2007

A Human Factors Analysis of Miscommunication Between Pilots and Air Traffic Controllers in Taiwan

Wen-Jiang Chang

Eric Min-yang Wang

Wen-Ling Tsai

Wei Hsu

Jin-Ru Yen

See next page for additional authors

Authors

Wen-Jiang Chang, Eric Min-yang Wang, Wen-Ling Tsai, Wei Hsu, Jin-Ru Yen, and Hero Ho

A HUMAN FACTORS ANALYSIS OF MISCOMMUNICATION BETWEEN PILOTS AND AIR TRAFFIC CONTROLLERS IN TAIWAN

Wen-Jiang Chang, Eric Min-yang Wang
Department of Industrial Engineering and Engineering Management
National Tsing Hua University
Hsinchu, Taiwan, R. O. C

Wen-Ling Tsai, Wei Hsu
Department of Applied Foreign Language, Shi Chien University
Taipei, Taiwan, R. O. C.

Jin-Ru Yen
Department of Shipping & Transportation Management
National Taiwan Ocean University
Keelung, Taiwan, R. O. C.

Hero Ho
China Airlines
Taipei, Taiwan, R. O. C.
d917821@oz.nthu.edu.tw

The objective of this research was to analyze the human factors, which involved in specific types of miscommunication between pilots and air traffic controllers (ATCs). The study was based on the transcripts of pilot and ATC communication, which including the thirty flight incidents filed by local ATC authority. The research team consisted of an experienced air traffic controller, a pilot, and professors of linguistics, transportation management, human factors, and several assistants. The cases were analyzed and discussed thoroughly; as a result, seventeen types of communication error were identified from these incidents. Among these communication errors, three of seventeen types were solely associated with ATCs: 1) forgetting the previously issued clearance, 2) incomplete clearance or information, 3) and the unconformity of issuing the clearance/instruction. Two types of communication errors, i.e., inappropriate operation and violation against the rules, only associated with pilots. The other twelve error types were found in both parties. In general, the most frequent error type was "incomplete call sign" (61.3%), followed by "incomplete clearance or information" (12.5%) and "syntax errors" (11.4%).

Introduction

Today, the more complexity aviation environment is the more difficult human have. In aviation operation, air traffic controllers (ATCs) and pilots are most important role for avoiding incidents. They just communicate by verbal transmission. Pilots must pay attention to variations in their surrounding environment, and get into closely to contact with controllers to exchange necessary information that is ensured flight safety (Prinzo, 1993). Precision of communication is essential during ground inspection of aircraft, pre-departure, taxiing, take-off, cruising, final approach and landing.

The criteria of ATC phraseology in aviation operation is accuracy, correctness and certainty. Rapid globalization of aviation transport has caused a sharp increase in air traffic density, which makes the accuracy of communication between pilots and controllers even more important. The issues resulting from misunderstandings between crews and controllers have become more serious (Narinder, 2002). Due to these problems, the ICAO has actively joined in research related to aviation language evaluation in order to propose the aviation professional language level in 2008. The objective is to reduce the misunderstanding and miscommunication in the international aviation environment.

There are many aviation accidents/incidents in which the main factors were misunderstandings between pilots and controllers (Cushing, 1987; Goguen, Linde, and Murphy, 1986). However, ATC phraseology was used by the international aviation transport services to ensure communication was conducted with the same modality. The issues of misunderstanding still impact

flight safety. At present, there are two phrase systems to use, one is FAA published Order 7110.65P Air Traffic Control, the other one is Doc 9432 Manual of Radiotelephony by ICAO. The standardizing of ATC phrase is the basic operation criteria to communicate without barriers. The experiences of communication errors and misunderstandings were induced by culture, mother language and cognition. Hence, there are a few differences in the two systems. It has caused the misunderstanding of cognition and communications.

The purpose of this research was to generalize miscommunication types and induce human factors which caused these misunderstandings from transcripts of controller-pilot in incident reports. It was included two parts, one is the communication error categories and quantitatively analysis from ATC transcripts and the other is the effected misunderstanding of human factors analysis.

