

Monitoring the Effectiveness of Fatigue Risk Management: A Survey of Pilots' Concerns

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- INTRODUCTION:** Airlines are required to monitor the effectiveness of their pilot fatigue risk management. The present survey sought the views of all pilots at Delta Air Lines on fatigue-related issues raised by their colleagues participating in regular airline safety audits.
- METHODS:** All 13,217 pilots from 9 aircraft fleets were invited to participate in an anonymous online survey. Questions related to aspects of scheduling, fatigue mitigations, and fatigue safety culture.
- RESULTS:** There were 1108 pilots who completed the survey (response rate = 8.4%). On 7/9 fleets, most pilots thought 5- to 7-d rotations were too long (exceptions: B747, median = 14 d; A330 median = 8.5 d). In the previous year, on average across all fleets, 60.6% of pilots had worked up to or beyond their personal rotation limit (minimum, B747 = 6.3%; maximum, MD88/90 = 75.9%). Rotations where duty periods start progressively earlier were considered highly fatiguing by 73.8% of pilots, compared to 14.7% for rotations where duty periods started progressively later and 1.6% for rotations with successive duty periods starting at the same time. The median optimum break length between rotations was 3-4 d. On 7/9 fleets, fewer than 20% of pilots tried to build their monthly schedules with back-to-back rotations (exceptions: B747, 43.8%; A330, 34.3%). Awareness of fatigue and perceptions of company fatigue risk management activities varied widely among fleets.
- DISCUSSION:** The findings identify possible improvements in fatigue risk management and highlight that care is needed when extrapolating from one operational context to another. As a safety assurance exercise, we recommend repeating the survey biannually, or sooner if warranted by specific circumstances.
- KEYWORDS:** Pilot fatigue risk management, safety assurance processes, pilots' views about fatigue risk and mitigations, pilots' rostering preferences.

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Pilot fatigue is a recognized safety issue in commercial aviation. The International Civil Aviation Organization (ICAO) requires airlines to monitor the effectiveness of their processes and procedures for managing pilot fatigue risk.^{12,13} For operations covered by an approved fatigue risk management system (FRMS), this task is a required part of the FRM processes and FRM safety assurance processes. For operations compliant with prescriptive requirements, this safety assurance task should be carried out as part of an airline's safety management processes. Despite these regulatory requirements, published examples of safety assurance processes are rare.

A fundamental ICAO principle is that fatigue risk management is a shared responsibility among regulators, operators, and individual pilots, but pilots' views are not often sought. This paper describes an online survey of all Delta Air Lines pilots

that was undertaken to follow up on fatigue issues raised by pilots involved in Line Oriented Safety Audits (LOSA¹⁴) in 2010 and 2015, and the 2016 Line Audit by the Flight Operations Quality Assurance Department.

At the time of the survey, the airline had nine fleets using different aircraft on three main types of operations:

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1. Five fleets flew two-pilot short-haul operations within the USA, with duty days containing multiple flight sectors and crossing up to three time zones (McDonnell Douglas MD88/90; Boeing B717; B737N, B767-300ER (abbreviation, B7ER); Airbus A320).
2. Three of these fleets also flew two-pilot or three-pilot mid-range operations to Canada, Central and South America and crossed up to three time zones (B737N, B7ER, A320).
3. Four fleets flew three-pilot or four-pilot long-range and ultra-long-range (ULR) operations crossing more than three time zones (B747, B757/767, B777, A330). The B747, some B757s, B767, B777 and A330 aircraft had crew rest facilities approved by the Federal Aviation Administration (FAA) to enable three-pilot or four-pilot crews to take in-flight sleep.

For fatigue risk management, the B777 fleet was covered by an approved FRMS,^{4,5} while fatigue on the remaining fleets was managed in compliance with the prescriptive flight and duty time requirements in FAA Rule 14 CFR Part 117.⁵ The Fatigue Risk Management Team (which includes labor and management representatives) covers all fleets. All fatigue reports and safety reports are monitored and follow-up action taken where necessary. Operational data for flight times, flight duty period lengths, and layover lengths are routinely monitored and there is periodic review of fatigue risk management procedures and mitigations. Pilots from all fleets had undergone fatigue training meeting the FAA advisory circular AC-117-2 standards.³

The survey was designed as a fatigue risk management safety assurance exercise aiming to: 1) to gather more information on the prevalence of fatigue issues raised by pilots in other safety audit processes; 2) to ascertain whether they were specific to certain aircraft fleets or types of operations, in order to enable targeted interventions if necessary; and 3) to thereby improve the fatigue risk management processes at Delta.

