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Towards the Zero Accident Goal: Assisting the First Officer: Monitor and Challenge Captain Errors

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TOWARDS THE ZERO ACCIDENT GOAL: ASSISTING THE FIRST OFFICER MONITOR AND CHALLENGE CAPTAIN ERRORS

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In this article the authority system in the airplane cockpit is related to thirty year old authority studies of Stanley Milgram. Human errors made in the cockpit are found similar to those made in the authority experiments. It is argued that up to 20% of all airplane accidents may be preventable by optimizing the monitoring and challenging of captain errors by the first officer.

INTRODUCTION

In a hierarchical organization, the boss's authority in the work function can be more or less absolute. In 1963, the eminent social psychologist Stanley Milgram measured the strength of the United States society authority. He found that it was about much stronger than expected - a psychology experimenter was able to make subjects carry out orders that led to the simulated injury and death of a confederate. Such strong authority tends to create situations in which errors made by authorities will not be corrected. In particular, this is the case in the airplane cockpit: a disproportionate number of accidents occur with the captain flying erroneously and the first officer failing to monitor and challenge the captain errors.

We make the case that any lack of monitoring and challenging of the captain by the first officer is due to the already well documented difficulty of monitoring and challenging authority in our society. The Milgram experiments are described briefly, specific connections between the experiment and the authority structure in the airplane cockpits are made and using this frame work an accident is analyzed more closely using a cockpit voice recording. We make a numerical estimate of how often inadequate monitoring and challenging errors results in accidents. Finally, we suggest ways to achieve the proper amount of monitoring and challenging by use of a simple "monitoring and challenging optimization" technique during LOFT.

THE SOURCES OF THE CAPTAIN'S AUTHORITY IN THE UNITED STATES COMMERCIAL AIRPLANE COCKPIT

In a typical commercial airplane cockpit there is a captain, a first officer and sometimes a flight engineer. In this chapter we will limit ourselves to considering the relationship between the captain and the first officer. We begin by describing the many sources of the captain's authority. They include rules, different levels of flight experience, aviation tradition, military, corporate, and societal norms and values.

The Code of Federal Regulations (CFR) states that a captain, nobody else, is the final authority on the airplane.

The CFR sets differential requirements for captains and first officers. For a captain it requires about 1500 hours of flight time and for a first officer the requirement is only 200 hours of flight time. Once a first officer fulfills the CFR requirement to become a captain, he or she must also fulfill the captain requirements of the particular airline. Personnel policies provide additional thresholds for both overall flight hours and flight hours in the particular aircraft and the pilot also needs to have seniority on the airline's union list. It typically takes a decade or two to become a captain on a large airplane. In the NTSB's accident sample (see below), captains had 3-4 times more experience than their first officers whether measured by the historical total flying time (median times of 14,000 vs. 5,100 hours) or the experience in the accident aircraft type (median times of 3300 vs. 880 hours).

Aviation organizational norms include the individualistic thinking from the historical period of the single-pilot planes. This tradition devalues the first officer. Thus, the institution of the first officer is "not fully developed," and the latter plays a "distinctly secondary role". Indeed, "in 1952 the guidelines for proficiency checks at one major airline categorically stated that the first officer should not correct errors made by the captain" (Helmreich & Foushee, 1993, pp. 4-5).

Military values enter commercial airlines when pilots who are military veterans enter the civilian workforce. These values include "respect for rank, for leaders who take charge and act decisively, and for subordinates who understand that it is usually not appropriate to question the decisions of their superiors" (Birnbach & Longridge, 1993, p. 265).

Additionally, the values of a hierarchical corporate culture contribute to strong authority relationships. For example, in a New York Times article, the strength of the authority of the CEO of a particular airline was indicated by the CEO's staying power in conjunction with seemingly extreme incompetence. He would "doze off" in meetings and call the company officers, and even the airline, by the wrong name (Bryant, 1994, p. 17N).

The captain's authority can be even stronger in other societies. Merritt and Helmreich (1996) found that the statement, "Senior staff deserves extra benefits and privileges," elicited a neutral position to slight disagreement among American captains and first officers from four airlines, but those of a Brazilian airline agreed with it. The statement, "Crewmembers should not question the decisions or actions of the captain except when they threaten the safety of the flight," elicited variations between 15 and 93% agreement among pilots in different countries, and the statement, "If I perceive a problem with the flight, I will speak up, regardless of who might be affected," elicited variations between 36 and 98 % agreement. Finally, the statement, "The organization's rules should not be broken – even when the employee thinks it is in the company's best interests," elicited variations between 22 and 76 %. That these statements carry over to actual differences in behavior seems reasonable.

