Organizational and Inter-Organizational Factors Affecting Aircraft Maintenance Safety in China: A Preliminary Study

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ORGANIZATIONAL AND INTER-ORGANIZATIONAL FACTORS AFFECTING AIRCRAFT MAINTENANCE SAFETY IN CHINA: A PRELIMINARY STUDY

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The main aim of this research was to explore the organizational and inter-organizational factors affecting aircraft maintenance safety. Specifically it is intended: (a) to probe the categories of organizational factors which effect maintenance safety through the study of an aircraft maintenance organization; and (b) to explore the interface between pilots and maintenance technicians, which is referred to as the information interface due to the exchange of the information between both parties for the safety of flight. The study consisted of 17 interviewees from one aircraft maintenance organization in China, who participated in structured one-on-one interviews. The data were coded using content analysis techniques which could convert the qualitative interview data into quantitative data. Four categories of factors were revealed, including individual and environment, factors relating to the technical systems, non-technical systems, information interface. Results of this research also show that compared to the pilots, the maintenance personnel were less strict with the departure standards for the aircraft (e.g. minimum equipment), which may lead to the conflict between pilots and maintenance personnel.

Introduction

Aircraft maintenance is a critical component of the overall system for ensuring safety in aviation (McDonald, Corrigan, Daly & Cromie, 2000). Mistakes by maintenance technicians contribute to quite a few percent of aviation accidents (O'hare, Wiggins, Batt & Morrison, 1994; cited in McDonald, Corrigan, Daly & Cromie, 2000). And thhe number of `maintenance concern' accidents had increased recent years (cited in McDonald, Corrigan, Daly & Cromie, 2000; cited in ICAO, 2003). In China, there is no specific statistic data describing the maintenance problems, but it still could be predicted that the number of aviation events will probably increase due to the rapid growth in civil aviation recent years. So the systematic theoretical exploration on maintenance safety is necessary and important.

The study on organizational factors

The organizational safety and accident causation model developed by James Reason can be considered a milestone of safety study in behavioral sciences (Reason, 1990). It illustrates how organizational and other human factors contribute to the breakdown of human performance in a system and thus adversely affect safety, which broke through the limit of human factors study taken individuals as source of problems.

After Reason, many experts began to explore the organizational factors with the term organizational errors. Summarized them, the organizational errors mentioned were included incomplete training, inadequate communication between pilots and controllers (Amalbeti, 1993); unhealthy safety culture(Wilpert, 1993); Management or organizational errors, incompatible management goal, failure in communication (Baram, 1993); decision making, communication, organizational structure, human-computer interaction, culture (Grabowski & Robert, 1998) ; lack of holistic thinking, lack of communication and supervision because of the application of FMS also were taken as the organizational factors (Wagenarr, 1993; Qvale, 1993; Helmreich, 1997). Most of the documents above were reviews, theoretical articles or results of case study.

Recently years, many researchers use the words "organizational factors" to study the factors affecting the safety. Most of them use the questionnaire methods, and research fields include civil aviation, petroleum industry et al (Hofman, 1994, Rundmo, 1998, Probst, 2004). And the results included: the commitment and involvement of supervisor and management to the safety, social support, the attitude of management and employees on the human factors, organizational structure, the role of regulation in the standard and training plan, change of technology and

organization, organizational culture, training and recruitment, safety climate, safety management system, risk management, urgent measures et al. Actually, different researchers use different term to express the same topic, organizational factors and organizational errors to study the effect of organizations on the safety of systems. To unify the term, our research will use organizational factors.

Another popular approach to study organizational factors is event/ incident/ accident analysis (Fahlbruch & Wilpert, 1997). This kind of hindsight method is easy to meet information collection difficulties and being blocked by blame, organizational politics and cover-up (Pidgeon & O'Leary, 2000). So what we concern is if there is a research method which could go around the disadvantage of questionnaires, during which the respondents could only answer the questions passively (not so many persons will answer the open-ended questions), and the difficulties of accidents investigation. One-on-one interview and content analysis technique which is a method to change the qualitative data into quantitative data was used in our study. This paper was the preliminary study results of our interview which focusing on the organizational factors affecting maintenance safety.

Method

Sample

A total of 17 maintenance technicians randomly selected from one maintenance company attended the interview, which including 13 advanced technicians (T2), 1 technician (T1), and 3 trainee-technicians (T0).

Interview questions

The research was designed semi-structure interviews. Questions included the individual and organizational demographic information used as warming up question; Factors promoting the safety of the organization and the whole flight system, especial the organizational factors; factors hindering safety; describing e a impressive successful or failed events during interviewee's work, and the last question was asked the technician's attitude to the attitude to the flight standards of differences.

Interview Procedure

After being admitted from the interviewee, the whole interview process was recorded with cassette recorder. And the sound file was converted to the transcript for the further analysis.

Coding procedure

The main procedures to analysis the interview data was as follows:

Coders selection. Three graduate students major in industry and organizational psychology were invited to join the coding work.

Coders training. All the three students had the coding work experiences and mastered the coding skills. They visited the fields and attended some of the interviews, which could help them know more of the aviation knowledge and understand the interview transcripts completely.

