0 MIA MIA MIA MIA A... LAS LAS A. ATL ATL <no name> PHX A...PHLPHL A... LAS LAS PHX <no name> PHX 1/1/0//0/0/0/0/0//0 PIT "DFW TPA CLT CLT "D "CLT CLT <no name> 1/1/0//0/0/0/0/0//0 SAT MIA MIA OFW CHS CLT <no name> CLT 1/1/0//0/0/0/0/0//0 DCA BOS PHX LAX LAX <no name> ORD BOS PHX 1/1/0//0/0/0/0/0//0 ILM MCI MCI MEX IL CLT <no name> CLT 1/1/0//0/0/0/0/0//0 I ... <no name> 1/1/0//0/0/0/0/0//0 Weekly 'rotating' plan. Layovers on <no name> home base to build realistic <no name> 1/1/0//0/0/0/0/0//0 working blocks' up to 7 days long. <no name> 1/1/0//0/0/0/0/0//0 BDL ORD ORD ORD <no name> PHL 1/1/0//0/0/0/0/0//0 <no name> LAX MCO MCO STL STL 1/1/0//0/0/0/0/0//0 MKE DFW SAT SAT " "DFW DFW " "DFW DFW <no name> 1/1/0//0/0/0/0/0//0 DEN PHXPHX MCI PHXPHX MKE DFW <no name> DFW 1/1/0//0/0/0/0/0//0 MIA MIA RDU MCO MCO A... LAX <no name> LAX 1/1/0//0/0/0/0/0//0 A... PHL PHL A... DFW <no name> DFW DFW 1/1/0//0/0/0/0/0//0 LGA DFW PNS DFW <no name> CLT CLT 1/1/0//0/0/0/0/0//0 DEN DEN TUS TUS "CUT <no name> CLT

Example of a pattern produced



- MH 330
- Planned only using the EASA FTLs
- Six consecutive nights
 disrupted
- [NOT how they operate, but how they would be allowed to operate]



The metrics



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FTL Effectiveness:

The ability of a regulatory flight and duty time ruleset to limit fatigue risk while allowing for crew efficiency.