SOCIAL PSYCHOLOGY FINDINGS: THE DIFFICULTY OF CHALLENGING STRONG AUTHORITY

Excessively obedient behavior in the presence of authority was found in the psychology laboratory by Stanley Milgram over thirty-five years ago (Milgram, 1974). In these experiments, a subject, the teacher, is asked by the experimenter to give electrical shocks to a confederate, the learner. The stated purpose of the experiment is to understand how punishment affects memory recall. The learner first fakes discomfort and as the fake electrical shocks increase to dangerous levels, he suddenly becomes quiet. There are four of Milgram's findings that can help shed light on inadequate monitoring and challenging in the airplane cockpit:

1. Excessive Obedience: Milgram found that most people can be made to inflict intense pain and even kill the learner.

2. Hesitant Challenging: The teacher's objections to giving the learner electrical shocks were often hesitant and easily overruled by the experimenter's replies, such as telling the teacher that "the experiment requires that you continue."

3. Lack of Monitoring: The teacher accepts the authority's definition of the situation, which does not include the choice of disobedience but only the necessity of continued obedience. Indeed, in the Milgram experiment not one out of almost a thousand teacher-subjects came up with an interpretation leading them to call the police or free the learner (Zimbardo, 1974).

4. Physical Closeness Matters: The strength of the authority of the experimenter was found to be higher the closer the teacher was to the experimenter.

In addition, there is the Milgram Prediction Error: It was shown that predictions (done by psychiatrists, graduate students and faculty in the behavioral sciences, college sophomores, and middle-class adults) underestimate the rate of obedience to authority by a factor of a hundred (Milgram, 1974)! This Milgram Prediction Error, which remains the same, keeps organizations from addressing the issue of how to protect against erroneous authority.

THE DIFFICULTY OF CHALLENGING AN ERRONEOUS CAPTAIN

There are similarities between the Milgram experimental situation and the behavior in the cockpit during distress. We make a simple correspondence between the Milgram experiment and the cockpit dynamics: the role of the experimenter is taken by the erroneous captain, the teacher is the first officer, and the harm to the learner and everybody else is the airplane crashing.

Observers of behavior in the aviation field have noted the tendency of the captain-first officer relationship to be too authoritarian in many instances. Ginnett (1993) writes about the tendency of the first officer not to question the captain (here, and later in other examples, I have inserted the applicable findings of Milgram, mentioned above, in square brackets):

The authority dynamic surrounding the

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> role of the captain must be extremely powerful. . . . [and] has resulted in crewmembers not speaking up when necessary [Hesitant Challenging]. . . . This inclination may also result in excessive psychological dependence on the captain as leader to the extent that individual contributions to problem-solving are neither voiced not attempted [Lack of Monitoring]. For example, one captain with whom I flew made a particularly poor approach ... setting off numerous alarms. In reviewing crew members' inactions afterward, the young second officer (who literally said nothing during the final approach) admitted that he had never seen an approach quite like that, but figured "the captain must know what he's doing" [Lack of Monitoring] (Ginnett, 1993, pp. 88-89).

A first officer also comments on how difficult it was for him to convince the captain that an error was being made:

> I was the first officer on an airline flight into Chicago O'Hare. The captain was flying .... On our approach, Approach Control told us to slow to 180 knots. I acknowledged and waited for the captain to slow down. He did nothing, so I figured he didn't hear the clearance. So I repeated, "Approach said slow to 180," and his reply was something to the effect of, "I'll do what I want." I told him at least twice more and received the same kind of answer [Hesitant Challenging] .... [Approach Control] then asked us to turn east. I told them we would rather not because of the weather and we were given present heading and to maintain 3000 ft. The captain descended to 3000 ft. and kept going to 2500 ft. even though I told him our altitude was 3000 ft. His comment was, "You just look out the damn window." (from a confidential report submitted to the NASA/FAA Aviation Safety Reporting System; quoted in Ginnett, 1993, p. 74).

Two researchers write similarly about the difficulty of the first officer to get the attention of the captain that an error was being made, referring to "a co-pilot, concerned that take-off thrust was not properly set during a departure in a snow storm, failing to get the attention of the captain [Hesitant Challenging] with the aircraft stalling and crashing into the Potomac River" (Helmreich and Foushee, 1993, p. 6).

Wiener et al (1993) have classified typical crew errors. If we investigate this classification we find that several are related to elements of the Milgram experiment. Three of these errors may be related to, Lack of Monitoring: "failure to set priorities", "inadequate monitoring", and "failure to utilize available data." A fourth error is related to Hesitant Challenging: "failure to communicate intent and plans." (Wiener et al, 1993, p xvii).

