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Measuring Safety Culture to Promote Aviation Safety Culture

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Objective: The objective of this research is to study preceding literature on safety culture surveying tools and indicators used in aviation organizations to help the further understanding of aviation safety culture by presenting Korea-Safety Culture Survey Indicator (K-SCSI) as a relevant case.

Background: The aviation field puts a great deal of effort in preventive safety management through the application of Safety Management System (SMS), which was co-developed by international aviation organizations such as ICAO and FAA. To successfully operate safety management system, safety culture factors such as the organization member's level of consciousness, attitude and faith regarding safety must be put together. However, the aviation field currently lacks programs to promote safety culture and the exact understanding of some safety culture concepts.

Method: This research inquired into the definition of safety culture in the aviation field and the surveying tools used to measure it. It then described the development and application process of the Korea-Safety Culture Survey Indicator (K-SCSI) mainly focusing on case studies.

Results: In this research are presented safety culture promoting programs that can be applied to subordinate indicators of K-SCSI such as organization commitment, management involvement, rationality of reward system, employee empowerment and reporting system.

Conclusion: For a mature safety culture to settle successfully, it is essential that safety culture survey indicators are developed and applied in a way that fits the organization's features. Also, behavior measuring indicators are required to develop a more objective indicator and thus must be standardized.

Application: Cases that deal with the development and application of safety culture measuring tools within the aviation field can be studied and applied in other domains to spread safety culture.

Keywords: Safety Culture, Korea-Safety Culture Survey Indicator (K-SCSI), SMS, CASS, SCISMS

1. Introduction

Safety Culture, which was first used by INSAG (International Nuclear Safety Group) after the Chernobyl accident is an essential factor in promoting an organization's overall safety (EEC Note No. 11/06). Safety Culture was at that time defined as "That assembly of characteristics and attitudes in organizations and individuals which

establisheds that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance" (IAEA, 1991). Since then the term "Safety Culture" was mentioned in various accident reports (Piper Alpha, Railway Collision in the Clapham Juction Station, Air Ontario Aviation Accident in Dryden, the explosion of the Challenger and the Columbia etc.) and adopted in other domains, being defined slightly differently according to the domain's characteristics (Meshkati, 1997; CAIB, 2003).

The concept of safety culture in the aviation field can be well explained using HFACS (Human Factors Analysis and Classification System). HFACS is the application of the Swiss Cheese Model (Reason, 1990), a model that explains the accident incurring mechanism by human factors, to the aviation field accident analyzation and classification system. According to HFACS, accidents occur due to unsafe acts conducted by humans and underlying such unsafe acts is the combination of many potential hazard factors. And among such potential hazard factors, an organization's safety culture plays a crucial role. The results of recent accident investigations show that an organization's safety culture is an important factor of the accident regardless of domain (Oien, 2001). A case within the aviation field that adopted HFACS also shows that the fundamental reason for the accident is safety culture. Even in Flight Safety Occurrences in 2008 and 2009 HFACS analysis data, published by privately owned airlines, is reported that safety culture is an important factor of safety. "Inadequate supervision, Such as failure to provide proper guidance, inadequate inspection or monitoring, and inadequate supervision of training, is the most contributing causal factor and appears to be steadily increasing in frequency" (Lee, 2010). Thus, the fundamental solution to preventing accidents is related to dealing with organizational safety culture, which naturally brings to the conclusion the settlement of a mature safety culture (Kim, 2011).

Recently, the aviation field puts a great deal of effort in preventive safety management through the application of Safety Management System (SMS), which was initiatively developed by International Aviation Organizations such as ICAO (International Civil Aviation Organization) and FAA (Federal Aviation Administration) (ICAO, 2006, 2009, 2013; FAA, 2004). The successful execution of safety management system requires the combination of mature safety culture factors such as the members' awareness, attitude, confidence, enthusiasm. However, as is the case in other domains as well, the aviation field lacks safety culture promoting programs and the exact understanding on some safety culture concepts. Therefore, this research, by studying preceding literature on safety culture surveying tools and indicators used in aviation management organizations and providing relevant examples regarding K-SCSI (Korea-Safety Culture Survey Indicator), intends to help understanding and promoting aviation safety culture.

2. The Definition of Aviation Safety Culture and its Measuring Tools

The interaction of value and belief sharing systems intended to achieve the ultimate goal of the organization combined with the standards of behavior which is a rule within the organization forms an organizational culture. And factors such as the members' awareness of the necessity of safety and riskiness of each task and faith in the organization's accident preventive measures decide the organization's safety level and forms safety culture (Cooper, 2000). For a proper safety culture to take root within an organization and for organization members to be able to improve it, the measurement and evaluation of the current organization's safety culture must be done foremost. This is because safety culture measurement and evaluation give information about the forte and foibles of the organization and the results of it contribute to setting plans to promote safety activity (Wiegmann et al., 2002). There are many safety culture measuring methods such as the safety activity observation method, which directly observes insecure activities and safety management and the system inspection method, which measures safety culture indirectly by inspecting the safety management system, and the questionnaire method, which examines the members' awareness and consciousness by giving out questionnaires. However, since each of them has different characteristics and its own pros and cons, there is no standardized measuring method that can be applied universally across all fields (Partankar et al., 2012).

