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WHEN LANGUAGE BECOMES A BARRIER INSTEAD OF A BRIDGE: COMMUNICATION FAILURES BETWEEN PILOTS AND AIR TRAFFIC CONTROLLERS

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For tasks like air traffic control that require coordination among multiple players, communication is critical. While normal communication between controllers and pilots is highly standardized, involving many formulaic expressions to request and provide clearances, errors occur even when all parties speak the same native language. In international operations the possibility for miscommunication is even greater. A search of the Aviation Safety Reporting System (ASRS) was conducted to understand types of communication problems experienced by flight crews and controllers in international operations and to suggest possible measures to overcome these problems. The most commonly reported problems dealt with the English language, such as controllers' accent or proficiency. Problems with content, such as ambiguous or incorrect information, and failures to catch misunderstandings were also reported, but with less frequency. Additional analyses examined the consequences of communication problems, including regulatory actions and resulting undesired aircraft states.

Introduction

An Air Liberté MD83 was cleared, in French, to take off from runway 27 at Paris Charles de Gaulle airport. Just five seconds later, a Shorts 330 was directed, in English, to "line up runway 27 and wait, number two." The controller mistakenly believed that both aircraft were at the threshold of the runway, not realizing that a previous controller had cleared the Shorts to takeoff at the intersection of runway 27 with an intermediate taxiway. The Shorts entered the runway at the moment the MD83 was reaching its rotation speed. The tip of the MD83's left wing went through the Shorts 330's cockpit and hit both pilots, killing the first officer (BEA, 2003).

As in most aircraft accidents, no single error was identified as the cause of this accident that resulted in the death of the Shorts' first officer (BEA, 2003). However, contributing to the accident were certain aspects of the communication between the French controller and the French and Canadian pilots, such as the controller's ambiguous reference to the "number two" aircraft. In addition, since the controller spoke French rather than English to the local pilots, the Canadian crew was unaware that another aircraft had been cleared to take off on the runway they were about to enter. Also, the French MD83 crew did not realize that the Canadian aircraft would be entering the runway at the midfield intersection rather than the departure end, so was not looking for them.

For tasks like air traffic control that require coordination among multiple players, communication is critical. While the communication between controllers and pilots is normally very standardized, involving formulaic expressions to request and provide clearances, errors nonetheless occur, at times with fatal consequences. Aviation incidents and accidents in which communication errors by ATC and pilots played a significant role point to several problem areas. The first concerns the content of a message and refers to use of ambiguous terms or non-standard phraseology[1]. That is, what a speaker said was unclear and left room for alternative interpretations. The misunderstanding occurred because the addressee missed the intended meaning, and understood the message in a way unintended by the speaker. Unfortunate examples of this type of communication problem are the collision of KLM Flight 4805 and PanAm Flight 1736 on Tenerife in 1977 and the Avianca Flight 052 fuel-exhaustion crash in 1990. In the Tenerife accident the Dutch crew acknowledged their departure clearance with the ambiguous phrase "We are now at takeoff." The controller interpreted this to mean: "We are at the takeoff point awaiting takeoff clearance," rather than "We are in the process of taking off," which the crew apparently intended, as became clear in the unfolding events (Cushing, 1994; NTSB, 1977). In the Avianca accident, the first officer did not use the standard terminology for declaring an emergency and consequently the controller did not realize the severity of their fuel situation (NTSB, 1991). Ambiguous and non-standard communications were also relatively frequent in aviation incidents submitted to the Aviation

[1] Standard phraseology in the U.S. is based on the FAA published Aeronautical Information Manual, Pilot/Controller Glossary (FAA, 2002b). International operations are based on ICAO Standards or Recommended Practices.

Safety Reporting System[2] (Reynard, 1993). In an earlier analysis of 100 ASRS reports, Orasanu, Fischer, and Davison (1997) found that 11% involved non-standard phraseology.