A Case Study With a Cockpit Voice Recording

On December 1, 1993, Express II Airlines Inc. / Northwest Airlink Flight 5719 descended too quickly and crashed before it hit the runway in Hibbing, Minnesota. All sixteen people on board died. According to the NTSB (NTSB, 1994a) the crash was caused by several factors: the captain flew the airplane inappropriately; did not "exercise proper crew coordination"; the first officer did not properly monitor [Lack of Monitoring] and alert the captain of the problematic descent [Hesitant Challenging]; the captain intimidated his first officer; there was inadequate airline oversight of the captain, who had a history of intimidating his first officers; and there was inadequate FAA surveillance of the airline.

That the captain's authority was strong in the cockpit can be deduced as follows. The captain intimidated five out of six first officers interviewed. He had actually struck one of them for mistakenly leaving the intercom on, and this fact had been passed on to the first officer of the accident flight. His first officers never reported the fact that the captain did not fly by the book, violated company policies on sexual harassment, sleeping in flight, and flying with mechanical irregularities.

The first officer, on the other hand, was a new probationary employee who "had just spent $8,500 of his own money to be trained for a job that provided an annual earning potential of $18,000." Such high stakes make it less likely that such a first officer would challenge a captain who could have a detrimental effect on his career.

The Cockpit Voice Recorder (CVR) transcript showed that "most of the captain's communication with the first officer was either to correct him or to tell him what to do." Other captains testified afterwards that the first officer had not needed these directions during their flights. Some of these instructions were even absurd. Further, according to the NTSB, "the statements of the first officer on the CVR suggest a tense and almost reserved attitude toward the captain [Excessive Obedience]. Information provided by the first officer to the captain was couched in a questioning manner rather than as an assertion." [Hesitant Challenging].

Finally, the airline only provided a single approach chart, which both captain and first officer had to use. This vital piece of information could only be shared by making the interpersonal distance minimal, thus further increasing the captain's authority [Physical Closeness Matters].

Here are some excerpts from the CVR transcript provided in the NTSB report. We begin as the captain and the first officer discuss where they are going to stay that night, a passage that seems to imply a rather large power difference between them:

> First Officer: it's not the Radisson or anything?
> Captain: yeah right.
> First Officer: no are you serious with this thing .. travel?
> Captain: no I'm kidding it's the Holiday Inn.
> First Officer: they have a Holiday Inn in .. in ah I' Falls? so then I assume they have a bus?
> Captain: they have a van.
> First Officer: and they ah don't care if it's a four o'clock ah -
> Captain: nope because they're also taking our people to the airport besides us.
> First Officer: ah (that's right). do we get our own room?
> Captain: no you're going to have to room with me and it's only a single bed so there's a little carpet at the base of my bed and you can curl up at the base of my bed .. course you get your own room ... you're under contract now ... this is ALPA [Air Line Pilots Association] contract.

The captain then asks about the time:

> Captain: what time were we out of the gate.
> First Officer: fifty-two
> Captain: okay. according to your watch or according to the clock?
> First Officer: ah well it's the same.
> Captain: oh okay.
> First Officer: I think I'm showing the same .. yeah.

The time issue suggests that the First officer is somewhat deferentially checking whether his watch and the airplane clock show the same time.

The first officer keeps asking the captain questions as if the captain is his teacher: How long does it take to go between different locations, are there jetstream routes, where they are at the moment, what the control tower said, what approach they can take to the airport?

> First Officer: okay .. what's the ah see that falling star?
> Captain: either that or a falling Cessna.

The first officer's questions keep coming. He fails to make standard call-outs for lowered altitudes, and , according to the NTSB, fails to call out the need to execute a missed approach. The captain did not fly the approach according to the stated plan, but remains at a high altitude too long, suggesting that the landing is going to be very steep. The first officer makes one attempt to challenge it:

> First Officer: just .. you just gonna stay up here as long as you can?
> Captain:yes. guard the hor- I mean an speeds one hundred.

When the captain asks the first officer whether Hibbing's control tower gave him the weather, the first officer affirms it after a pause even though this did not happen.

According to the NTSB, at the time of the approach, the captain should have made clear to the first officer what were his duties. The consequence of his failure is indicated by a variety of orders given during the approach, distracting both pilots. At the point the plane is scraping the trees, the

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following dialogue occurs:

> Captain: did you ah click the ah airport lights .. make sure the co-common traffic advisory frequency is set. [sound of seven microphone clicks]. click it seven times?
>
> First Officer: yup yeah I got it now. [momentary sound of scrape lasting for .1 secs]
>
> The plane crashes.