The nuclear field, which was the first to introduce the concept of safety culture classifies safety culture components into three levels. The first is policy level, in which is included safety policy, management structure, and self-regulation. The second is supervisor level, which includes clarifying responsibilities, safety practices, qualifications and training, prize and punishment, auditing and investigation.

The last is worker level, encompassing a questioning attitude, prudent approach and comminication etc (IAEA, 1991). It also suggests that the characteristics of safety culture are definite awareness of safeness, showing leadership and pointing out the responsibilities regarding safety, and finally constantly learning what safety is (IAEA GS-G-3.1, 2006). In the manufacturing industries, there is a detailed guideline published in UK, which is focused on how to measure safety culture. Namely, it is the "Health and Safety Executive Safety Climate Measurement User Guide and Tool Kit". The toolkit was required to provide a pragmatic approach for the measurement of safety culture in rail organizations. The HMRI (Her Majesty's Railway Inspectorate) requested that the approach should focus on a limited number of indicators that are known to influence safety culture. The five indicators are as follows: Leadership, Two-way communication, Employee involvement, Learning culture, Attitude towards blame (HSE, 2005).

It was not until the occurrence of accidents of Continental Express No. 2574, the explosion of Challenger and Columbia that safety culture was paid attention to as the cause of such accidents (CAIB, 2003). The aviation field defines "Safety Culture" as follows, referring to Reason (2000)'s definition. "The ability of individuals or organizations to deal with risks and hazards so as to avoid damage or losses and yet still achieve their goals". For a mature safety culture to settle, superintendents and managers should name it as the foremost objective of the organization and the CEO should regard it as the number one priority. If this way of thinking takes root as the organization's culture, an advisable and desirable safety culture is formed. In GAIN (Global Aviation Safety Network)'s Operator's Safety Handbook (2001) is provided an individual safety surveying tool consisting of 25 questions. They serve to measuring the safety culture of airline companies. This measuring tool measures the level of agreement/disagreement using a 5 point likert scale. The safety culture level of the surveyed airline company is evaluated according to how much it scores. Companies with scores over 93 are rated "Positive", those between 59 and 92 points are rated "Bureaucratic", and finally those that score between 25 and 58 points are rated "Poor". This classification evaluates and describes an organization's aviation safety culture level with a three-grade system; poor, bureaucratic, and positive (ICAO Doc 9859). The Poor Safety Culture defined by ICAO is a culture with numberless hazard factors that could lead to problems. Necessary information is buried, members are prone to avoiding responsibilities, dissatisfaction prevails, defects of the system is covered up, and finally new ideas are ignored. In a Bureaucratic Safety Culture, omens are overlooked, useful information is ignored and responsibility is divided uniformly considering the interrelationship. Defects of the system are improved partially, and new ideas are usually suggested only when problems occur. In Positive Safety Culture, hazard factors are prepared for in advance and information is sought actively while members share responsibility. Also, dissatisfaction of the members is alleviated and the defects of the system are investigated and taken care of while new ideas are always welcome. The ICAO Safety Management Manual (ICAO Doc 9859) and National Aviation Safety Program of Korea (MLIT, 2015) defines safety culture based upon Reason's 5 subordinate factors of a desirable safety culture; Informed Culture, Reporting Culture, Just Culture, Flexible Culture and Learning Culture (Reason 1997, 1998, 2000).

Safety culture measuring tools within the aviation field were mostly developed and applied according to the mission traits of the worker. Representative measuring tools for pilots and flight attendants include CASS (Commercial Aviation Safety Survey; Wiegmann, 2002), and FMAQ (Flight Management Attitude Questionnaire; Helmreich and Merritt, 1998). The CASS measuring tool, developed by Wiegmann et al. (2001), extracted 5 subordinate indices by exploring and meta-analyzing 107 research literature on aviation safety culture and is constituted of 86 questions that use the 7 point likert scale.

The 5 subordinate indices are as the following. The first is Organizational Commitment: The executives' attitude towards and consciousness regarding safety. The second is the Management Involvement of the executives: The participation rate of high and middle level executives. The third is the Reward System: Providing a consistent and fair judgment, prize and punishment. The forth is Employee Empowerment: Empowering employees to take responsibility for safety the encouragement of the organization. The last is Reporting System: Whether or not the personnel can report safety issues freely. Consisting of these five subordinate indices, CASS was finally developed after being verified for its credibility and validity by being experimented on pilots of 8 regularly operated airline companies. In Korea, CASS has been modified and developed into a tool fit for diagnosing regulatory and private specialized organizations and is used to measure domestic airline companies as well as being applied in controlling, maintenance areas (Lee,

2008) and pilot schools (Han and Kim, 2015).