Factors of Effected Communication

Communication between flight crew and ATCs is always used by verbal style. Some specific words are misused to represent the same meaning. In some situation especially emergency, these words were sounded like other words by intonation. Even there are phraseologies to use for them, the problem still exists. In other words, the function of ATCs' phraseology is necessary to make the same meaning of cognition from pilots and ATCs. As a result they could transfer information, ideas and explain what they want to do. Therefore, if there are no common specialized vocabularies such as phraseologies, it would be very difficult to carry out the ATC operations effectively. While it was in emergency or high-density traffic situation, they lacked full time to understand the specialized vocabularies that is used to tell each other what they want. Finally, it causes the risk increasing of aviation incident happened significantly.

Reviewing the references, the influenced communication factors were described by many communications models and theories, such as the linear communication theory by Lasswell, which is thought the composition of communication, are only the transfer and the receiver. Though, it is not complete for describing the controller-pilot communication. Many correlations theories would base on the Lasswell's model to make the variation and discussion (Berlo, 1960). According to different concepts to develop these communication models, they proposed many influenced communication factors including individual factors, culture, social behavior as well as cognition ability and so on.

Therefore, based on these communication theories we could divide affected communication factors into three groups. One is the linguistic factors, another is machanical/environmental factors and the other is human factors. The results of analysis in research are based on these categories to find the factors that are caused misunderstanding in controller-pilot communication.

Communication Errors between ATCs and Pilots

Many researchers did the related studies were used by simulated experiment and pronunciation analysis to induce communication errors from the dialogues between pilots and controllers (Morrison, Wright, 1989; Monan, 1986; Grayson & Billings, 1981). Morrison and Wright (1989) focused on operational errors of ATCs' in their research. They divided errors into three groups including controlled errors, communication errors and the errors from factors of performance. From the results of this research, it showed that the communication errors are the most common one in all failure types. According to the results of Monan (1986), active listening during information transferred process is a major problem for controllers and pilots. Its error type is including hearback failure but the messages transmitted correctly, the deviation of the messages or numeric hearback, readback due to cockpit mismanagement and hearback failures of controllers.

In Grayson and Billings's (1981) research, the results were listed the most common ten communication errors between controllers-pilots from the reports of ASRS (Aviation Safety Reporting System). It indicated that 70% of the reports involved one type of oral communications problem at least. According these results, it is more significant the effect of oral communication errors to risk of aviation safety. Communication errors caused by pilots and controllers are really not major only language or action ones. From the results in past research, it was showed that communication errors were induced by interaction of serious complex factors in process of information transmitted. Hence, the communication errors between them are classified and induced by three parts such as the contents of clearance, syntax/linguistic types and hearback/readback in advance.

Methodology

The method of this research that we took was quality-research. We regularly discussed and analyzed these cases with different scenario domestic ATC incidents. The research group are consists of experienced controllers and pilots, linguistic scholars

and human factors experts to discuss and classify the error types from these cases that were unexpected incidents reports in Taiwan.

These cases were realistic ATC's incidents that were divided into hazardous and non-hazardous in Taiwan. In research, it had been thirty cases collected, the hazardous cases are nineteen; the non-hazardous cases are eleven. According to the classification from authority investigated results, the cases mostly were TCAS Alert from insufficient isolation or runway incursion by pilots' violation and so on. All kinds of communication failures from transcripts were analyzed by human factors of research structure.

Results and Discussion

The results are presented by two parts. One is communication errors types categorized and the other is human factors analysis of misunderstanding in ATC's phrases. There are seventeen communication error types classified from the transcripts of thirty incident cases referring to related literature. There are 3 classifications particularly by controllers, 2 classifications unique by pilots; 12 classifications by both. From the statistics results of communication error types, the most significant misunderstanding type is incomplete call sign; the second is incomplete clearance/information and linguistic format errors.

At last, the result is human factors analysis and reorganization for influencing communication failure types. According to the definition of communication failures by this research, human factors hiding misunderstanding are induced appropriately by scenario, flight phase and related factors in ATC's incident cases.