METHODS

The project was notified to Massey University's Human Ethics Committee (Notification Number 4000017882). The methods and ethical considerations were evaluated by peer review and judged to be low risk. To ensure anonymity of the online responses, no personal identifying information was collected, the Survey Monkey option that blocks recording of IP addresses was activated, and all data analysis was carried out by the Sleep/Wake Research Centre.

A draft questionnaire was designed by the first three authors (PG, JM, AP) by working through the three safety audit reports. It was then revised based on feedback from the Delta Fatigue Risk Management Team and the Sleep/Wake Research Centre Team. The final questionnaire had the following sections:

1. *Demographics*: the aircraft type (fleet) currently flown; crew position (Captain/First Officer) and how long they had been in that position on that fleet; and how long it takes to travel to work.

2. *Rotations*: in relation to fatigue, how many days is too long; preference for back-to-back rotations in monthly schedules (yes/no); optimum length of time off between rotations; preference for 30-h breaks during rotations (yes/no); maximum number of consecutive days worked in the last 12 mo on scheduled rotations; fatigue ratings (low, medium, high) for rotations when start times move earlier, later or do not change; contribution of operational pressure to fatigue (never, rarely, sometimes, often, always); and an opportunity to name specific airports that need special consideration because of unique situations or high workload.
3. *Unaugmented domestic red-eye flights (2-pilot night flights)*: if flown, preference for them being at the start, middle, or end of a rotation; for red-eyes at the beginning or middle of a rotation, the preferred length of recovery time (about 12 h, about 24 h, at least 30 h).
4. *Layovers*: opportunity to name airports where staying at a hotel near the airport was preferable on layovers longer than 12 h; and restorative value of sleep in hotels compared with sleep at home (hotel sleep is much better, a little better, about the same, a little worse, much worse).
5. *Fatigue culture*: do you routinely talk about fatigue as a threat in preflight and approach briefings? (yes/no); In your opinion, is Delta receptive and responsive to safety reports for fatigue reporting? (yes/no); for calling in too fatigued? (yes/no).

A copy of the questionnaire can be obtained from the first author.

All Delta pilots were invited to participate via an advertisement on the company intranet with a link to the Survey Monkey questionnaire. Weekly reminder advertisements were posted on the intranet and the survey remained open for one month (23 August to 29 September 2017).

All analyses were carried out in R version 3.3.3 by ESF and LJW.¹⁵

RESULTS

A total of 1133 pilots opened the questionnaire on Survey Monkey and 1108 pilots completed it, including 622 Captains, 483 First Officers, and 3 who did not give their crew position. The overall response rate was 8.4% (1108/13,217). **Table I** summarizes the participants by fleet type and their median months of experience in their current crew position on that fleet. Median commute times by fleet ranged from 1.2 h (MD88/90) to 2.8 h (B757/767), with individual commute times ranging from 0–12 h (with one outlier at 24 h).

Two questions related to the number of consecutive days worked. Participants were asked: 'In relation to fatigue, how long is too long for a rotation?' and 'What is the maximum number of consecutive days you have worked on scheduled rotations(s) in the last 12 mo?'. These two values were compared to identify participants who had worked more days than their personal estimate of too long. Pilots can bid for rotations to

Table I. Survey Participants by Crew Position and Fleet Type.