The FMAQ is a tool developed to use as data for aviation safety by measuring several real-life safety culture threatening factors (organization culture, occupation culture, the way of thinking about human errors etc.) with the help of statistics. It aims to be used in establishing the education course of flight attendants, by measuring their altered attitude and culture in a objective and credible way. The FMAQ was being developed as CMAQ by Dr. Helmreich, a psychology professor of the University of Texas until it was modified into FMAQ (Helmreich et al., 1993) after emboding Hofstede's culture theory. The current FMAQ is adopted by numberless airline companies across the world after the gathering of 40,000 samples across the world and being updated into two versions, the International and USA/Anglo version, by Dr. Merritt (Merritt et al., 1996). The national airline of Korea is also participating in the FMAQ voluntarily. The FMAQ is divided into four parts. Part I is a recommendation and evaluation on the satisfaction rate, teamwork & cooperation, the overall management of headquarters from the corresponding airline's pilot's point of view. Part II is the attitude evaluation on performing aviation missions whereas Part III is the evaluation on leadership style. Part IV evaluates work goals and values. Lastly, Part V records demographical information such as gender, work years, number of years as pilot, type of aircraft, one's career record in the army and private sector, work position and duty, nationality and etc. as background information.

FMASS (Flight Management Attitudes & Safety Survey) an abridgement of FMAQ, records the satisfaction rate, level of teamwork & cooperation, management attitude towards safety and aviation missions, demographical information and also includes recommendations on how to promote aviation safety, navigation and training. The characteristic of FMAQ is that it measures the culture and attitude of members with a survey consisting of questions that has safety-related optimal responses to them. Also, normative data exist since the response data of airlines across the world were collected through worldwide research. It is possible to diagnose the strengths and weaknesses of the participating organization by comparing it with the normative data. Since the FMAQ is managed by LOSA (Line Operation Safety Audit) Collaborative, an organization certified by the FAA/ICAO, the performance predictability is verified as FMAQ/LOSA Linkage research results are well-supported and thus the results are credible.

The research on Euro-control controllers is as a measuring tool for controllers and controlling organizations (Gordon et al., 2007). The safety culture evaluating indices are made up of the following; 1. Priority of Safety, Safety Management Commitment, Responsibility for safety, Resources for safety, 2. Involvement in Safety, Involvement of ATCs (Air Traffic Controls) in safety, Management involvement in safety, Teaming for safety, 3. Learning from Safety, Reporting incidents, Communicating problems, Learning from incidents, Blame & error tolerance, Communication about system or procedure changes, Trust within an organisation, Real working practices and Regulator effectiveness.

Domestically, there is an application case that adjusted the subordinate indices of CASS to fit controllers and control towers (Kwak, 2010). Since controllers and controlling organizations are normally public servants or public organizations, the processes and results are usually bureaucratic. To be specific, asking members' opinions when a procedure or regulation is about to be amended or revised, supervisors taking care of things only after they are brought up, high level executives not taking part in activities directly related to safety and providing no rewards or incentives to reporting systems are among the examples. According to Park (2014), some controlling organizations are measured using the SCISMS (Safety Culture Indicator Scale Measurement System) diagnosing tool developed by the Human Factors Research Center of UIUC (University of Illinois at Urban Champaign), and also uses the system that measures the maturity and level of fulfillment of the safety management system provided by CANSO (Civil Air Navigation Services Organization). As a result, the controlling organization's safety culture is measured and the maturity and level of fulfillment of the SMS is checked (Terry and Alyssa, 2008; CANSO, 2015).

For research data on groundwork, engineers and maintenance organizations, the FAA repairmen related safety culture example which used the SCISMS diagnosing tool can be presented. The SCISMS contains the norms of Commercial Aviation Operations (e.g., FAR Part 121 & Part 135), FAR Part 91 & Part 91K Aviation Operations, Air Tour Operations (FAR Part 135), EMS Operations

(FAR Part 135/Part 91), Domestic, International and Foreign (to the US) Major Air Carriers, Passenger and Cargo Operations, Air Carrier Owned (US and non-US) Maintenance Facilities, MRO (Maintenance Repair and Operations) Facilities (FAR Part 145) and is used after being modified to fit the following fields of work: Flight Operations, Maintenance Operations, Ground Operations, Cabin Operations and Dispatch Operations. Asa (2006) developed and applied a evaluation criterion consisting of 102 questions of which have a 5 point scale by extracting 9 indices such as learning, reporting, justness, flexibility, communication, attitudes toward safety, safety-related behaviors, reisk perception and working situation in order to evaluate the groundwork of airline companies and the safety culture of air controllers and the shipping field. Domestically, 64 questions, derived from classifying the evaluation tool of Asa Ek, ICAO, IATA (International Air Transport Association) using Reason's 5 safety culture composing factors, was applied to measure the safety culture of engineers (Kim, 2014).

The US Air Force Safety Culture Assessment Program is a representative example of the military aviation field. Its characteristics are that it executes Online Safety Culture surveys and Organizational Safety Assessments (OSA) program (AFI 91-202, 2015). The Online Safety Culture surveys are web-based, provide immediate feedback and are run anonymously. Also, the Commanders and designers are only allowed limited access to the results. The OSA comprises in-person visit by human factors-led team and customized surveys and focus group. By adopting such Safety Culture Programs, the US Air Force was able to reduce mishaps by 29% (Neubauer, 2014).