DOING THE NUMBERS: MONITORING AND CHALLENGING ERRORS

In 1994 the NTSB (1994b) reviewed all serious airplane accidents between 1978 and 1990 subject to the conditions that (1) a voice recorder had to be required on the plane, that (2) the NTSB had conducted a major investigation (limiting the number of accidents to 75), and that (3) the flight crew's actions were a causal or contributing factor (limiting the number of accidents further to 37). Twenty-three of the 37 accidents resulted in fatalities.

The NTSB found that after procedural errors, errors of the type "monitoring/challenging" were the most common, occurring in 80 % of the accident sample. These were errors in which the non-flying crew-member (the first officer in 81-87% of the cases) did not properly monitor and challenge the flying crew-member when errors were committed. Usually the errors that should have been monitored or challenged were listed as causal or contributing to the accident.

Using this data we can calculate how many accidents are related to inadequate monitoring and challenging. According to the NTSB in 19 of the 37 accidents a monitoring/challenging error followed a causal error. Since the initial pool consisted of 75 accidents, approximately 25% of all accidents could have been prevented by better monitoring and challenging. Keeping in mind that in 81-87% of all the accidents the captain was the flying pilot, about 20% of all accidents could have been prevented if the first officer had better monitored and challenged the captain.

OPTIMIZATION MONITORING AND CHALLENGING

The NTSB's discussion of human errors included the need for practicing monitoring/challenging behavior in LOFT scenarios and emphasizing monitoring and challenging (M&C) errors in the LOFT debriefings. In particular, the NTSB felt that an important avenue would be the "intentional introduction of a procedural or decisional error by the flying pilot in the LOFT scenario. This technique would make certain that the non-flying pilot is confronted with the opportunity to detect and challenge the error made by the flying pilot." This leads us, next, to propose M&C optimization as a technique.

It is evident for the sake of error correction, that the degree of M&C is a parameter that should be modified to some best value between 0 and 100%. The intelligence and experience of the first officer should be utilized (high M&C), while at the same time a structure of hierarchical accountability needs to be present (low M&C). This is similar to Edward's conjecture that the trans-cockpit authority gradient should not be too high, nor too low, but optimized (Edwards, 1975).

We begin by quantifying the M&C level by introducing intentional errors on the captain's part. These errors vary on a scale from small to large. Some of the decisions, whether erroneous or not, will be challenged by the first pilot and others will not. Each correct challenge will subtract a number from the overall M&C score of the captain–first officer relationship, while incorrect challenges and each error not challenged will add a number to the overall M&C score.

The intentional errors can be introduced at any time during LOFT. For illustrative purposes, let's introduce errors on the checklist in Appendix I. The captain's instructions include the point value of a first officer challenge. The point value is negative if an appropriate instruction is challenged or if an intentional error goes unchallenged and positive if an intentional errors is challenged. At the end of the checklist procedure, the total score is added up and reported to the LOFT control tower.

The M&C score can now be used in three ways: First, the score can be discussed by the trainer. If the score was too high, the first officer can be asked to practice and challenge the captain according to a script, while the captain can be asked to respond to those challenges in amenable ways. If the score was too low, the first officer has to be told that the captain is in charge of the plane and cannot be challenged that much and the captain should be taught how to deal more effectively with challenges to his authority.

Second, a database can be made of the M&C score and the corresponding error rate (intentional or not) during the rest of the simulation. The expected result would be a strong correlation of the M&C rate with the unchallenged captain error rate. If this is proved to be the case, the M&C rate can be used as a predictor of the error rate and a checklist such as the on in Appendix I could be used, if the economics permit, during an actual take-off to prevent crews in which the captain can make unchallenged errors from taking off.

Third, the regular use of M&C optimization will serve to create a norm for what orders can be given, and to encourage critical evaluations of future orders throughout the flying organization.

If one accepts the figure of 20% of all airplane accidents as being due to inadequate M&C of the captain by the first officer, optimizing the authority level of the captain could lower the total number of serious airplane accidents by as much as 20%.

CONCLUSION

The captain–first officer relationship in the airplane cockpit was related to the obedience studies of Milgram. It was shown that many of the factors leading to human errors in the cockpit are similar to ones that were present in the Milgram obedience experiments including the lack of monitoring and hesitant challenging. In addition, the organizational context, values from the corporate and military cultures, and regulations may have created a captain role with too much power.