Investigation and Collection of ATC Phraseology Misunderstanding

Communication main are represented by message of transmitted language and expression of body language to accomplish the interaction between speaker and receiver. Hence, the comprehension of transmitted contents from different receivers is varied with environment and transceiver. From the collected ATC's incident cases, we concluded the seventeen communication error types as Table 1. There are three error items, 1) especially for ATCs including a) the published clearance that air traffic controllers forgot, b) the incomplete clearance/information, and c) the errors of clearance/instruction published. 2) For only pilots, there have two items involved the improperly operation from pilots and the pilots violation; 3) the finals are twelve items error types from both of them. According to the seventeen items communication error

types from thirty ATC incident cases, the statistic results of errors frequency ratio are as Figure 1. The most frequent is incomplete call sign (61.3%), the second is incomplete clearance/information (12.5%) and the last is errors of syntax format (11.4%). From the chart we could understand many communication errors were caused by non-standard phraseology format and syntax, it was emphasized the questions of organization culture, training and standard operation process. Consequently, from these statistic data it is generalized human factors affected significantly the communication efficiency in using ATC phraseology. The more complex the contents of dialogue are, the more frequent of the communication error types and quantities are. General speaking, the incomplete call sign and the incomplete clearance/information were happened together, especially the complexity of flight situation that controllers published departure and landing clearances. Besides the accuracy wordings, the ATC's dialogues still should be given for the suitable clearance in the correct time. Due to the increasing complexity of aviation operation, controllers always pay more attention to handle extra situations and solve the problems. In ATC's incident cases, the more complex of aviation controlled situation is, the higher opportunity of air traffic control phraseology errors is. Finally, the main communication error types were call sign errors, errors of syntax format and misused phraseology caused by these factors.

Table 1. Communication Error Types by Role

Classification	Role
Improperly Operation from Pilots	○
Pilots Violation	○
Mistimed Messages	
Published Clearance that Air Traffic Controllers Forgot	
Misunderstanding	
Errors of Syntax Format	
Incomplete Call Sign	
Incomplete Hearback/Readback	
Incomplete Clearance/Information	
Uncorrected Responders	
Uncorrected Receivers	
No Response	
Phraseology Misused	
Errors of Hearback/Readback	
Errors of Clearance/Instruction Published	
Errors of Information	
Call Sign Errors	

   :Error Types in ATCs
○:Error Types in Pilots
   :Error Types in Both

Analysis and Reorganization of Human Factors Effected Communication Error Types

From these results of communication error types, it was analyzed in advance. It was found the human factors of caused failures in aviation situation and environment at that time. The transcripts of ATC's incidents are limited data that human factors analysis is induced by errors theories. The effected factor was listed in this paper as far as possible. In order to understand the influence of the regarding communication faults in advance, the induced human factors in this research would be the controlled variables in simulated experiment.
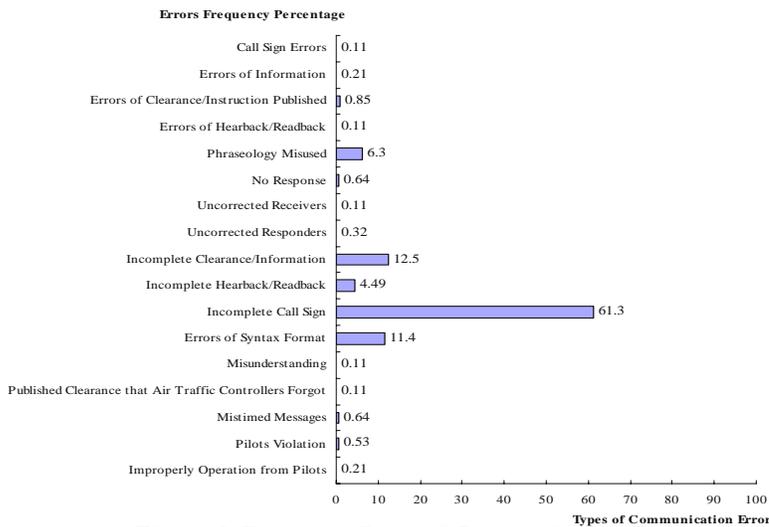
Errors Frequency Percentage

Call Sign Errors	0.11
Errors of Information	0.21
Errors of Clearance/Instruction Published	0.85
Errors of Hearback/Readback	0.11
Phraseology Misused	6.3
No Response	0.64
Uncorrected Receivers	0.11
Uncorrected Responders	0.32
Incomplete Clearance/Information	12.5
Incomplete Hearback/Readback	4.49
Incomplete Call Sign	61.3
Errors of Syntax Format	11.4
Misunderstanding	0.11
Published Clearance that Air Traffic Controllers Forgot	0.11
Mistimed Messages	0.64
Pilots Violation	0.53
Improperly Operation from Pilots	0.21

Types of Communication Error

Figure 1. Frequency Ratio of Communication Error Types

We divided the human factors into three parts, there are included psychological, physiological and the others. The details are listed as table 2. Physiological factors are physiological workload influence, that pilots and controllers were responded from bearing in aviation environment. It is involved age, physical situation, workload, and fatigue.