3. Measuring Aviation Safety Culture and Comparative Analysis Cases

In this chapter will be introduced the cases and results in which the safety culture of the Republic of Korea Air Force, which had been assessed and processed periodically, was measured and analyzed. The ROKAF conducts on-line surveys as well as adopting the modified version of CASS, designed to fit the features of ROKAF, as a safety culture assessment tool (Kim, 2015). K-SCSI (Korea-Safety Culture Survey Indicator), a tool developed jointly with the Korean government, is an upgraded version of CASS to fit the Korean culture (Lee, 2008). ROKAF, similar to the OSA Program of the US Air Force, conducts safety culture diagnosing and field safety analysis in the form of safety consulting by sending special agents to fighter wings. Also, a compulsory professional safety education is provided every 2 years to squadrons. The education promotes safety culture by providing feedback on the activities performed during education. Among it are safety culture assessment and evaluation done in the form of off-line survey, focus interviews, role plays, and group activities.

3.1 Application to the aviation field

The K-SCSI was modified to fit ROKAF by referring to the Korea-Oriented CASS questionnaire (Lee, 2008). It is composed of 5 subordinate indicators and 58 questions, while 4 factors and 16 questions comprise the dependent variable that is affected by safety culture (Figure 1).

The K-SCSI collected data from 364 pilots using intranet based on-line survey for 4 weeks, from March 2010 to April 2010. In analyzing the gathered data was revealed that the overall level of safety culture, Organization Commitment (OC), Management Involvement (MI) and Reward System (RS) was normal, while the level of Employee Empowerment (EE) level was fairly favorable and that of Reporting System (RS) was poor (Figure 2).

The analysis results were again examined into details according to the subordinate indicators; organization, level, qualification. A comparative analysis with 8 private and US airlines was conducted (Figure 3).

The purpose of developing safety culture diagnosing tools within the aviation field is to figure out the future course of Air Force safety culture by objectively diagnosing the status quo among units and comparing it with the safety culture levels of private

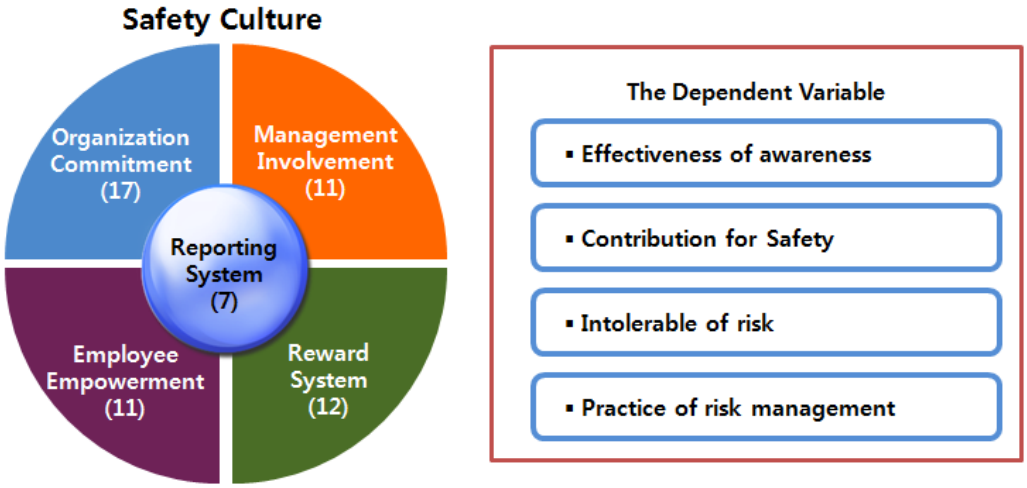


Figure 1. Subordinate indicators

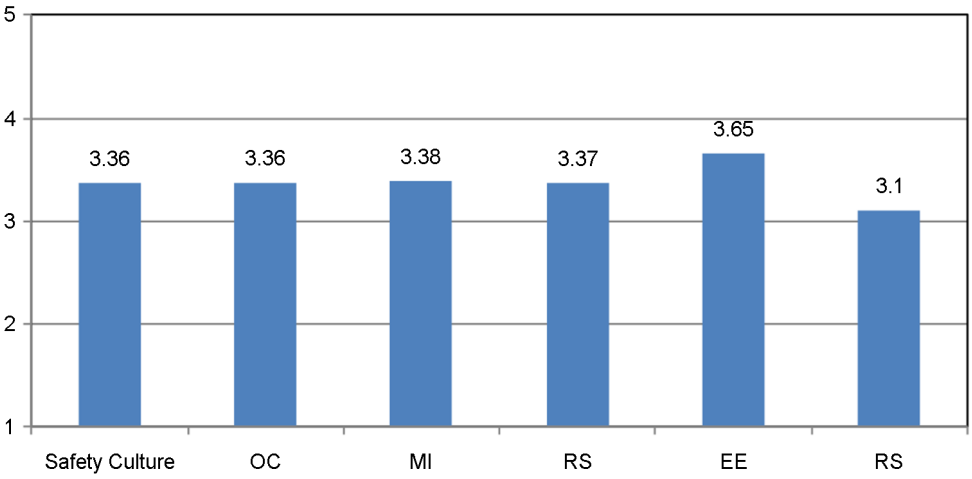
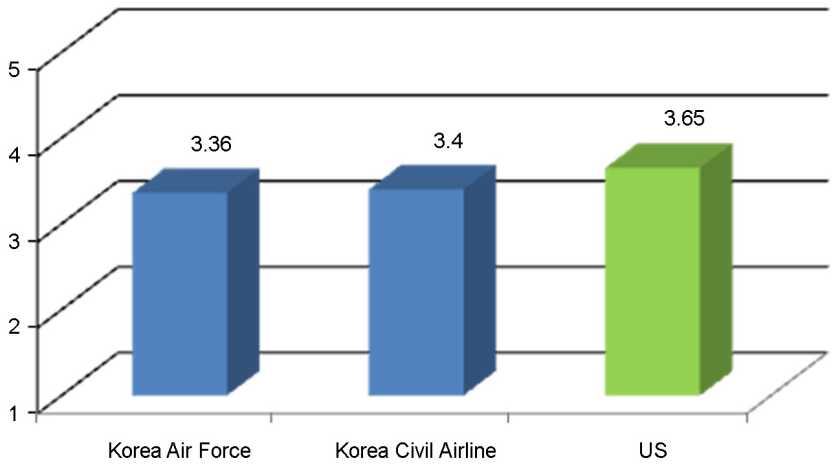