Understanding and i	mproving upon the situa	tion for crew fatigue ris	k in an operation is of course	
greatly simplified with	h a well thought-through	way of quantifying this	risk. To some extent one can	
use fatique reports, o	collected data and crew	feedback after-the-fact	but what is the best practice	
metric for the fatigue	risk in upcoming crew p	pairings and rosters to c	operate next month?	
			+	
Defining Fatigue	Risk E	Proportional odds	Risk vs. Sleepiness	
There is no formal defi	nition of fatigue		The risk of a lapse, slip,	The second secon
risk set by ICAO or IAT	A. A proven	1	mistake or violation for	Figure 3. The same shape of acceleration in risk
useful definition when	planning crew 🔒	1	an individual has been	decrement in human performance, observed in I
members is: the risk of	crew §n	1	shown to accelerate as	data (ratio of low speed events) when correlating
performing a lapse, sly	b, mistake or	i	Figure 1 illustrates the	
violation, negatively in	ipacting hight	1	development in the	
salety, as an ellect of a	ow levels of	1.1	probability of an accident	What is really achieved if we reduced t
aron moda.	2	1.1	(dotted line) in a driving	on, say, the twenty worst hight duties, i
With this definition, the	focus thus lies	11	simulator where an	with the overall risk increasing? (Exam
on flight safety and hur	man error	11.	inflection point is seen	below.]
primarily among pilots	on active		just above where	
flights, rather than 'cre	w comfort' or ° L	23434744	L subjects are	Example: A reduction of 'maximum duty time' t
sleepiness during com	mute, ground	otert and Arritert Could	experiencing KSS 6.	overnight flight duties may seem as a great ide
dubes or a deadnead r	igni.		However when	reducing fatigue risk. However, the flights are s
A motrie (or one l	Figure	 Probability of an accident as a of out accessed KOP (1) 	predicting future	modified rule may lead to the creation of a lot n
A metric for one in	igne along that	on servassesses russ, [1]	sleepiness, a fatigue	duties, each with commute time before and after
the notential for human	nt it is clear that		model will have limited	potentially inflicting on physiologically sound to
impacting flight safety	is greatly elevated during	accuracy for one in	dividual, due to a number of	consecutive night duties, stacking up sleep de
approach and landing.	which is the phase of	reasons; the model	s are not perfect, models are	What was perceived as an improvement when
flying most taxing on p	ilot capabilities. During	under-informed, an	d there are significant inter	ONE night duty in isolation, may well have been
this time, the workload	is normally at its highest	Eloure 2 illustrates	how the odds-ratio for an	response from changes made is far to often ov
and there is little margi	in for slowing down or	actual accident dev	elops as a function of	
double checking onese	elf or a colleague in order	predicted sleepines	s from a bio-mathematical	For this reason, it is crucial to have me
to reduce risk. The cor	isequence of a slip, lapse,	model.		quantifying, tracking and controlling ov
A vast majority of fation	also potentially disastious.			fatigue risk, using a metric that adds up
aviation are related to	human error during this	The conclusion to d	raw, is that a predictive	probabilities for the individual flight ass
phase of flying.		metric capturing fat	igue risk should also include	rather than working with flights in isolat
		a risk contribution in predicted sleepines	is than those close to or	doing so, it is logical to use a weighted the set of flights with a 'weight' that acc
For these reasons it m	akes sense to focus a	passing KSS 8. Hu	man physiology, when being	when the predicted sleepiness increase
metric on estimating fa	tigue risk primarily using	predicte	ed into the future, does not	reflecting how fatigue risk develops in i
silectness (or		have a	ny sharp 'thresholds'	(figure 2 and 3 again).
sleepiness) close to	28.81	separa	ting safe from unsafe. The	
the end of active	× 8	/ probab	lity of an accident	There is no formal standard for this, let
flights. An often	- A	acceler	rates more slowly, and from	way of practically establishing the optin
used point in time	8 1	sower is	ed compared to the risk	tor such a weighting function. Even so,
for collecting data is	50.0	/ preuica	oment observed for self-	allowing perfect to become the enemy
close to top of		assess	ed sleepiness. Figure 3,	acceleration of risk we do know exists
descent (TOD) -	3.	further	below, based on FDM data,	Jeppesen, a simple quadratic shape fo
choice for predicted	8 1 2 3 4 5	tells a s	similar story.	contribution is used, accelerating from
alertness level to	Course 2. Onthe series 4			and assigning risk contribution to all flig
represent a flight.	riguré 2. Udds ratio tor a road function of predicted KSS (2)	crasmas a A met	tric for a set of flights	that level. Our scale is, however, the of
	in the province woo let	The for	cus of fatigue risk	round as BAM is predicting alertness o
		manag	ement when scheduling crew	Common Alertness Scale (CAS) from (
		should of course be	e to reduce the <u>overall</u> risk for	aging in the opposite direction
		the operator to sum	er an incident or accident.	going in the opposite direction.



Using AFR AFR is now our best practice metric reflecting overall fatigue risk in a set of flights. It takes both frequency (number of flights) and the severity into account and can be used in a number of Ipful ways when planning crew:

gure 4 shows how the same set of flights I planned in two different sce been plained in two different scenarios but will a clear difference in risk. Both scenarios respec-the same planning rules but we can, by just looking at the distributions, quickly confirm that scenario B is to prefer as it contain much lower risk. (Fower flights in the folt all of the distribution). Our AFR and NFR metrics are confirming the same thing but also quantifying that the risk has been reduced by 45%.

The AFR/NFR approach described is today by a large number of Jeppesen customers to control and reduce overall fatigue risk and is an adv established best practice.



link



--- Results ----

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EASA and European-based operators





- European-based operators
- AFR: volume & severity, proxy for the probability
- Planned with current EASA FTLs only
- [NOT how they operate, but how they would be allowed to operate]

EASA and European-based operators





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- AFR: volume & severity, proxy for the probability
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EASA FTLs, NFR per fleet

IPA2 Absolute Numbers





Risk of a fatigue-related incident/accident:

47/53% Short haul/long haul

Shift in Efficiency and Risk Subpart Q \rightarrow EASA FTLs



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Sun Express737

242

223

(-7.9%)

-1.2%

249

(+2.9%)







Long-haul (Europe)

Subpart Q \rightarrow EASA FTLs

NFR: 380.2 → 350.4 (-7.8%)

FT/TAFB: 17.30% → 16.10% (-7%)

Elasticity in long haul – it's there!