FLEET	PARTICIPANTS						TOTAL PARTICIPANTS	PILOTS IN FLEET	% OF FLEET PARTICIPATING
	CAPTAINS		1 ST OFFICERS		NUMBER	MEDIAN EXPERIENCE (MONTHS)			
	NUMBER	MEDIAN EXPERIENCE (MONTHS)	NUMBER	MEDIAN EXPERIENCE (MONTHS)					
A320	79	84	59	24	138	2080	6.6%		
A330	32	24	38	30	70	1141	6.1%		
B717	63	12	35	12	98	1288	7.6%		
B737	135	60	88	24	223	2364	9.4%		
B747	9	144	7	72	16	169	9.5%		
B7ER	22	60	17	36	39	530	7.4%		
B777	43	72	37	36	80	615	13.0%		
B767/757	142	96	105	36	247	2970	8.3%		
MD88/90	97	84	97	12	194	2060	9.4%		
Totals	622		483		1108*	13,217	8.4%		

* Includes three participants who did not identify their crew position.

build a personalized monthly flying schedule and so were asked whether they try to build monthly schedules with back-to-back rotations. These questions relating to the duration of rotations are summarized in **Table II**, which highlights major differences between fleets. The B74-400 fleet stands out in their preference for longer rotations (median = 14 d), the lowest proportion who have exceeded their own safe rotation limit in the last year, and the highest proportion who try to build monthly schedules with back-to-back rotations.

Fig. 1 summarizes the question on how fatiguing pilots find rotations where each consecutive flight duty period (FDP) starts earlier, at the same time, or later. At least two-thirds of pilots on each fleet consider rotations in which FDPs start progressively earlier to be highly fatiguing.

For layover sleep, **Fig. 2** summarizes the proportions of pilots who rated the restorative value of their sleep in hotels as better (combining much better and a little better), about the same, or worse (combining a little worse and much worse). Averaged across all fleets, 43.8% of crewmembers rated their hotel sleep as a little worse than sleep at home and 23.2% rated it as much worse.

There were two questions that asked pilots to identify: 1) airports where they would prefer to stay at a hotel near the airport

rather than in the city when they have layovers longer than 12 h; and 2) airports that they think need special consideration because of unique situations or high workload. The frequency of identification of specific airports on both these questions is clearly related to the number of Delta flights in and out of these airports, and fleets differ in the airports to which they fly. The top 15 identified airports for each question are summarized in **Fig. 3**.

For the analyses of data on red-eye flights, the B717, B747-400, and B777 fleets were excluded because of the low proportion of participating pilots who flew these operations (B717, 3%; B747, 0%; B777, 1%). For the remaining six fleets, **Table III** summarizes the proportion of pilots who reported flying red-eyes and their preferences for when red-eyes occur in a rotation. In four fleets (A320, A330, B757/767, MD88/90), at least two-thirds of pilots preferred red-eye flights to be at the end of rotations. For the B737 and B767-400 fleets, half the pilots preferred red-eye flights to be at the end of rotations.

There was a clear preference for longer breaks after red-eye flights occurring at the start or in the middle of a rotation. After red-eyes at the beginning of rotations, 42.8% of pilots (averaged across fleets) preferred breaks of at least 30 h, 50.3% preferred 24-h breaks, and only 6.8% preferred a break of about 12 h.

Table II. How Long Is Too Long for a Rotation, Percentage of Pilots Who Have Exceeded This in the Last Year, and the Percentage Who Try to Build Monthly Schedules with Back-to-Back Rotations?

FLEET	MAXIMUM DAYS SAFE	MAXIMUM DAYS WORKED		% PILOTS EXCEEDING THEIR OWN LIMIT	% PILOTS WHO BUILD BACK-TO-BACK ROTATIONS
	MEDIAN*	MEDIAN*	RANGE		
A320	6	8	4-15	67.6%	10.1%
A330	8.5	8	4-19 [†]	27.5%	34.3%
B717	5	7	4-26	68.8%	8.2%
B737	5	7	3-18	71.2%	14.0%
B747	14	12	7-14	6.3%	43.8%
B7ER	7	6	3-15	55.6%	18.9%
B777	7	8	4-16	48.1%	18.8%
B757/767	7	9	4-22	49.6%	18.4%
MD88/90	5	7	4-23 [‡]	75.9%	11.5%

* The data distributions are right-skewed.

[†] Extreme value of 140 (reported by 1 individual) excluded.

[‡] Extreme values of 0 and 210 (reported by 1 individual in each instance) excluded. Extreme high values are unlikely, given that cumulative FDP time may not exceed 60 h in 7 d and 190 h in 28 d.