A second problem area in ATC-pilot communications concerns the physical transmission of the message. That is, communication is impeded or disrupted because addressees cannot discern what speakers are saying. Examples include instances of controllers talking too fast or providing too much information so that pilots found it difficult to follow and even missed part of the transmission (Reynard, 1993). Experimental evidence of a link between the length of controllers' clearances and pilots' comprehension is provided by Morrow and Rodvold (1993). They found that readback and other memory errors increased significantly with the length of clearances. In addition to their rate of speech, the accent of controllers or their overall English language abilities were noted as a problem. In 31% of the incidents analyzed by Orasanu et al. (1997) pilots reported that they had difficulty understanding foreign controllers or mentioned that they did not request clarification because of the controller's poor language skills.

While the previous problem areas reflect shortcomings of the speaker, errors can also arise within the addressee. Cushing (1994) lists instances of pilot-ATC miscommunications in which the pilot's comprehension was at fault. Pilots misheard what a controller said, or made wrong inferences, often based on expectations, and consequently misunderstood the controller's intention, despite the fact that they had received a perfectly clear message.

Another area in which addressees contribute to miscommunications concerns feedback on their understanding. In pilot-ATC communications, explicit feedback in the form of readbacks and acknowledgments is needed to ensure that both parties understood what has been said and to provide them with the opportunity to catch errors or misunderstandings (FAA, 2002a; FAA, 2003). Problems in feedback are of two kinds. On the one hand, controllers were found to miss errors in pilots' readbacks and thus failed to resolve their misunderstanding (Cushing, 1994). Cardosi, Falzarano and Han (1998) referred to this problem as hearback/readback error and noted that the majority (47%) of communication failures in their corpus of 386 ASRS reports were of this type. At other times, controllers stood little chance to even detect any misunderstanding. In these instances pilots confused the reference of a clearance, for instance mistook a heading for a flight level, and repeated only the number part of the clearance, leaving the referent ambiguous and thus providing no indication of any misunderstanding. Partial readbacks by pilots was the second largest error category in the Orasanu et al. (1997) data set as well as in the Cardosi et al. study, contributing to 16% and 25% of the analyzed incidents, respectively.

A problem area that is unique to the aviation environment concerns the availability of party-line information. Listening to the communications between controllers and other pilots in the same airspace provides crucial background information to pilots on the basis of which they can interpret ATC clearances given to them. Dual-language operations reduce the party-line information available to pilots and can lead to fatal misunderstandings as illustrated by the accident described at the beginning of the paper.

The purpose of the present study was to determine which of these communication problems continue to be a threat to flight safety in international flight operations and to discuss advantages and disadvantages of possible countermeasures.

Problems in Controller-Pilot Communications

A search of the ASRS report database was conducted using the keywords language, accent, culture, English, or communication problems (ASRS Database, 2002). Of the 100 reports selected, 55 were relevant to the topic, i.e., each contained at least one communication problem involving the flight crew and air traffic controller. These reports were coded according to the airspace (foreign or domestic) and the reporter (pilot or controller), as well as the type of communication problem mentioned, and the consequences that resulted from the communication problem.

Of the 55 coded reports, 43 (78%) took place in foreign airspace and 12 (22%) occurred in domestic airspace. Pilots submitted 51 of the reports (93%); controllers submitted only 4. Most incidents (73%) involved at least two different unrelated types of communication problems, with a total of 106 problems found in the 55 reports. Note that cascading problems were coded only once based on the core problem. For instance, an ambiguous clearance that led to a misunderstanding was classified only as ambiguous language use and not

[2] The ASRS is a non-jeopardy system that provides limited immunity to pilots, controllers, and others who report events that might result in a possible violation or a threat to safety. ASRS reporting is voluntary, so may be subject to bias; these reports do not represent a random sampling of incidents.

as an additional misinterpretation of intent on the part of the pilot. Aside from communication problems, pilots and controllers rarely mentioned other issues as having contributed to an incident. Radio-frequency congestion and poor transmission quality were noted as additional factors in only 4 (7%) reports, while 11 (20%) reports also referred to non-communication issues such as fatigue.

The communication problems were coded with respect to the locus and type of the problem as indicated by the reporter. That is, we distinguished whether a problem concerned ambiguous or non-standard language use by a speaker, referred to a speaker's accent or English language ability, reflected misinterpretations by an addressee, or was related to improper feedback. The types of communication problems identified in the ASRS reports are presented in Figure 1 and will be discussed in the next section.

