FLIGHT CREW PERFORMANCE WHEN PILOT-FLYING AND PILOT-NOT-FLYING DUTIES ARE EXCHANGED

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ABSTRACT

This study compares reports from the ASRS database depicting operational anomalies related to flight crew performance when pilot-flying and pilot-not-flying duties were exchanged. A greater number of near midair collisions, takeoff anomalies, and crossing altitude deviations were reported when the Captain was flying. More altitude deviations, near midair collisions during approach, and landing incidents occurred when the First Officer was flying. There were differences in monitoring effectiveness and in the type and distribution of information transfer problems associated with the anomalies. In addition, a number of crew performance factors were noted that were not affected by the exchange of duties. Several of these were deemed important enough to be included as matter of general interest.

INTRODUCTION

It is a frequent practice for the Captain and the First Officer to exchange pilot-flying and pilot-not-flying duties. While hard data regarding the frequency of this practice are not available, it has been estimated that it may occur between 40 and 45 percent of the time.

Inevitably, accidents and incidents have occurred when the First Officer was flying; this has led to concern that the exchange of flying and non-flying duties may have been a factor. Perhaps surprisingly, the concern expressed regarding First Officers' flying does not involve their handling competency.

> "The risk in First Officer flying is not that First Officers are less capable, but that Captains are less efficient in the assisting role." (Lufthansa policy statement as paraphrased in a United Airlines flight publication)

> "...it had been discovered that coordination which was satisfactory when the Captain landed the aircraft, was often less so when the copilot was controlling the aircraft, and the Captain undertook the duties normally those of the copilot." (Summary of Discussions, IATA 20th Technical Conference)

OBJECTIVE

The objective of the study was to determine whether or not there were changes in the character, frequency or distribution of flight crew performance problems reported to the Aviation Safety Reporting System (ASRS) which seem to depend upon which pilot was flying the aircraft.

APPROACH

The study plan was to compare samples of ASRS reported anomalies that occurred when the Captain was flying and when the First Officer was flying. Only U.S. air carrier operations were considered. The study was concerned with operational anomalies which were associated with deviations from expected flight crew performance.

Expected Flight Crew Performance

In current airline industry practice, the primary duty of the pilot-flying (PF) is to know the intended flight path of the airplane and then to keep it on that flight path in a safe and efficient manner. He or she is expected to follow established rules and procedures and is responsible for complying with air traffic control clearances. The PF's job, in short, is to "mind the store". The pilot-not-flying (PNF) is expected to handle radio communications, perform operational monitoring, assist in traffic watch, and perform other supplemental or supportive tasks as required by standard operational procedures or as directed by the PF.

While it is clear that PF and PNF duties can be exchanged, it is equally clear that the Captain's command responsibility cannot be transferred. Consequently, regardless of other flying or non-flying duties, command responsibilities place an additional cognitive and psychological load on the Captain. It is a factor which varies with individuals but nevertheless must be considered in any evaluation of comparative performance.

Flight Crew Performance Failures

At least two individual performance failures are involved in each operational anomaly. The first is the responsibility of the PF and usually consists of a failure to

keep the airplane on its desired flight path at its desired speed and configuration. The second failure is a failure of flight crew monitoring and is usually the responsibility of the PNF. It consists of either a failure to detect the departure from expected performance in time to prevent the unwanted occurrence; a failure to communicate the detection in a timely and effective manner; or, less frequently, a failure to take effective action when an adequate and timely monitoring communication does not elicit an appropriate response.

Information Retrieval

The dataset for this study consisted of two independent report collections resulting from computer searches of the 12,500 reports submitted voluntarily to ASRS between May 1, 1978 and September 15, 1980. Only pilot submitted reports were considered since they were the only reports which permitted identification of the PF. Reports unrelated to the operation of the aircraft and taxiing incidents were excluded -- the taxiing incidents because it was frequently not possible to identify the cockpit position of the pilot taxiing the aircraft and, in many aircraft, control for taxiing cannot reasonably be exchanged.

Interpreting ASRS Data

The distribution and comparisons made in this study concern reported anomalies. While they provide reliable information regarding the type and distribution of the anomalies reported, they cannot be used to calculate the actual frequency of occurrence of such anomalies in the real world because there is no reliable way to determine the number of unreported ones. Also, it is not possible to determine the amount of flying, and therefore the exposure, which should be attributed to either pilot. ASRS reports describe "unwanted occurrences" in the aviation system which adversely affect air safety. The problems identified can be considered with an assurance that the number of times they occur has not been overstated.