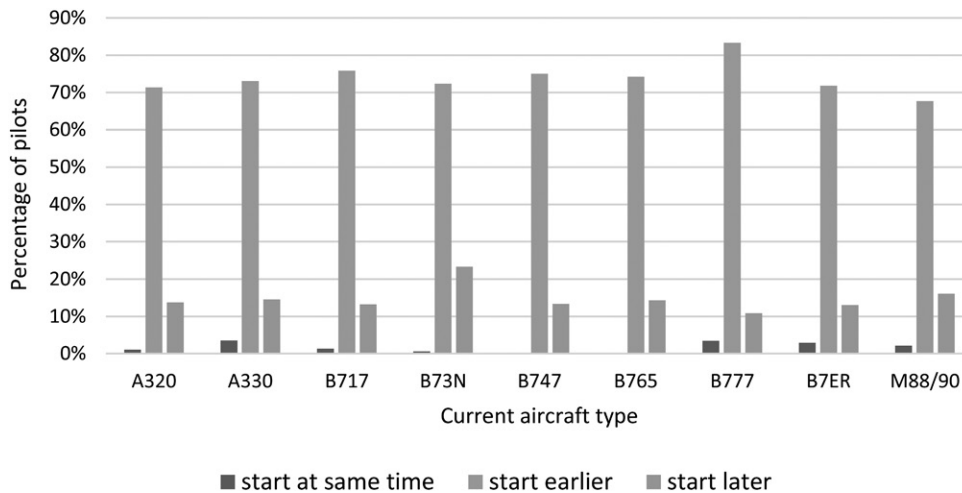


Fig. 1. Percentage of pilots in each fleet who find different rotation patterns highly fatiguing (successive duty periods beginning at about the same time, or progressively earlier or later).

Similarly, after red-eyes in the middle of rotations, 48.1% of pilots preferred breaks of at least 30 h, 47.2% preferred 24-h breaks, and only 4.7% preferred a break of about 12 h.

Table IV summarizes pilot preferences (across all nine fleets) regarding the length of breaks between rotations. The median is 3–4 d across all fleets.

The prescriptive flight and duty time regulations (14CFR Part 117) require a 30-h break in 168 h, but do not specify where that break must occur. The small proportion of pilots who indicated that they bid for 30-h breaks during rotations is not surprising, given that the regulatory requirement is included in Delta’s scheduling algorithm.

Table IV also summarizes ratings of how often operational pressure contributes to fatigue. A Pearson’s Chi-squared test (based on simulations with 100,000 replicates to help compensate for the small numbers in the B747-400 and B767-400 fleets) indicated significant differences between fleets ($\chi^2 = 59.813$, $P = 0.0029$). Post hoc pairwise comparisons confirmed that A330 crewmembers were more likely to report that operational pressure ‘never’ contributed to their fatigue, compared to

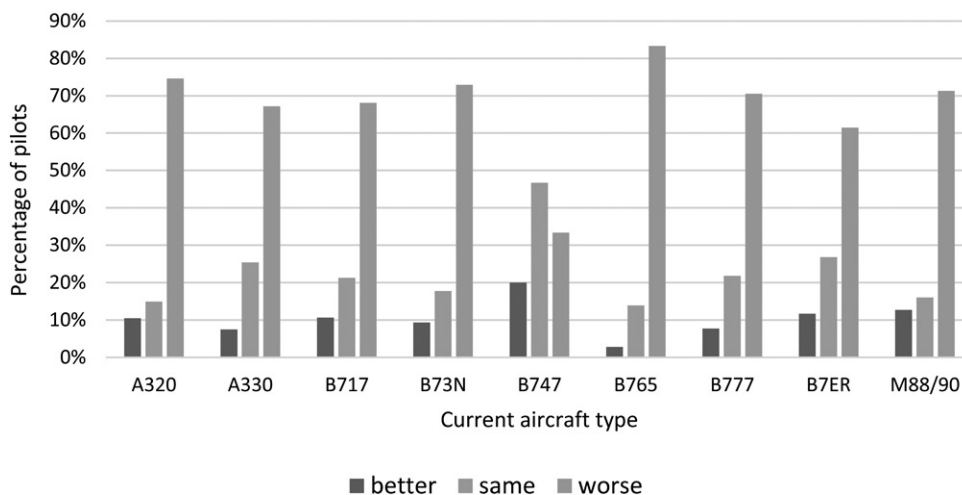


Fig. 2. Ratings by pilots in each fleet of the restorative value of sleep in hotels vs. sleep at home.

crewmembers from all other fleets. B747-400 and B777 were more likely to report that operational pressure ‘seldom’ contributed to their fatigue than crewmembers from the A320, B717, B737, B7ER, B757/767, and MD88/90 fleets.