Figure 2. Results of the K-SCSI, 2010

airline companies. With K-SCSI, the relationship between safety culture and its dependent variables can be more closely examined while the way to improve Air Force safety culture level is searched for. The organization's overall level of safety culture and strengths and weaknesses were obtained by assessing the survey indicators and comparing it with other organizations. Since the aviation mission difficulty is higher in the army compared to the private sector, it is necessary to clearly state the procedures that should be followed in case of an emergency to provide pilots psychological comfort and readiness when on a mission. Also, since safety issues are not usually dealt with in meetings, efforts to point out the importance and value of addressing safety issues in meetings is demanded. To add on, due to mission specialty there is a tendency for army pilots to keep sticking to the mission because the burden imposed on the pilot in case of aborting it owing to external factors such as bad weather is relatively higher. It was thus possible to write a recommendation that could serve to prevent aviation accidents and improve the organization's safety level by actively taking complementary measures to fix the obstacles and problems existing within the reporting system and forming an organization culture that enables pilots to prudently suggest the necessity of aborting a mission in case of danger.



Korean Air Force N=364, Korean Civil Airline N=248

Figure 3. Comparative analysis on safety culture with other organizations

The developed safety culture diagnosing tool is assessed and used regularly by professional safety organizations and also gets feedback on the results of the 3 day unit-level compulsory safety education program which is scheduled every 2 years. The diagnosing tool was modified and developed in accordance with the participation rate. The K-SCSI (Korea-Safety Culture Survey Indicator, K-SCSI V2) which was remodified in 2014, took into account the Korea oriented CASS assessment questionnaire and combined it with the 2010 ROKAF safety culture assessment questionnaire. In addition to that, there was the safety inspection conducted by Regulator, the exclusion of aviation law related matter, selection of terms that are appropriate for the army, consideration on the possible response level of the ROKAF and remodification after a preliminary survey. As a result, it consists of 5 subordinate indicators and 8 questions. The Reliability of the modified questionnaire is mostly over 0.9, indicating that it is reliable. The modified questionnaire was distributed using an intranet based online survey from January 2014 to February 2014 for 4 weeks and a total of 228 pilots responded.

The results in 2014 show that most indicators with the exception of reward system have become more favorable compared to 2010 (Figure 4). Among the subordinate indicators of safety culture, there were 18 questions with over 0.5 point difference, indicating a 34% overall improvement. When looking at the correlation between the safety culture level and dependent variables, there was a negative correlation between safety culture level and the possibility of accident and a high positive correlation between safety culture level and faith in aviation safety (Table 1).

Table 1. The correlation between safety culture level and dependent variables

	Safety culture level	Organization commitment	Managing/ supervising system	Reward system	Member identification	Reporting system
Possibility of accident	-.523	-.584	-.528	-.221	-.528	-.469
Faith in aviation safety	.540	.546	.468	.261	.515	.463

Such improvement in safety culture level is thought to be the combined effect of applying the recommendation which was