It was emphasized that the amount of the M&C has an optimal value and that this value should be sought after. M&C optimization is an application of the Milgram experiment that measures the crew's M&C level in LOFT on a scale from too low to too high. Feedback into the social system includes crew debriefing. Organizational feedback includes M&C levels as predictors of expected error rates, and the setting up of an organizational norm for M&C optimization. It was argued that M&C optimization may prevent perhaps up to 20 percent of all aircraft accidents.

Studies of authority dynamics are notorious for their evoking organizational defenses (Milgram's experiments, for examples, provoked the American Psychological Association to forbid the experiments from being ever carried out again). In cockpits, however, due to the high costs of mistakes, the organizational defenses are lowered. Helmreich & Foushee, 1993, write in the context of teaching crew decisions:

> ...one is struck by the willingness of very disparate organizations to embrace a training concept that counters many of the traditions of an industry.

Finally, we may note that there are many other potential areas of society in which M&C optimization could be used, especially in social systems that handle large risks such as financial trading floors. □

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AUTHOR'S NOTE

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APPENDIX

The following checklist is derived from Normal Procedures, Aircraft Operating Manual - DC-9 revision 10 (9/4/95). Additions made by this author are indicated in italics.

FINAL COCKPIT PREPARATION

The Final Cockpit Preparation is performed by both crew members in final preparation for flight. This, in conjunction with the first officer's preflight inspection previously described, prepares panels and related components prior to initiating the BEFORE START checklist.

The captain's and first officer's final cockpit preparation procedures are shown below. If the manner of accomplishment is described in the BEFORE START expanded checklist, reference is made to the specific item.

INSTRUCTIONS SPECIFIC TO THE CAPTAIN: THE AUTHORITY FIELD OPTIMIZATION

The final authority over this plane is yours. Should you make a mistake during the flight, it is imperative, however, that your error is properly monitored and challenged by the first officer. Sometimes, first officers will not challenge their captain. The absence of a challenge can make a mistake more serious than it need to be. In italics you will see <u>inappropriate instructions</u> you are to give in order to test the strength of your authority. This is the only known way to find out whether your first officer will, in the case of a real error, challenge you. Your first officer should obey all your appropriate commands but challenge at least two of the ones given in italics. You are required to report the result to the control tower and to the first officer before take-off.

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Task	**Point value of first officer challenge**	**Check if challenged by first pilot**
OVERHEAD PANEL..................................SET AND CHECKED	-1	
Fire Detection Panel..CHECK - Check that both engine and APU Fire Detector Loop switches are set to BOTH. Maintenance Interphone Switch...................CHECK - Check that switch is OFF.	-1	
Ground Servie Electrical Power Switch............CHECK	-1	
The next two checks on your list have been switched to see whether the first officer will challenge the apparent skipping of a check. If the first officer challenges, thank him or her and say that you made a mistake.		
Circuit Breakers.......................................CHECK - Check all circuit breakers are in or collared. Under most conditions, the three (3) Anti-Fog circuit breakers will be pulled but not collared.	1 if missed check detected -1 otherwise	
Observer's Oxygen Panel.........................CHECK - Check that Oxygen Lever is ON, Diluter Toggle is set to 100% and that Emergency Toggle is set to NORMAL.	-1	
Winshear Detection System.....................CHECKED - Press the WINDSHEAR TEST switch and observe annunciations indicated in Pilot Manual Chapter 19. - Any system failure detected will cause the WINDSHEAR INOP light to remain illuminated at the end of the test. - Aural messages as given in Chapter 19 will accompany any system failure(s), internal or external.	-1	
NOTE This task cannot be performed in flight. - Check that WINDSHEAR INOP light is extinguished.	-1	

Tell the first officer you need to leave the cabin for a minute. Ask him to continue the checklist himself. Then change your mind and remain. Take note of whether the first officer challenged your initial decision or not.	5	
Voice recorder.......................................TEST - Press and hold Test switch for at least five seconds and observe monitor meter indicates in green band.	-1	
Electrical Panel..................SET AND CHECK - See "Electrical Panel" items in the Before Start expanded checklist in section N-3.	-1	
Galley Power Switch.......................ON or OFF	-1	
DC Start Pump..OFF	-1	
Ignition...OFF	-1	
Cabin Emergency Lights Switch...............ARM - Place switch to ARM.	-1	
No Smoking Sign Switch............................ON - Place switch to ON. *In an absent-minded way, please set the No Smoking Sign Switch to OFF. In case the first officer did not challenge your decision, you will be reminded later to switch it to ON.* *etc.*	-1 1 if off-switch challenged	

<u>*AUTHORITY FIELD OPTIMIZATION REPORT TO TOWER*</u>

Number of challenges to inappropriate checklist orders (those with positive values):	
Number of challenges to regular checklist orders (those with negative values)	

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