Table 2. Human Factors Category

Human Factors	**Contents**
• Physiological	Age, Physical, Workload, Fatigue
• Psychological	Attention Resource, Distraction, Expectation, Memory Limitation, Situation Awareness, CRM, Time Pressure, Cognition, Organization Climate, Teamwork,
• Others	Position, Nationality, Work Experience, Professional Training, Education, Culture, Race

Psychological factors mean that variation and influence in mentality from different situations or stimuli in environment are sensed by human being. It is included attention resource, distraction, expectation, reaction, decision making, memory limitation, situation awareness, and others. The others are excluded psychological and physiological factors, such as position/place, nationality, work experience, professional training, education and culture.

Conclusion

Based on the results of our research, the outcomes were showed by collected the misunderstandings in these ATC transcripts. Actually, the root causes of misinterpretation could be analyzed by three categories. The root causes including non-language (human factors and environment/equipment) and language, which would be completely describing the all scenario of errors. Preliminary analysis from errors chain theory and transcripts of ATC cases, we have three points for conclusions.

1. Communication error types apparently were not enough represented the root causes of misunderstanding.

The results of errors on the surface are not showed the root causes of misunderstand. In terms of Cheese model, mishaps are brought by a series of errors (Reason, 1990). Therefore, the errors showed on the surface were needed to analyze and verify in advance.

2. Misunderstandings between pilots and controllers come from cognitive difference of linguistic and environment regarding human perception.

In the communication closed loop, the environment is the outside factors that affected cognition of language. Human to cognition and recognition of language are inside factors. Therefore, the difference of linguistic is from influence of media and the other outside factors.

3. The air situation sometimes is not suitable to transmit by using limited wording in specific time; hence it is easy to cause situation awareness failure.

Dialogues between controllers and pilots were needed to response as soon as possible. However, it is still accuracy. The pressures of keeping messages briefly and information of accuracy wordings always exist to non-English of ATCs and pilots. The complex situation awareness cause them could not use the accurate terminology to represent the scenario.

References

Narinder, Taneja. (2002). *Human Factors in Aircraft Accidents: A Holistic Approach to Intervention Strategies*. Proceedings of the 46th Annual Meeting of the Human Factors and Ergonomics Society.

Prinzo, O. V., & Britton, T. W. (1993). *ATC/Pilot Voice Communications: A Survey of Literature*. DOT/FAA/Am-93/20. Washington, DC: Federal Aviation Administration.

Cushing, S. (1987). *Language and Communication-related problems of aviation safety*. Paper presented at the annual meeting of the American Association for Applied Linguistics, San Francisco, CA.

Goguen, J., Linde, C., & Murphy, M. (1986). *Crew communications as a factor in aviation accidents* (NASA Technical Report 88254). Moffet Field, CA: NASA Ames Research Center.

Berlo, D. (1960). *The Process of Communication*. New York: Holt, Rinehart and Winston Inc.

Morrison, R., Wright, R.H. (1989). *ATC control and communications problems: An overview of recent ASRS data*. In R. S Jensen (Ed.) Proceedings of the Fifth International Symposium on Aviation Psychology (pp. 901-7). Columbus, OH: The Ohio State University.

Monan, Capt. William P. (1988). *Human Factors in Aviation Operations: The Hearback Problem*. NASA Contractor Report No. 177398.

Grayson, Ralph L.; Billings, Charles E. (1981). *Information Transfer between Air Traffic Control and Aircraft: Communication Problems in Flight Operations. In Information Transfer Problems in the Aviation System*. NASA Technical Paper 1875. Table, adapted from Grayson and Billings, was created by Prinzo and Britton

Reason, J. (1990). *Human Error*. New York: Cambridge University Press.