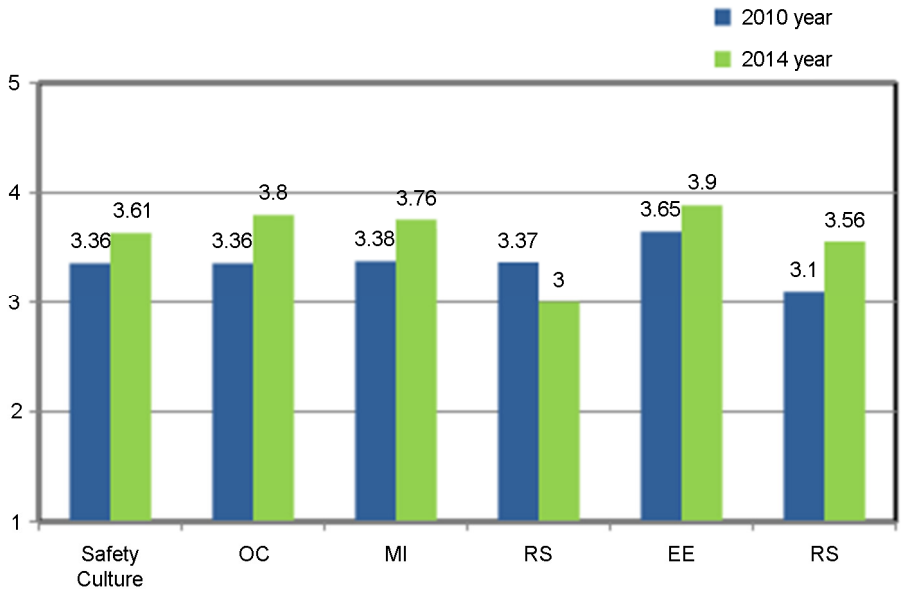


Figure 4. Safety culture comparative analysis

obtained as the result of safety culture research conducted since 2010, enlarging safety education, and finally improving safety policies and safety systems.

3.2 Application to the maintenance and groundwork field

ROKAF oriented safety culture survey indicator is applied to areas other than aviation. One example is the application to the maintenance area. The ROKAF maintenance area safety culture measuring indicators took into account the K-SCSI V2 and Korea-oriented CASS maintenance area measuring questionnaire, modifying them to fit ROKAF. It consists of 5 subordinate indicators with 53 questions. Also, the dependant variables that are affected by safety culture is composed of 3 questions related to perceiving accident possibility and 8 questions related to accident factors. The Reliability of the modified questionnaire is mostly over 0.9, making it reliable. the modified questionnaire was distributed using an intranet-based online survey for 4 weeks from Jan. 2014 to Feb. 2014 and a total of 565 engineers responded to it. The results of analysis on the collected data helps to establish safety measures by extracting strengths and weaknesses through comparative analysis with pilot groups, maintenance groups and engineer qualifications (Figure 5).

The next is application to the air defense missile area. The ROKAF ground level safety culture measuring indicators were a modification of K-SCSI V2. It is composed of 56 questions by adding 3 questions related to sharing safety reporting system, safety emphasis and practice, to the original 53 questions from 5 subordinate indicators. Among these questions, 5 questions deal with dependent variables affected by safety culture.

The Reliability of the modified questionnaire is mostly over 0.9, making the result reliable. The modified questionnaire was distributed using an intranet based on-line survey, during 8 weeks from May 2015 to July 2015 and a total of 287 ground level workers responded to it. The analysis result on the collected data helps to establish safety measures by extracting strengths & weaknesses through the detailed comparative analysis with ground level workgroups, other organizations and qualifications.

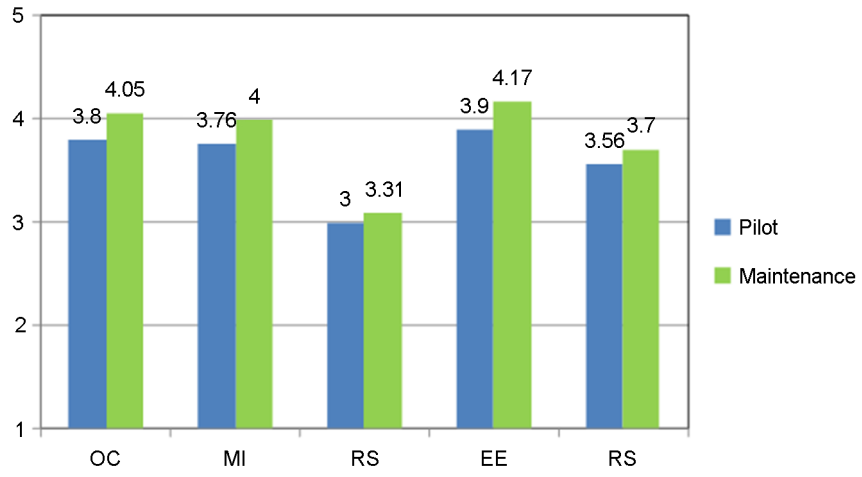


Figure 5. Comparative analysis on safety culture between organizations

4. Discussion and the Conclusion

Most organizations try to prevent accidents by developing SMS that is made up of safety policies, procedures and safety engineering techniques that suits the organization's characteristics. However, safety culture is essential apply a physical safety management system successfully. For a proper safety culture to settle, the organization members' consciousness on safety must be heightened while the current safety culture is evaluated with its weaknesses being complemented. In other words, continuous attention and interest must be given to safety culture. Since the voluntary participation of organization members is required to enhance the safety culture level, the organization should strive to form an organization culture that encourages members to participate voluntarily.

As was inquired in this paper, the biggest merit of using safety culture measuring and diagnosing tools with its related processes is that it promotes the entire personnel's understanding of safety culture. It is when the members' perception of safety culture is shifted from viewing it as simply the role and attitude of agents to regard safety importantly to understanding the fact that the concept and components that supports and sustains safety culture are complex that the direction to where the efforts to improve safety culture must be headed can be materialized. Such efforts to improve safety culture bring about the rise of safety culture index. Besides, the differences in the perception of safety culture among the superiors and inferiors can be dissolved by sharing one's level of understanding with the other through activities such as safety conferences and education.