Establishing recoding book. At first, a researcher drafted a coding book according to the literatures and 5 randomly selected interview transcripts. The three coders reviewed it respectively and extracted relevant variables. Based on the four persons' discussions, they came up to the common opinions about the named variables, establishing the coding book. There were total 36 variables in the coding book which were showed in table 1.

Coding. Coders would code the data in accordance with two criteria, one is mentioned or not by the maintenance personnel. If the variable was mentioned, coded as 1, otherwise it is 0. The second criterion was the attitude or opinion of the maintenance personnel. The coders will assign values (negative as 1, neutral as 2 and positive as 3. 0) to different variables according to interviewees' expression.

The coders coded the transcripts respectively, and then discussed their code together, the process of which followed the majority principle, which meant at least two of the coders coded the same value to a particular transcript' particular variable, it would be the final value of the variable for this transcript except that the third coder could prove that his code was right.

Before the coding, the coders practiced one transcript, and the inter-rater reliability was calculated, if it's above .70, the code could be started. The coders would discuss the practiced result to get a high agreeable coding.

Results

Reliability analysis

The formula being used to calculate the inter-rater reliability raised by Winter(1992) is $R = 2 (n_{A \cap B})/(n_A + n_B)$, in which, A and B refers to either two of the

coders, and n_A, n_B are the numbers coded as mentioned *by coder A and coder B respectively*. In order to get the three coders' inter-rater reliability, either two of the coders' inter-rater reliability were calculated respectively, and then the function fisher and fisherinv were used to calculate the three coders' reliability. The value of inter-rater reliability is .77 in this study, which is acceptable.

Descriptive results. Table 1 showed the descriptive results about the variables mentioned or not by the interviewees. Table 2 demonstrated the interviewees' evaluation score.

Cluster analysis. Due to the limited numbers of interviewees, experts' subjective cluster analysis was used to replace the statistic cluster analysis. Similar to the coding process, the coders classified the 36 variables into different respectively according to their understanding to organizational factors respectively, then discussed and integrate their categories together. Actually, due to the former experience, it's easy for the coders to reach agreement on the number of categories, as well as the variables' distribution in different category.

According to the experts' opinion, the factors affecting the quality of maintenance and flight safety were classified into 4 factors. The first category was the factors relating to individual and environment, including physical environment, individual physical status, emotion, attitude to work, events during life, technical skill; the second category referred to the factors relating to the technical systems, including technical supervision system, quality supervision system, the system of T2 ' signature, technical appraisal to employee, technical training, clarity of responsibility et al; the third category was relating to the non-technical factors, including meeting system, system of human resource recruitment, salary and welfare, humanistic management, the variables relating to culture, such as team building, bad model leaders et al.; the fourth category was the factors relating to the information interface, including coordination between maintenance and flight crew, coordination between departments, coordination between the members within department, communication between the supervisor and subordinate, shift system et al, of which the second to the fourth categories are the organizational factors concerned by this research.

Inter-organizational factors affecting safety. The interviewees from pilots and maintenance staffs mentioned MEL (minimum equipment list) and this attitude variable is coded into two levels: At MEL and above MEL. The results are shown in table 3. The data of pilots were from the interviews with pilots.

Table 3. Attitude comparison between pilot and maintenance personnel

	MEL Over MEL	at MEL	Total	χ^2	Sig.
Pilots	16	2	18		
Maint. Person.	1	6	7	12.89	.001
Total	17	8	25		

The χ^2 analysis showed that the maintenance personnel's attitude to MEL was significant different from the pilots' which may lead to the conflict between them and affect the safety.

Table 1. Variables Mentioned by technician(n=17)

Variables	frequency	%
Working attitude	17	100
Technical system and rule	17	100
Signature regulation	17	100
Salary and welfare regulation	17	100
Administrative regulation	14	82.4
Technical training	14	82.4
Coordination between departments	13	76.5
Violation	13	76.5
Shift	12	70.6
the regulation of T2 ' signature and supervision	12	70.6
Penalty regulation	12	70.6
Implementation of regulation	12	70.6
Physical status	11	64.7
Emotion	11	64.7
Lack of human resource	11	64.7
Time pressure	10	58.8
Relationship with other jobs within department	10	58.8
Non-technical training	10	58.8
Individual technical skill	9	52.9
Clarity of responsibility	9	52.9
Tools and equipment	8	47.1
Supervision of quality department	7	41.7
Bad model leaders	7	41.2
Team building	7	41.2
Humanistic management	7	41.2
Effect of events in life	6	35.3
Coordination with pilots	6	35.3
Technical appraisal to employee	6	35.3
Individual career development	6	35.3
Conflict between rules and experience	6	35.3

Variables	frequency	%
Conflict between signature regulation and time pressure	6	35.3
Physical environment	5	29.4
Participation management	5	29.4
Experience feedback	5	29.4

Discussion

Variables interviewees concerned

As the results of table 1 shown, the factors maintenance personnel concerned were not only directly related to the safety, such as technique training, but also some factors relevant to the their personal interests, such as penalty system, Salary and welfare system et al., which may not have direct effects on safety, they do have some unavoidable effects on employees' psychological states and moods.