RESULTS AND DISCUSSION

Five types of flight crew performance problems were identified in the combined datasets. They are depicted in Figure 1.

Flight path control errors were responsible for nearly half of the 245 operational anomalies examined. The next most frequently reported category was near midair collisions (NMACs). Aircraft handling, air traffic control procedures, and a small group of anomalies not classified made up the remainder. Their distribution by PF is shown in Figure 2. The differences in altitude

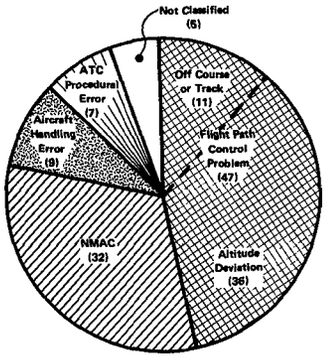

FIGURE 1. DISTRIBUTION OF TYPES OF OPERATIONAL ANOMALIES (Numerical values are percentages of total)

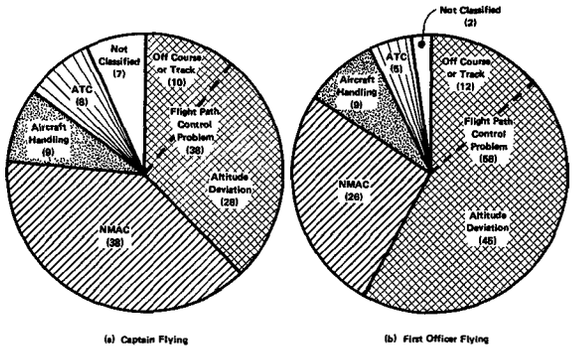

FIGURE 2. DISTRIBUTION OF OPERATIONAL ANOMALIES BY PILOT FLYING (Numerical values are percentages of total)

deviations and NMACs are statistically significant ($X^2 < .05$).

A majority of the anomalies occurred at the lower altitudes and their number decreased consistently with altitude. Nearly 70 percent of them occurred between the surface and 10,000 feet. This follows from the fact that cockpit activities vary considerably with phase of flight, and, of course, increased activity provides an increased opportunity for blunders. Not surprisingly, the arrival phases of flight--descent, approach, and landing--were particularly critical. They included 60 percent of all anomalies and are portrayed in Figure 3.

Virtually all anomalies reported, with the exception of the NMACs, occurred because an operational function that was well within the capability of both the PF and the PNF was not performed, was not performed effectively, or was not performed at the right time.

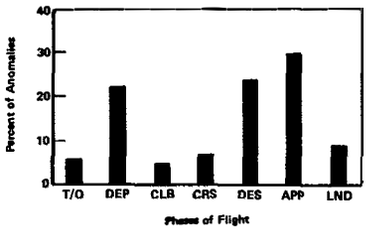

FIGURE 3. DISTRIBUTION OF ANOMALIES BY PHASE OF FLIGHT

Pilot handling skills were a minimal factor except in a small number of handling incidents.

Crew Performance Comparisons by Operational Anomaly

Altitude deviations constituted 76 percent of the flight path control anomalies and 36 percent of all anomalies reported. They represented the largest single category. Forty-five percent of the First Officers' anomalies were altitude deviations, while the comparable figure for Captains was 28 percent. Nearly 80 percent of these deviations were either overshoots (failures to stop climb or descent at cleared altitude), or excursions (deviations greater than 300 feet above or below an altitude at which an aircraft had been cleared and was maintaining before the deviation).

There was a statistically significant difference in the distribution of overshoots by pilot-flying and phase of flight. Thirty-two percent of the First Officers' altitude deviations were overshoots that occurred during departure and climb. The comparable figure when the Captain was the handling pilot was 14 percent. There were virtually no differences during descent and approach. While the report narratives did not provide enough detailed information to develop firm conclusions regarding the reasons for these differences, the data do suggest that First Officers may have less "altitude awareness" than do Captains because of the frequency with which overshoots seem associated with a lack of such awareness.