Responses to the three questions addressing the airline’s fatigue culture are summarized in **Fig. 4**. Averaged across all fleets, 68.2% of pilots indicated that they routinely talk about fatigue as a threat in preflight and approach briefings. However, only 38.5% of pilots agreed that Delta is receptive and responsive

to fatigue reports and only 32.0% of pilots agreed that the company is receptive and responsive to them calling in too fatigued to either start or continue a duty period. There were marked differences between fleets in the percentages of pilots agreeing with these two statements.

DISCUSSION

This survey sought the views of the entire Delta pilot workforce on fatigue issues raised in routine safety audits. Response rates by fleet ranged from 6.6% in the A330 fleet to 13.0% in the B777 fleet (Table I), with an overall response rate of 8.4%. The higher response rate from B777 pilots may reflect the fact that their operations are covered by the Delta FRMS, so they might be expected to have a greater awareness of fatigue and possibly more contact with the Delta Fatigue Risk Management Team. Volunteers from five of the fleets have participated in sleep and fatigue monitoring studies, which may have increased their awareness of fatigue issues and their perception of the importance of fatigue (70 B777 pilots;⁸ 39 B747 pilots;⁷ 35 B7ER pilots;¹⁰ 41 A330 pilots;¹⁰ and 30 B757/767 pilots⁹).

Factors that may have reduced the response rate include that participation was voluntary and no incentives were offered. Also, although pilots receive specific fatigue risk management training, fatigue is only one of many safety issues that they have a shared responsibility to report on and manage. The priority afforded fatigue risk management has increased globally in recent years^{11,12} and this was the first fatigue risk management survey across the airline.

On the other hand, to our knowledge, this survey is unique

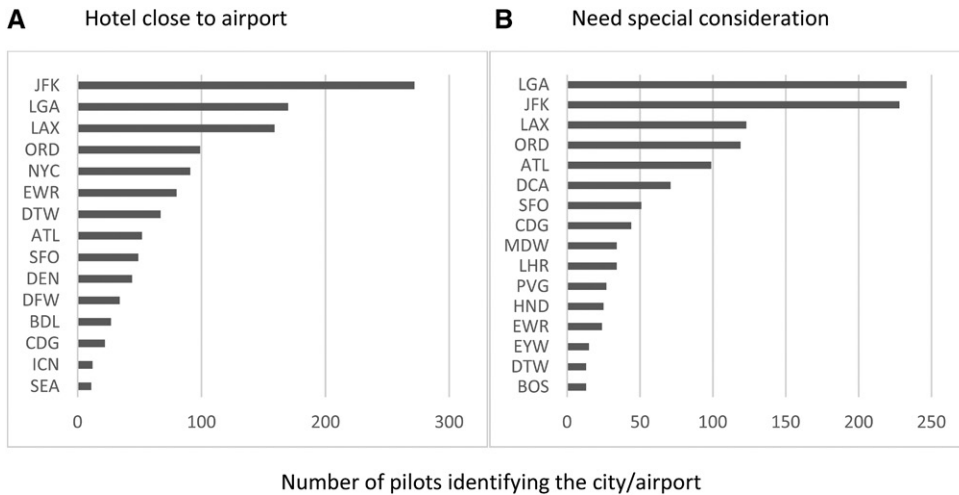


Fig. 3. The top 15 cities identified by pilots where they would prefer a hotel close to the airport on layovers longer than 12 h (left-hand panel), and that they consider need special consideration (right-hand panel). ATL, Atlanta; BDL, Hartford (Connecticut); BOS, Boston Logan; CDG, Charles de Gaulle (Paris); DCA, Washington DC; DEN, Denver; DFW, Dallas Fort Worth; DTW, Detroit; EWR, Newark (New Jersey); EYW, Key West; HND, Haneda (Tokyo); ICN, Incheon (South Korea); JFK, John Fitzgerald Kennedy (New York); LAX, Los Angeles; LGA, LaGuardia (New York); LHR, London Heathrow; MDW, Midway (Chicago); NYC, New York area airports (including JFK, EWR, and LGA); ORD, O'Hare (Chicago); PVG, Shanghai Pudong; SEA, Seattle; SFO, San Francisco.

