Aircraft Exceedances Vary According to Time of Day and Workload

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INTRODUCTION

The Flight Operational Quality Assurance (FOQA) programs have been implemented in US and Europe to identify anomalous flights based on data recorded on board an aircraft in an effort to improve flight safety. Numerous methods have been developed to support the analysis of FOQA data.

It is unclear how FOQA data relates to the performance of the pilot. We sought to characterize the frequency and type of flight exceedances extracted from FOQA data during a controlled pilot schedule in order to determine whether patterns of exceedances related to human control of the aircraft would change according to scheduling factors.

METHODS

- **Methods**
- Pilots flew a roster consisting of a cycle of five days of short duty hours (baseline –low workload, easy schedule) followed by four days off, five early duty (duty starts before 0900) followed by three days off, five midday starts with many sectors followed (duty starts after 0900 and ands before 2400) by three days off and then five late duties with finishes that generally ended during the night followed by four days off.
- FOQA data was collected via on board sensors from 1141 aircrafts (A319 , A320) and was evaluated through exceedance detection (the traditional approach to Flight Data Monitoring (FDM) that looks for deviations from flight manual limits, standard operating procedures and good airmanship).

Measures

- Exceedances were classified in three levels (Dubois - Airbus S.A.S, 2015):
  - Level 1 (LOW) - a small deviation from the Standard Flight Profile (SFP), which would not be serious individually, but which can indicate an unsatisfactory safety situation if occurring in specific areas in statistically significant numbers.
  - Level 2 (MEDIUM) - a significant deviation from the SFP that may indicate a more serious situation, especially if occurring regularly in particular circumstances.
  - Level 3 (HIGH) - a large deviation from the SFP that may have flight safety implications and which should be investigated as an individual event (Table 1).
- The events were further categorized according to the definitions of exceedances for the aircraft. Event categories are areas of operational interest (e.g., aircraft type, phase of flight) on which FOQA data event monitoring is based (Table 1).

TABLES AND FIGURES

Table 1. Example of categories of events for Airbus 319.

Category	Event	A319	Low limit	Medium limit	High limit
Speed	Speed high in approach (at 1000f)	CAS>	VAPP + 15 Kts	VAPP + 20 Kt	VAPP + 31 Kts
Take Off	Brake temp monitor	Brake temps > 150,250,290	0 Deg	150 Deg	290 Deg
Pitch	Pitch high at touchdown	PITCH >: (At Touch Down);	7 °	7.5 °	9.2 °

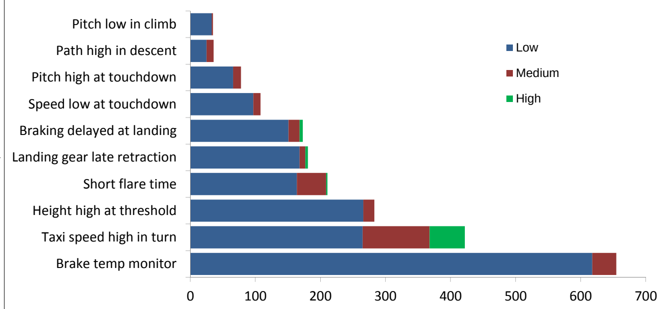

Figure 1. Top 10 events by severity type.

Note: Brake temperature monitoring – determines when the brake has cooled sufficiently for a safe take-off. *Taxi speed high in turns* – speed of the aircraft during taxiing. *Height high at threshold* - the height at the beginning of the designated space for landing. *Short flare time* – the nose of the plane is raised, slowing the descent rate, and the proper attitude is set for touchdown. *Landing gear late retraction* – the undercarriage of the aircraft was retracted later than planned. *Braking delayed at landing* – the brakes were used late. *Speed low at touchdown* – aircraft speed was lower than planned. *Pitch high at touchdown* – the nose of the aircraft was too high. *Path high in descent* – the airplane was too high on the path from TOD to the start of approach. *Pitch low in climb* – the nose of the aircraft was too low.

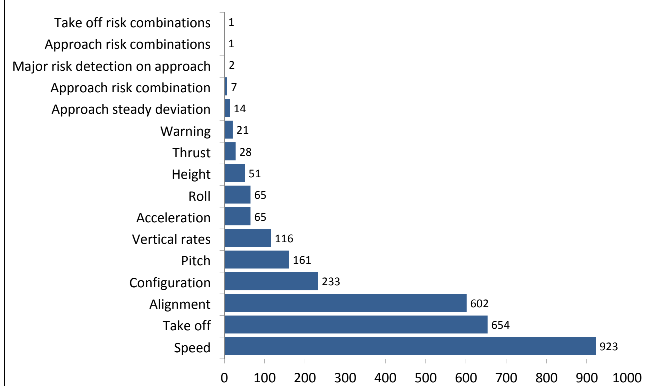

Figure 2. Categories of events identified for all severity types.

Table 2. Overall exceedances and by severity type by duty schedule.

	Severity Type			Overall
	Low	Medium	High	
Baseline	1.73(1.78)	0.18(0.47)	0.08(0.27)	1.99(1.99)
Early duty	2.31(1.79)**	0.31(0.61)*	0.12(0.90)	2.74(2.10)**
Midday duty	2.44(1.56)*	0.30(0.61)	0.07(0.29)	2.81(1.85)*
Late duty	2.27(1.65)	0.44(0.73)	0.04(0.24)	2.73(2.07)

*= $p < .01$ ** = $p < .001$. Standard deviations appear in parentheses near means.

RESULTS

- N = 44 short-haul commercial airline pilots (4 female); average age 30.8 (± 7.1) yrs; flight hours: 1,000-3,000.
- 82% of the flights had at least one exceedance. The average number of exceedances for all flights was M=2.58 (SD= 1.92) .
- The most common exceedance was the brake temperature monitoring. The top 10 most common exceedances are presented in Figure 1.
- We identified 16 categories of events. The highest number of events were in the speed category (N=923), followed by take o (N=654) and alignment (N=602). The smallest numbers of events were in the "take off risk combinations" and "approach risk combinations" categories, each with only one event. The total number of events for each category is illustrated in Figure 2.
- Overall, early duty and mid-day starts had significantly more exceedances relative to baseline ($p < .001$, $p < .01$). (Table 2).
- Low severity exceedances were higher during flights that started early relative to baseline ($p < .001$)
- Low severity exceedances were higher during high workload shifts relative to baseline ($p < .01$).
- Medium severity exceedances were higher for flights that started early relative to baseline ($p < .01$)
- In the high severity category of events, 80% were speed event (taxi speed high in turns, high speed in approach, and braking delayed at landing).

CONCLUSIONS

- We found that more than half of the flights examined had a least one exceedance and speed was the most common category of exceedances related to human influence.
- The number of exceedances was significantly different from baseline for early and mid starts but not for late.
- More information is needed to determine which exceedances relate to human performance. Combining information from different sources (e.g., pilot reports, maintenance records, weather reports) could allow airlines to identify precursors to human factors aircraft exceedances.

REFERENCES

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Research supported by NASA System-wide Safety Program.