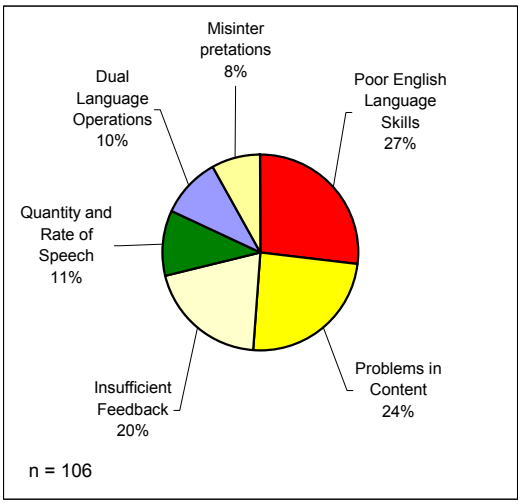

Figure 1. Types of communication problems mentioned in ASRS data set.

English-Language Problems

The majority of problems (27%) identified in the ASRS reports concerned the ability of controllers and pilots to converse in English. While controllers mentioned six instances in which they had trouble understanding a foreign pilot, most English language issues (22 or 79%) were reported by pilots and concerned their interactions with foreign controllers. Pilots most frequently implicated controllers' foreign accents in the incidents, but also noted that their overall poor English language proficiency discouraged pilots from requesting clarification. Reporting pilots stated for example: "Havana Center was very difficult to understand. We had to ask Havana to repeat the clearance several times….Due to the limited English speaking capability of the controller it would be unlikely that we could get any kind of clarification from him (ACN #510640)."

Problems Concerning Ambiguous Content

The next most common problem (25 or 24%) dealt with content issues referring exclusively to ambiguous, non-standard or incorrect clearances given by ATC. Most content issues concerned the use of ambiguous referents (11 or 44%) as in the following incident: "On departure, we were given 'Fly heading 240 degrees to 4,000 feet.' The controller then stated 'Proceed as cleared (ACN #518886)." The crew mistook the last part of the clearance to mean that they could proceed as filed. However, the controller had meant for them to proceed at 4,000' until told otherwise. Non-standard terminology was reported in seven instances, including a near-mid air collision that resulted when "Santo Domingo ATC instructed us to turn 90 degrees to the left, no ICAO [International Civil Aviation Organization] language stating 'immediately' was issued in the instruction from ATC (ACN #512629)." The remaining seven incidents in this category involved incorrect ATC instructions where pilots did not have sufficient knowledge to actually detect and question the errors. For example a pilot reported that, "initial climb clearance was given to 14,000' by first departure controller while climbing through 12,500' to 14,000'. The second departure controller told us that we were given 12,000' as an initial altitude…My guess is that NAS [Nassau] control thought they said 12,000' when in fact they said 14,000' (ACN #497439)."

Insufficient Feedback

The third largest group (20%) of communication problems in our data set was made up of instances in which controllers overlooked errors in the readbacks of pilots and thus missed the opportunity to correct some misunderstanding. None of the feedback issues in our data set concerned partial readbacks by pilots. Examples of controllers failing to correct pilots include the following instances: In response to the clearance "Flt XYZ, you are cleared to six zero" the pilot read back that they were cleared to climb to FL260 (flight level 260, or 26,000'). The controller responded in the affirmative, although he intended them to climb only to 6000'. This incident actually began with an error caused by homophony (confusion of "two" and "to"), compounded by a feedback error. Another pilot reported a departure from their assigned altitude in Chinese airspace, stating that Beijing Control cleared them to descend to 4500 meters. According to the pilot who submitted the report: "I read this back slowly and

distinctly, and controller rogered my readback (ACN #532666)." Shortly after leveling off at 4500 meters, the controller asked why they had not maintained 4800 meters.

Quantity and Rate of Speech

A smaller set of problems (11%) comprised instances in which pilots reported that controllers had talked too fast or had provided too much information. For instance one pilot remarked: "I consider his accent, the very fast delivery of his clearances and his tendency to not annunciate clearly altitude assignments and clearances a contributing factor to our altitude deviation. Other aircraft and crews were having a problem understanding the controller as well (ACN #514758)." An instance of a controller including too much information into one transmission was described by another pilot: "The Japanese controller gave a great deal of information (i.e., route change, holding instructions, new runway in use, altitude change) without any preparation or indication of these coming … combine that with some language difficulty (ACN #503219)."