in addressing concerns raised by the pilots themselves and in its coverage of such a diverse range of operations. The number of participants and range of responses within and between fleets have considerably broadened understanding of pilots' views. A caveat is that it is not possible to evaluate whether the views of those who responded are in any way systematically different from those who did not (response bias).

While most pilots have commute times of 3 h or less, some are much longer, which reduces the time available for recovery sleep and for all other nonwork activities between rotations. The questionnaire did not address whether crewmembers lived in the same time zone as their crew base. Across all fleets, the median preferred break between rotations was 3–4 d. On seven of the nine fleets, fewer than 20% of pilots tried to build their monthly schedules with back-to-back rotations (the exceptions were both long-range fleets: A330, 34.3%; B747-400, 43.8%).

With regard to rotation preferences, the B747-400 fleet generally differed from other fleets. They reported much longer rotations (median = 14 d) as being too long from a fatigue point of view, with relatively few pilots reporting that they had reached or exceeded their personal limit in the past year (6.3%).

Table III. Preferred Timing of Domestic Red-Eye Flights (Night Flights with Two Pilots) in a Rotation.

	% PARTICIPANTS FLYING RED-EYES	PREFERRED TIMING OF RED-EYES IN THE ROTATION		
		START	MIDDLE	END
A320	49.3%	19.7%	6.1%	74.2%
A330	13.2%	11.1%	22.2%	66.7%
B737	86.0%	21.1%	28.6%	50.3%
B7ER	16.7%	50.0%	0.0%	50.0%
B757/767	85.2%	20.0%	13.5%	66.5%
MD88/90	20.9%	5.4%	2.7%	91.9%

This fleet also had the highest proportion of participants who reported trying to build back-to-back rotations (43.8%). The B747-400 fleet has been the subject of a monitoring study (39 pilots on 9- to 13-d rotations).⁷ The present findings are consistent with the rotations monitored, which included multiple back-to-back transpacific flights (East Coast USA—Japan—East Coast USA; Japan—Hawaii—Japan) with 1- to 2-d layovers. It is relevant to note in this context that the B747-400 pilots joined Delta as part of an airline merger and had different practices in their allocation of in-flight rest breaks, compared to the standard in Delta fleets. However, it is also important to note that the B747-400 fleet had the smallest number

of pilots at the time of the survey (169), and the total number of participants from this fleet was much lower than for other fleets (9 Captains and 7 First Officers). Delta ceased B747-400 operations at the end of 2017, with pilots moving mostly to the B777 fleet and the new A350 fleet, in both of which pilot fatigue is managed under the Delta Fatigue Risk Management System. Nevertheless, the survey findings highlight that there can be important differences in the views of pilots across different fleets in the same airline.

At least two-thirds of crewmembers on all fleets rated rotations in which FDPs start progressively earlier as highly fatiguing. There are several physiological factors that could contribute to this. First, starting FDPs progressively earlier can restrict the amount of time available for sleep.^{6,16} It can be difficult to fall asleep earlier than usual because of the evening wake maintenance zone (a period in the hours before usual bedtime when the circadian body clock exerts maximum drive on the waking centers of the brain).² Having to wake up earlier and earlier can thus make sleep shorter across successive days, which makes sleep debt accumulate faster.¹¹ Second, starting FDPs progressively earlier creates duty/rest cycles that are shorter than 24 h, whereas for most people, the innate period of the circadian body clock is slightly longer than 24 h.¹ Thus, the findings support the practice of starting each FDP in a rotation at the same time or later than the previous FDP.

The majority of crewmembers (67.0%) rated their sleep in hotels as worse than sleep at home. Possible contributing factors include the sleeping environment (e.g., bed and bedding

Table IV. Breaks Between and Within Rotations, and Operational Pressure During Rotations.