- Weighted, remaining, potential in EASA FTL on these three fleets:
 - -16,1% fatigue risk, OR
 +18,0 % crew efficiency !!!
- …to be compared with the overall change with Subpart Q → EASA FTL:
 - -7.8 % risk
 -7.0 % crew efficiency
- [Note: The 16 & 18% are for only one (1) mechanism. Then there is acclimatisation, minimum rest...]

Discussion. Next steps?



- Hold here for a moment. Is anyone (at all) interested?
- Then:
- What are the rules to praise/blame?
- What can be learnt from FAR and CAAC?
- Add CAP 371, CAO, CAR... and learn also from them?
- Add more planning periods?
- Measure with one more fatigue model?
- Add also Embraer fleets?
- What-if analysis to reformulate and improve the rules on a few selected problems.
- *Pressure-test* the rules? Direct the optimizer to produce the worst legal patterns allowed...

FTL Effectiveness. How much lower risk? At what	cost?
Chapter 1: A bold ide	a
Join us in a series of articles, here in the FRM News the safety and cost differences between different re- working patterns for care yoverned by these nules, actual flight schedules, both before and after COVII tems. This will be followed by suggesting and apply arrive at answering: 'How much lower risk did the n	Flash, where we will step by step take on quantifying gulatory rule sets. We will do so by building reakistic for a huge number of different atime fleets. We will use 0, and perform the planning with real production sys- ing a crisp definition of FTL affectiveness - to fmally we rules define?? and At what cost to the industry?"
In February 2016, the new EASA FTLs came into effect. All European-based operation were then required to use these new rules for planning their crew, instead of the previous Subgent C rules. The new rules had been steep and performance science and verse designed to de a better pib of limiting crew fatigue.	
In March 2019, EASA published the first of two reports attempting to establish the effec- tiveness of the rine EASA FTLs [1]. The ex- ecutive summary concluded:	A A A A
This first phase of the research assessed the impact of "night duties longer than 10 hours" and dis- nuptive schedules on the factor of attraves. The irre- search found an increased probability of high flatgoe levels during nights and duty periods with late finan- ee, among both pilots and cabin cerek. No significant increases of probability of high week of factore at TOD was found for wenty start FDPs. A marginal longeness was found for inverse of discupter s codule IPDs. A marginal longeness of discupter schedule IPDs.	rules will need to alto altow for operators to (at all) more passengers and cargo (b). If that aspect is not considered, the utilizate effectiveness cold easily be achieved by having just one single rule imposing a maximum number of block hous to be zeno. That rule maximum number of block hous to be zeno. That rule the second second second second second second second to a second second second second second second second technology. A second secon
The research study was designed such that various "fatigue-related" data was collected from pilots and cabin crew, to then try to connect that back to prove, or disprove, the effectiveness of the regulatory rules themselves. Evaluating rules, by collecting data from volunteering reve, comes with a number of challenges. Let's look	A better definition of FTZ definct/enses could be semi- thing like ability to timin fatigue risk, while allowing for a certain liked of crewe afficiency. A thor-dimensional meti- nic. That would be helpful in order to measure on con- finguas scalar, to hat w can mease detailed compar- sons. Because what would a help if we, for axample, were to find both the new rules and the old nikes to be
a little closer at some of these.	they are better or worse, relative to each other. We will go further into detail on a possible metric in later chap- ters.
If we are to evaluate the effectiveness of a set of rules, would it not be heipful to start by defining what, in this constant, we actually mean with the term effec-	Sample size and bias
thereas? Would learning on terms often used here, such as 'sufficiently here from failingue', or as low as reasonably practicable', be an option? Well., such descriptions do not easily learn thermselves to be quantified. They are more digital in nature; yes/no. A more crisp definition would be needed in order to perform measurements.	Collection of tatgua-related data trom rew is always difficult. It often encyteris enavering a stazbia initial survey form with questions around general health and sidee habits (e.r.). This is tolowed by data collection during working hours, often for all wast 10-14 days stargist, where here investigation and the star- regular relation in the star Audipsoly's is also some- imput relation to the star and the star and the mean suide to hole-layby record is also some-
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Chapter 4 - Had we not hoped for more?







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