Altitude deviations are critical from an air safety standpoint because the deviating aircraft may encroach upon an altitude reserved for, or occupied by, another aircraft. While there were virtually no differences in the magnitude of deviations by pilot flying, nearly 60 percent of the deviations reported were of 1,000 feet or more. the primary behavioral problem associated with the altitude deviations was a form of aural or visual information transfer. The effectiveness of the altitude warning system, which is required on all turbo-jet transports, was impaired by a lack of consistency in its use and by a tendency to utilize it as a primary instrument for determining when the desired altitude had been reached. Warning systems cannot perform their back-up function if they are used as a primary source of information.

Nearly one-third of all anomalies reported were NMACs. A majority of them occurred between 10,000 feet and the surface -- with a preponderance of them occurring during arrivals. Unlike the other kinds of anomalies, not all the NMACs were caused by performance lapses on the part of the reporting flight crew. NMACs can also occur as a result of less than expected performance on the part of the crew of the conflicting airplane or the air traffic control system. They also can and do occur under conditions where the problem is simply a limitation of the system and where no one is at fault. Particularly in the latter case, the occurrence of an NMAC can reflect exemplary flight crew performance in having maneuvered successfully to avoid a collision.

NMACs were reported with greater frequency when the Captain was flying and the First Officer was monitoring than when these duties were exchanged. Very few of them were associated with a prior flight crew related anomaly. They were a particular problem during departure when the Captain was the handling pilot and a particular problem during approach when the First Officer was flying. This difference is shown graphically in Figure 4.

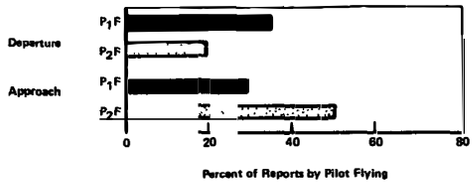

FIGURE 4. DISTRIBUTION OF NEAR MIDAIR COLLISIONS DURING APPROACH AND DEPARTURE BY PILOT FLYING

While the 22 aircraft handling anomalies reported constituted only a small part of the study dataset, several had potentially serious consequences. Seventeen occurred during approach and landing. Ten involved wing tip or engine pod strikes. Eight of the ten

occurred while the First Officer was flying and the Captain was responsible for the assisting role. While these numbers are small, the difference by pilot-flying is believed to be operationally significant. No information was available regarding the quality of the Captains' performances of PNF duties during these incidents. First Officer experience, or recency of experience, did not seem to be a factor. The Captains' intervention in four of the eight incidents appeared to further complicate an already deteriorating situation. The belief that the flight crew operates more efficiently when the Captain is flying than when he is performing PNF duties is given a measure of support with these incidents.

An even more striking difference occurred in the fifteen takeoff anomalies. All but one of these occurred when the Captain was flying. Eleven involved routine legal or technical questions and clearly careless or unprofessional actions, suggestive, in many cases, of complacency. There was no discernible reason for them to vary by pilot flying.

Eleven anomalies considered significant to this study were placed in the "not classified" category. They consisted of miscellaneous events that did not fit into the other groupings. The nine of these anomalies that occurred while the Captain was flying included four of his takeoff anomalies. His others were of a similar nature. Both of the anomalies which occurred while the First Officer was flying were landings at a wrong airport.

Monitoring of Operational Anomalies

The first line of defense for the prevention of flight crew related operational anomalies is monitoring of the aircraft's state and progress by the PNF. Two tasks are involved. The first is to prevent operational anomalies from occurring. The second is to detect those which occur despite all efforts to prevent them.

A preventive monitoring failure by the PNF precedes a significant operational anomaly in most cases. From a system safety standpoint, this monitoring failure is as critical as the failure by the handling pilot because it allows the initial failure by the PF to develop into a reportable incident or an accident.

If an anomaly does occur, it is important that it be detected promptly for the airplane's vulnerability increases as the anomaly persists. Fifty-three percent of all anomalies were detected by the flight crew. Forty-one percent were detected by an air traffic controller in spite of the fact that detections are not their primary responsibility. If only ATC related anomalies are considered, controller detections rise to 67 percent.

When a controller is the detector, both flight crew preventive monitoring and detection have already failed. Despite their crucial system safety role, these monitoring functions failed in nearly half of all anomalies reported if the additional seven percent of anomalies which were not effectively detected are included.