Table 2. Interviewee's evaluation scores (n=17)

Variable	Mean	S.D.
Administrative regulation	2.53	0.78
Technical system and rule	2.94	0.25
Supervision of quality department	2.50	0.71
Shift	1.88	0.64
the regulation of T2 ' signature and supervision	1.73	0.79
Penalty regulation	2.17	0.98
Tools and equipment	1.13	0.35
Time pressure	1.11	0.33
Signature system	1.87	0.64
Implementation of regulation	1.91	0.70
Relationship with other jobs within department	2.29	0.76
Coordination between departments	1.55	0.82
Salary and welfare regulation	1.41	0.62
Technical training	1.50	0.91
Non-technical training	1.43	0.79
Lack of human resource	1.00	0.00
Technical appraisal to employee	1.00	0.00
Bad model leaders	1.40	0.89
Individual career development	1.33	0.82
Team building	3.00	0.00
Clarity of responsibility	2.11	0.78
Participant management	1.80	1.10
Humanistic management	1.00	0.00

Comparison of technique systems, rules and administration rules

During the interviews with maintenance staffs, all the interviewees mentioned the technique systems and rules and gave high evaluation scores. Here, the technique systems and rules refer to the technical operation manuals. The main body of this kind of manuals came from the aircraft manufactures. The other variables related to the technique guard have lower evaluation scores, such as T2 signed and supervision system. The basic meaning of that system was as follows: the technicians having professional titles as T2 could assign their partial work to T1 and T0, and have the supervising responsibility to their work. After T1 and T0's work, T2 should sign working card to indicating they would take responsibility for it.

"I did stamp the seal, but I didn't do that work. I think I am bad luck" (----one T2 said)

In practice, it is indeed very hard to realize this regulation. First, 64.7% interviewees mentioned that the company didn't have sufficient human resources. They did not satisfy with the existed training system, although the technique training is the foundation of technique exams, professional promotions. Due to the limited human resources, the training chances decrease and so do the promotion's probability. As a result, there have fewer T2 technicians. So the non-technical factors could affect the technical factors to some extent.

Regulation and its implementation

How well that the regulations implemented was another factor maintenance personnel concerned. 70.6% of the interviewees mentioned it and the evaluation score to it was lower than neutral. A relevant variable is bad model leaders. The leaders' behavior would influence their subordinates' behaviors because leaders play the "model" roles. There were 41.2% maintenance staffs mentioned their leader's influences. Eastern people "holistic thinking" view proposed by Ji, Peng and Nisbett (2000) is supported here.

"If the leader obeys the rules, 80-90% of his subordinates will obey the rules also. If the leader doesn't, his subordinates will not do it also." (a maintenance personnel)

76.5% maintenance staff mentioned about the existence of the behaviors against the rules. This brought about a question how to guarantee the

regulation's implementation. There were 58.8% interviewees talking about the time pressure. In order to guarantee the plane to take off one time, they must finish the corresponding maintenance work before the deadline. This pressure or objective requirement provides the chances of breaking the rules. In addition, it was worth thinking about whether the regulation itself is reasonable or not. For example, "Sign working card" has only 1.87 points of evaluation. This rule was planned to prevent "mistake, forget, miss" etc human errors of technicians. But one maintenance person said:

"If I sign the working card at every step, I couldn't complete three working cards a day." "My work is continuous, but it would be interrupted by singing work cards." "I was checking a filter. My hands were really dirty. How could I sign the working card at that time?"

At the same time, in order to guarantee the taking off time of the plane, rushing through their jobs will happen. Furthermore, the clients (airlines) evaluate maintenance companies based on the on-time-rate of the planes. For the sake of this reason, maintenance companies might rush through their work.

Inter-organizational factors

The airlines use plane-take-off-on-time rate to assess maintenance. The maintenance staff has a trade-off between on-time and safety. But the flight should place safety at the first place. On the other hand, the maintenance staff's working attitude and their responsibilities should be considered as well. This conflict may lead to different attitude to the capability of the equipment. From the perspective of the airlines, how to find a more reasonable and more comprehensive evaluation index instead of plane-take-off-on-time rate should be further explored. For the maintenance companies, how to ensure the maintenance staff's working attitude and responsibilities besides their professional skills should be further considered.

Conclusions, limitations and implications

Basic conclusion

(1) According to the experts' clusters, three categories of organizational errors in the domain of the civil air system are obtained. They are technique-controlled factors, non-technique factors and information interface.

(2) The maintenance personnel and pilots have different standards towards MFL. The pilots have strict MFL than the maintenance staffs.

Limitation and implication

(1) The data used in this study came from semi-constructed interviews. Due to limited time and energies, the number of interviewees is relatively small.

(2) The clustered analysis did not provide the expected results. The experts' clusters have been influenced by experts' previous studies, basically, following the previous research's logic.

(3) The study just had a very rough exploration to the organizational factors affecting safety. The culture issues which were an important part of organizational factors have been mentioned but need further study too.

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