FLEET	OPTIMUM BREAK LENGTH (DAYS)	BID FOR 30 H BREAKS (% PILOTS)	HOW OFTEN OPERATIONAL PRESSURE CONTRIBUTES TO FATIGUE (% PILOTS)				
	MEDIAN (RANGE)*		NEVER	SELDOM	SOMETIMES	OFTEN	ALWAYS
A320	3 (0.4-24)	20.6	2.2	11.1	45.9	25.9	14.8
A330	3 (0-14)	24.3	13.2	17.7	42.7	22.1	4.4
B717	3 (0.7-7)	24.7	0.0	15.8	47.4	27.4	9.5
B737	3 (0-7)	16.8	3.7	14.3	42.4	29.1	10.6
B747	4 (0.5-30)	18.8	6.3	37.5	25.0	12.5	18.8
B7ER	3 (0-5)	5.6	2.8	16.7	41.7	22.2	16.7
B777	3.2 (0-14)	6.3	7.7	25.6	41.0	20.5	5.1
B767/757	3 (0-24)	15.2	3.8	17.3	43.0	23.6	12.2
MD88/90	3 (0-7)	37.0	1.1	13.7	45.6	31.3	8.2

* Ranges exclude four extreme values (> 98 d). Excluding these did not change the median.

comfort, temperature, light, noise) and trying to sleep outside the optimal time in the circadian body clock cycle, particularly after transmeridian and red-eye flights and before early duty starts.

The New York airports (JFK, LGA, and EWR) were the most frequently identified as being where pilots would prefer to stay at a hotel near the airport on layovers longer than 12 h, followed by LAX (Los Angeles) and ORD (Chicago O’Hare). These findings reflect, in part, the frequency of layovers at these airports. However, they also indicate a consistent preference across fleets for having layover hotels near these airports, rather than in the nearby city. The same airports were also the most commonly cited as needing special consideration because of unique situations or high workload.

There was a clear preference across the fleets that fly domestic red-eye operations to have these flights at the end of a rotation. From a fatigue perspective, this combines the fatigue risk from any sleep debt accrued across the rotation with the fatigue risk of flying during the window of circadian low (WOCL).¹³ This is the part of the circadian body clock cycle when sleepiness and fatigue-related impairment are at their highest. On the other hand, the opportunity for recovery sleep may be longer at the end of a rotation.

After red-eye flights occurring at the start of a rotation, 93.2% of pilots preferred breaks of at least 24 h rather than breaks of about 12 h, while for red-eye flights in the middle of a rotation, 95.3% expressed this preference for longer breaks. From a physiological perspective, breaks of about 12 h after a red-eye flight provide a very limited opportunity for recovery sleep because they occur across the usual waking day, when the circadian body clock is promoting wakefulness² and environmental factors (e.g., light, heat, noise) are likely to be less conducive for sleep. Thus, scientific considerations support the pilots’ preference for longer breaks, which encompass the physiological night, to allow for recovery after red-eye flights.

With regard to fatigue culture, there were significant differences between fleets in ratings of how often operational pressure contributes to fatigue, which suggest that operational pressure is more of an issue in short-haul operations than in long-haul operations. There were also significant differences between fleets in views about how receptive and responsive the airline is to pilots filing fatigue reports or calling in too fatigued for an assigned duty. Careful consideration needs to be given to the factors that contribute to these perceptions in each fleet, and to how they can be improved.

The survey was intentionally designed without space for written comments, given the considerable workload and operational knowledge needed to undertake qualitative analyses of written comments from the expected large number of participants. However, this meant that pilots did not have the opportunity to offer additional commentary about any of their responses, or about fatigue-related issues not covered in the survey questionnaire. Future qualitative studies that focus on pilots’ perspectives and operational experience of fatigue could provide better understanding of the different fatigue issues within fleets. Consideration of pilots’ views is consistent with the regulatory