Captains detected 68 percent of the anomalies detected by the flight crew. First Officers were next with 25 percent and flight crew members whose cockpit position could not be identified also contributed 13 percent. While Second Officers detected 9 percent, it was not possible to evaluate their contribution because the presence of a two- or a three-member-crew could not be determined reliably. The distribution of detections is shown in Figure 5.

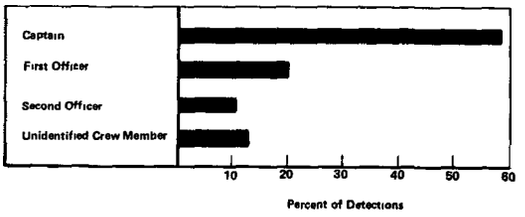

FIGURE 5. DETECTION OF OPERATIONAL ANOMALIES BY FLIGHT CREW MEMBER

It was of considerable interest to find that the flying or not-flying assignment did not affect either pilot's effectiveness as a detector. The Captain made 33 percent of the detections when he was the PF and 35 percent of them when he was the PNF. In contrast, the First Officer detected only 10 percent of the anomalies when he or she was the PF, and only 15 percent when he or she was the PNF. It is difficult to attribute the First Officers' poor detection performance to a lack of knowledge or understanding of the desired operation. While several reports suggested that one of the reasons may be a stereotyped and dated perception of cockpit relationships involving excessively authoritarian Captains, it is believed that it would be an oversimplification to attribute the statistically significant difference in detections to a single cause. There was considerable evidence that the importance of the monitoring function was not well understood by either pilot or, if well understood, was frequently neglected.

Anomalies and Information Transfer

The following discussion is limited to information transfer under normal operating conditions. Aircraft system problems or troubleshooting were factors in only 3 of the 245 operational anomalies examined.

Information transfer in flight operations has been defined as "the process whereby the human acquires information from other elements in the system and, after processing, communicates his decision verbally or otherwise back to the system" (1). Its importance was emphasized by Billings and Reynard when they suggested that a failure of information transfer may be the "most common problem associated with human error in air operations" (2).

The pilot-flying utilizes information primarily received through aural or visual channels in order to determine, and then carry out, the desired operation in a safe and efficient manner. The PNF utilizes similar information acquired in the same fashion and from the same sources to monitor progress of the flight.

Aural and visual communications have important differences. Particularly under routine conditions, aural communications have a very high priority and are usually two-way communications involving both the reception of a message and an appropriate response. A great many are generated by air traffic control. They are frequently distracting because of their attention-focusing nature and because of their often random occurrence from the cockpit viewpoint. The distractions they create can be minimized with good cockpit management; they are exacerbated if it is poor.

In contrast, visual communications are usually one-way communications. Examples are reading a chart, scanning an instrument, or looking for traffic. The need for the additional cognitive processing associated with an aural response is eliminated. Even more important, the flight crew has considerably more control over the timing of the visual task. It can often be preplanned and, if desirable, temporarily deferred. This is an important part of cockpit management.

Aural and visual perceptual channels were being utilized for supplemental tasks in approximately equal proportions at the time the reported anomalies occurred. There was little change in this distribution when handling pilots were compared with monitoring pilots. Neither was there a change when the Captains' aural/visual channel utilization under either duty condition was compared. This was not true for the First Officers. We found a statistically significant difference which depended on whether they were the handling or the monitoring pilot. A major factor was the large change in aural channel involvement.

There was little variation in the aural/visual distribution within the cockpit at the time a specific kind of anomaly occurred. The differences that occurred were related to the kind of anomaly, not to the pilot category. There are substantial differences in the information transfer activities of the monitoring pilot during flight path control anomalies and during NMACs. However, they were not affected by cockpit position.

The inappropriate timing of known and predictable tasks was a prime cockpit management factor associated with many anomalies. It was a distracting element in a great many information transfer difficulties. Complacency and a lack of "operational awareness" on the part of both the PF and the PNF were frequently reported and were also prominent contributing factors in the creation of information transfer problems.

It was not possible to determine if the additional psychological and cognitive load imposed on Captains because of their command responsibility affected their performance of flying or non-flying duties. However, the Captains did appear to have a higher level of operational awareness than did the First Officers. They were significantly more effective detectors of anomalies than First Officers regardless of their flying or non-flying role. It is believed that the Captains' higher level of operational awareness was directly related to the higher personal identification with the flight created by their command responsibilities and not to their relatively greater experience.

ACKNOWLEGEMENT

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