Dual language operations

Of the incidents examined for this study, 12 (10%) reported the use of dual-languages, which provided pilots with insufficient context for interpreting their clearance and impaired their situational awareness as in the following example: "We had trouble verifying the clearance because ATC was speaking Spanish to another aircraft on the frequency….Our situational awareness was compromised by not understanding the Spanish transmissions and not getting a timely verification of the clearance (ACN #499426)."

Misinterpretation of Information or Intent

The smallest group of communication problems (8%) comprised incidents in which the pilots or controllers misheard information or misinterpreted the intent of a communication. Most of the problems in this group (7 out of 9) referred to incidents in which pilots reported to have misunderstood ATC. For instance, a crew thought they heard the controller clear them to VOR/DME 2 RWY 31. Later on it became apparent that they had misunderstood the controller who in fact wanted them to land on RWY 13.

Consequences of Communication Problems

Two types of consequences resulted from the communication problems in our set of aviation incidents. The first concerned undesired aircraft states, such as airspace violations, near mid-air collisions, and runway incursions. The second involved some regulatory action, such as an investigation and/or action by the airline or the FAA.

All of the ASRS reports examined in this study led to some type of undesired aircraft state. The greatest number of them concerned altitude and heading deviations (25% each). Runway incursions accounted for 18% of the undesired aircraft states, followed by loss of standard separation (15%). Other ground conflicts were mentioned in 9% of the reports. Least frequently reported were loss of situational awareness, airspace violation, and running off a taxiway, with just one of each type reported. Fortunately, only one of the most serious consequences was reported - a near mid-air collision.

There are different levels of regulatory consequences, ranging from a company inquiry to an FAA review or FAA investigation (the most serious with respect to possible certificate action). Note that ASRS is only aware of these consequences if the reporter states the information in the narrative or provides it to the ASRS analyst during a possible telephone callback. ASRS indicates the consequences that have been reported in a separate data field, upon which our analyses are based. Of the 55 reports reviewed, 20 (36%) stated that there were no regulatory consequences. FAA reviews were reported in 29% of the incident reports, while an additional 12% related that a FAA investigation was being done. Company inquiry was mentioned in 13% of the events, and 5% resulted in both company inquiry and FAA reviews.

Correcting Communication Problems

As in previous analyses of communication problems in international flight operations, pilots in our data set most frequently reported difficulties in understanding foreign controllers due to their accents or because they used ambiguous or non-standard terminology. Unlike previous analyses, we also found that controllers' failures to correct errors in pilots' readbacks frequently contributed to the incidents.

Many procedures and guidelines have been established to ensure unambiguous ATC-pilot communications, such as the standardized vocabulary presented in the Pilot / Controller Glossary (FAA, 2002b) or in the guidelines proposed by ICAO. As data from this and previous studies indicate that problems in this area persist, it might be worthwhile to inquire as to why. Do controllers receive too little training in standard procedures and terminology? To what extent are the

standards internationally recognized and enforced? Are there too few standards?

While the use of digital, textual communication such as datalink will eliminate most of the major problems identified in our analyses, it will most likely introduce new problems and increase the frequency of some existing ones. Problems related to accent, ambiguous or non-standard terminology, misinterpretation of information or intent, and pace and quantity of speech all would become issues of the past if controllers could select standard clearances on their computer screen and send them up to a computer terminal on the flight deck. On the other hand, computerizing the communications between controllers and pilots will bring certain disadvantages. If controllers were to type their clearances, English language issues (except for accent) and ambiguities would not disappear, and the possibility of typing errors would be introduced. In addition, party-line information that has been found so useful will be eliminated. Moreover, foreign pilots and controllers will have less practice, and most likely less skill, in conversing in English once the majority of communications are carried out by computer. A decrease in their English language proficiency, however, will certainly pose a problem in crisis situations that require communications beyond preprogrammed phrases. How to overcome these disadvantages will be the real challenge in future ATC-pilot communication systems.

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