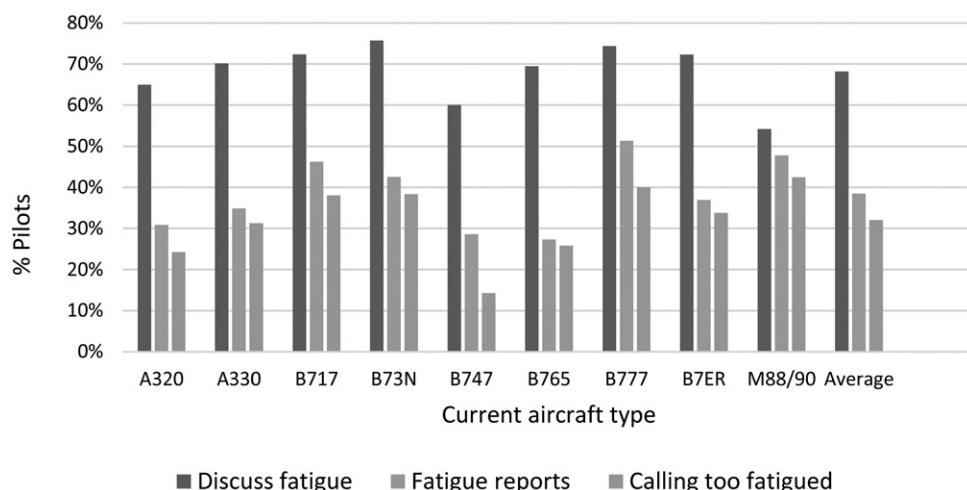


Fig. 4. Percentage of pilots in each fleet who routinely discuss fatigue in preflight and approach briefings and who agree that Delta is receptive and responsive to fatigue reporting and calling in too fatigued.

requirement that fatigue risk management must be a shared responsibility of pilots, airlines, and regulators.¹³

We conclude that the survey has been a valuable safety assurance exercise and recommend that it be repeated every second year, or sooner if warranted by specific circumstances. The findings highlight areas where additional investigation and/or action might improve fatigue risk management at Delta.

Findings relevant to rostering include the following.

- Scheduling successive FDPS to start progressively earlier across a rotation should be avoided. This pattern was rated as highly fatiguing by at least two-thirds of pilots in all fleets.
- Attention needs to be paid to the duration of rotations. Rotations of 5-6 d are regarded as too long by most pilots flying 2-pilot short- to medium-haul operations. In the last 12 mo, they were also more likely to have exceeded the maximum number of consecutive days that they thought was too long than were pilots flying 3- to 4-pilot long-range/ULR operations (average across fleets = 66.6% vs. 34.4%).
- For domestic red-eye operations, there is a clear preference for these to be at the end of a rotation. Where they occur at the beginning or in the middle of a rotation, more than 90% of the pilots prefer the next rest break to be at least 24 h.
- The preferred duration of breaks between rotations is 3-4 d across all fleets.

The findings also highlight the challenges of obtaining enough restorative sleep on layovers, with two-thirds of pilots rating their sleep in layover hotels as worse than sleep at home. Layover sleep is critical for minimizing cumulative sleep debt across a rotation. Mitigations include careful vetting of layover hotels, maximizing the amount of time available during layovers for sleep during the appropriate part of the circadian body clock cycle, and reducing travel time between the airport and the layover hotel. The survey highlights a clear preference across fleets for staying at a hotel near the airport, rather than going into the city, for the New York airports (JFK LGA, EWR), Los Angeles (LAX) and Chicago O'Hare (ORD).

Fatigue reports from crewmembers are a vital source of information for effective fatigue risk management, and pilots are also required not to accept or continue a duty assignment if they consider they are too fatigued to operate safely.^{11,12} Among the short-haul fleets, MD88/90 pilots were much more likely to agree that Delta is receptive and responsive to fatigue reports (47.8%) and to calling in too fatigued (42.5%) than were A320 pilots (30.8% and 24.2%, respectively; Fig. 4). Similarly, among the long-range/ULR fleets, B777 pilots were much more likely to agree that Delta is receptive and responsive to fatigue reports (51.3%) and to calling in too fatigued (40.0%) than were B757/767 pilots (27.3% and 25.8% respectively; Fig. 4). More information is needed to understand why the A320 and B757/767 pilots are less satisfied with the response of the airline to their input on fatigue-related issues. Improving their satisfaction would be expected to make safety reporting more effective and reduce fatigue risk in these fleets.

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