SMS operation process is applied to all organizations of the aviation field for the enhancement of safety. K-SCSI includes basic safety culture attributes for SMS operations. It is necessary to review safety promoting programs for each subordinate indicators derived from the safety culture results diagnosed with K-SCSI. The first is on organization commitment, which is to modify the attitude that runs couunter to managing mission hazard factors. To reform the organization culture so that safety is not overlooked at as in demanding aviation even uder inclement weather for performance is an example. Such hazard managing activities necessitate the active controlling of unsafe activities, not wearing safety-ware, within the members' living environment and running safety programs that induce people to think that mission safety starts from everyday-life safety achieved through personal self-management. Safety culture stemming from trivial everyday-life safeness increases the predicting capabilities of aviation missions and procedures through a more scheduled aviation management and performing specific safety management procedures in facing contingencies or emergencies during the mission. A plan that can systematically support the safety related resources and personnel devoted to taking preventive measures is needed to improve organization commitment. The second is on management involvement. It is

demanded that safety is declared and clearly stated an important value of the organization, while also being addressed with the foremost priority in work-related meetings. For this to happen, management must play a central role, acknowledging the fact that they also are the main subjects of safety activities. In practice, safety declarations and policy books are being published in safety regulations and guidelines. While the responsibility and authority of senior management and safety managers are being made clear. Also, programs that aim to strengthen bilateral communication on the subject of safety and enhance communication index are currently being operated. The third is on reward system. The dangerousness of reward-punishment reversal phenomenon must be clearly acknowledged and immunity should be bestowed upon reporters if mistakes are reported. This becomes feasible once the organization members give credit to the safety investigation results. It requires an independently run safety investigation organization providing scientific, just and clear results. A credible investigation result clearly recognizes what the root and potential cause of the accident are and leads to executing an effective safety activity. For a system to be reasonable, a 'Just Culture', one that takes consistent and unswerving measures to accidents and incidents that occur due to hazard factors, must settle and mature within the organization. The forth is on employee empowerment. Employee participation must be guaranteed in establishing safety policies. Running public hearings and circulating the proceedings is also helpful. After safety policies are established, it is a necessary to have a preliminary period to correct problems. Listening to the voice of field workers is of high importance when making decisions regarding safety. The last one is on reporting system. Studying and discussing methods to improve safety problems or hazard factors is considered to be negative and must be reformed. The situation in which members avoid reporting potential accident triggering factors for fear of getting disadvantage or making propositions that demand a lot of budget, time and staff must be improved. Also, rewards and incentives must be given to members who strive to activate the reporting system.

In Korea, how to incorporate the concept of safety culture in safety promotion programs is described in the National Aviation Safety Program as the following. Firstly, safety culture is an indicator of organization culture and group consciousness that allows the checking of how responsibility is given out to individuals and how the organization acts since safety culture defines how safety is recognized and values and priorities are placed within the organization. Secondly, an aviation organization must establish a system that assesses and manages safety culture for the purpose of measuring the organization's safety level and improving it. Thirdly, safety culture data of an aviation organization must not be used for the purpose of safety supervision and used solely for judging whether management systems are run normally or the voluntary measuring of safety culture levels. Lastly, it must be checked if objectivity and fairness is ensured in the aviation organization's safety culture management system when it is under safety supervision.

Measuring and diagnosing safety culture can bring about some promising safety effects. By disseminating diagnosis results, organization members are given a chance to reflect on their job attitude. Besides, it enables the organization to figure out its position among competing and related organizations regarding its safety culture level. It can also provide the baseline for making activities and references required for strengthening the "culture" aspect of safety by gathering long-term data on the members' attitude change. It other words, it is possible to give statistically processed management feedbacks such as CRM (Crew Resource Management) training effects and the quality of safety policies on safety programs and heighten the effectiveness.

In the above was inquired the definition of safety culture in the aviation field and relevant cases. For a more mature safety culture to settle, strenuous efforts to modify and complement the indicators of safety culture diagnosing tools to have a satisfiable level of objectiveness and to develop and apply the indicators to fit the corresponding organization is essential. Behavior observation indicators are also required to develop a more objective indicator and need to be standardized. This study describes the current status of aviation safety measurement. For the measurement and analysis of the field application of safety culture measurement tool, a thorough review and discussion of the detailed gap analysis (change, promotion, reinforcement, etc.) of the indicators related to safety culture is considered to be required.

References

AFI 91-202, the US Air force Mishap Prevention Program, 2015.

Asa, E.K., Safety Culture in Sea and Aviation Transport, Ph.d. Thesis, Lund University, Sweden, 2006.

CAIB, Report of The Columbia Accident Investigation Board, Vol. 1, Retrieved from <http://caib.nasa.gov/news/report/volume1/default.html>, 2003.

CANSO, Report on the status of the Safety Culture Network, CANSO Global ATM Safety Conference, 2015.

Cooper, M.D., Towards a model of safety culture. *Safety Science*, 36(2), 111-136, 2000.

FAA, Safety Management System Manual, Version 1.1, The US Federal Aviation Administration, 2004.

GAIN, Operator's Flight Safety Handbook, Appendix D: Safety Surveys & Audits, Issue 2, Working Group A, 2001.

Gordon, R., Kirwan, B. and Perrin, E., Measuring Safety Culture in a research and development center; a comparison of two methods in the Air Traffic Domain, *Safety Science*, 45, 669-695, 2007.

Han, K.G. and Kim, Y.S., A Study on the Safety Culture Index Measurement of Pilot Training School, *The Korean Society for Aviation and Aeronautics Fall conference*, 127-132, 2015.

Helmreich, R.L. and Merritt, A.C., Organizational culture. In R. L. Helmreich & A. C. Merritt (Eds.), *Culture at work in aviation and medicine* (pp. 107-174). Brookfield, VT: Ashgate. 1998.

Helmreich, R.L., Merritt, A.C., Sherman, P.J., Gregorich, S. and Wiener, E., The Flight Management Attitude Questionnaire, Tech. Per. No-93-4, Austin, Texas: The University of Texas Aerospace Crew Research Project, 1993.

HSE - Health & Safety Executive, A review of Safety Culture and Safety Climate literature for the development of the safety culture inspection toolkit, Research Report 367, Human Engineering Ltd., 2005.

IAEA, IAEA Safety Standards Series No. GS-G-3.1, Application of Management System for Facilities and Activities, 2006.

IAEA, Safety Culture, Safety Series 75-INSAG-4, 1991.

ICAO, Safety Management Manual, Doc 9859, First Edition, International Civil Aviation Organization, 2006.

ICAO, Safety Management Manual, Doc 9859, Second Edition, International Civil Aviation Organization, 2009.

ICAO, Safety Management Manual, Doc 9859, Third Edition, International Civil Aviation Organization, 2013.

Kim, C.Y., A Study on Learning Culture for the Safety Promotion in Aviation Maintenance, *Journal of Korean Society for Aeronautical Science and Flight Operation*, 22(1), 124-129, 2014.

Kim, D.H., Effect and Development Direction of Aviation Organization Against Human Errors, *Journal of the Ergonomics Society of Korea*, 30(1), 29-39, 2011.

Kim, D.H., An Review of Korean Airforce Aviation Safety Culture Considering the Organization and Generation Cultural Characteristics, *proceeding of spring conference for Korean Academy of Aerospace Human Factors*, 2015.

Kwak, S.M., The Introduction of Safety Culture Measurement method in the Air Traffic Control, *proceeding of 12th Aviation Safety Seminar*, 2010.

Lee, W.K., Flight Safety Occurrence Review Using the Human Factors Causal Analysis Tool (HFACS) (2008~2009), *SkySafety 21*, 105, 31-41, 2010.

Lee, K.J., A study on the development for an Aviation Safety Culture index and Application, Transportation Safety Research Report, 2008.

Manoj S. Partankar, et al., Safety Culture, Ashgate, 2012.

Merritt, A.C., Helmreich, R.L., Wilhelm, J.A. and Sherman, P.J., The Flight Management Attitude Questionnaire 2.0 (International) and 2.1 (USA/Anglo), Tech. Per. No-96-4, Austin, Texas: The University of Texas Aerospace Crew Research Project, 1996.

Meshkati, N., Human Performance, Organizational Factors and Safety Culture, *Paper presented on National Summit by NTSB on transportation safety*, Washington, D. C. 1997.

MLIT, KOREA Aviation Safety Program: State (National) Aviation Safety Program, Ministry of Land, Infrastructure and Transport Notice 2015-138, 2015.

Neubauer, G.K., USAF Aviation Safety Strategies, *Asia Pacific Aviation Safety Conference*, 2014.

Oien, K., A Framework for the Establishment of Organizational Risk Indicators, *Reliability Engineering and System Safety*, 74(2), 147-167, 2001.

Park, H.W., The Ways of promoting a safety culture of Air Traffic Control by Safety Management System, *proceeding of spring conference for Korean Academy of Aerospace Human Factors*, 2014.

Reason, J., Achieving a safe culture: theory and practice, *Work and Stress*, 12(3), 293-306, 1998.

Reason, J., *Human error*. Cambridge: Cambridge University Press. 1990.

Reason, J., Managing the Risks of Organizational Accidents. Ashgate, 1997.

Reason, J., Safety paradoxes and safety culture. Journal of Injury Control and Safety Promotion 7, 3-14, 2000.

Terry L. von Thaden and Alyssa M. Gibbons, The Safety Culture Indicator Scale Measurement System (SCISMS), Technical Report HFD-08-03/FAA-08-02, 2008.

Wiegmann, D.A., Zhang, H., Thaden, T., Sharma, G. and Mitchell, A., A Synthesis of Safety Culture and Safety Climate Research. Technical Report ARL-02-3/FAA-0202, 2002.

Wiegmann, D.A., Zhang, H. and von Thaden, T.L., Defining and assessing safety culture in high reliability systems: an annotated bibliography. *University of Illinois Aviation Research Lab Technical Report ARL-01-12/FAA-01-4.* 2001.

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