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Analysis between Aircraft Cockpit Automation and Human Error Related Accident Cases

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Abstract

Cockpit automation was developed with the purpose to enhance aviation safety and efficiency in aircraft operation by reducing pilot workload. However, automation has been recognized as a significant factor of sizable aircraft accidents. The present article analyzed 94 cockpit automation accident cases from Flight Deck Automation Issues.

According to the present analysis, rule-based errors caused automation accidents most frequently, followed by slip among other factors of unsafe acts. Under factors of precondition unsafe acts, technological environment caused automation accidents most frequently. Furthermore, training related matters such as local training issues/programs were considered as significant causes under unsafe supervision. Under organization influences, a difference in culture has had considerable influence on the occurrence of accidents related to automation.

To minimize the number of automation-related accidents, this study provides four recommendations on the basis of analysis. First of all, excessive automation dependency must be reduced. Secondly, proper understanding of the automation technology is required. Thirdly, as the current standardized education system is not designed to actively cope with cockpit automation, it is urgent to introduce a new concentrated training system such as AOP or ATOP, by analyzing individual weaknesses. Last but not least, minimization of cockpit automation-related accident requires us to properly understand various cultures and cultural differences.

Keywords*: Human Error, Pilot, Cockpit Automation, HFACS, Human Machine Interface*

1. Introduction

Although the aviation industry was initially pursuing cockpit automation in order to improve aviation safety, reduce the workload of pilots, and to increase aircraft operational efficiency, aircraft automation has become paradoxically one of the main causes of catastrophic accidents. The accident of Asiana Airlines Flight 214 on July 7, 2013 caused hull loss to an aircraft and left three passengers dead. An investigation report published by the National Transport Safety Board of the United States of America (hereinafter 'NTSB') pointed out excessive trust in and reliance of pilots on the aircraft automation system on board, as a significant cause of this accident.

What necessitates research concerning the significance of cockpit automation and how or if it enhances aviation safety is the number of fatalities. For instance, accidents that occur during the landing phase are typically linked to a bigger number of fatalities compared to ones that occur during other phases of the operation. Accidents involving an automation system also typically occur during the landing

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phase. This means that accidents involving an automation system on board have caused a number of fatalities. Also, as most automation-related accidents occur due to human error, detailed analysis on the types of error is required to minimize the number of accidents.

Because of these reasons, this research reviewed cockpit automation and analyzed automation related accidents using the Human Factor Analysis and Classification System (hereinafter the 'HFACS'). The HFACS classifies accidents using causes, such as unsafe acts, preconditions for unsafe acts, unsafe supervision and organizational influence.

2. Analysis

2.1. Aviation Accident Worldwide Trend

Worldwide, the number of accidents has decreased. However, the magnitude of these accidents has increased and pilot error-related accidents occur continuously. Boeing's '*Statistic Summary of Commercial Jet Airplane Accidents Worldwide Operations'* established that between 1959 and 2016, 1345 accident cases occurred due to Loss of Control-In Flight while another 1156 accident cases occurred due to controlled flight into or towards terrain and runway excursion (taking off or landing). This demonstrates that 45% of the total number of accidents were caused without any technical problems within an aircraft itself and most of these occurred due to pilot error.[1]

A cockpit automation system, which was developed for the purpose of enhancing aviation safety and decreasing the workload of pilots, has increasingly become the cause of accidents. As the improper use of the system frequently leads to accidents despite the purpose of its development, the aviation industry needs to pay more attention to accidents linked to automation. Therefore, proper attention should be given to the proper use of aircraft automation, in order not to trigger results that are contrary to its purpose.

Figure 1. Fatalities by CICTT Aviation Occurrence Categories

A summary of recent accidents involving the incorrect use of an automation system is as follows;

- B777-200 Asiana Airlines in San Francisco (2013): The pilot had approached with lower visual approach altitude than intended, relying on the automation system, which was not properly working at that moment.

- A340-300 Air France in Paris CDG (2012): While approaching Cat3 at Paris CDG, due to a problem with the automation system, false ILS GS had been connected and this created uncontrollable situations. Also, this led to confusion among crew members.
- A320 Air France in Tel Aviv (2012): While approaching the airport, a flight crew had used an automation device incorrectly, due to a lack of awareness and improper understanding of important matters related to automation systems usage.
- B737-800 Turkish Airlines in Amsterdam (2009): The flight crew members did not realize that autothrottle was abnormally applied while approaching. After a while, pilots realized the situation and tried to recover the condition but they did not succeed.

In other automation-related accidents as well, the primary cause is the flight crew's lack of understanding of automation systems and failures in synchronization of the automated processes with the pilots' control over the system. Therefore, these factors should be studied more in depth in accident cases concerning an automation system.

2.2. Aircraft Automation and Accidents

Cockpit automation studies require the understanding of the philosophy of the automation. Boeing and Airbus shared their automation philosophy. [2]

Boeing's philosophy is as follows;

- Pilots are the final decision makers of the aircraft operation.
- Both crew members in the cockpit are ultimately responsible for the safe conduct of the flight.
- Flight crew tasks, in order of priority, are; safety, passenger comfort, and efficiency.
- Design for crew operations based on pilot's past training and operational experience
- Use new technologies and functional capabilities only when; a) they result in clear and distinct operational or efficiency advantages, and b) there is no adverse effect to the human-machine interface

Meanwhile, Airbus' philosophy is as follows;

- Automation must not reduce overall aircraft reliability; it should enhance aircraft and systems safety, efficiency and economy
- Automation must not lead the aircraft out of the safe flight envelope to its full extent, should this be necessary due to extraordinary circumstances.
- Automation should allow the operator to use the safe flight envelope to its full extent, should this be necessary due to extraordinary circumstances.
- Within the normal flight envelope, the automation must not work against operator inputs, except when absolutely necessary for safety.

Both manufacturers insisted on a few points; 1) automation shall be applied in a normal operational situation 2) it shall remain the safe flight envelope, 3) the pilot is the final authority for the operation. While these points do not particularly mean that the pilots' final discretion may create an error, they mention the possibility that human error may occur and that, therefore, there will be a solution. [3]

Despite the fact that numerous types of automation-related accidents have happened, there have not been many studies regarding this issue. Richard Batt from the Australian Transport Safety Bureau has reported that 20% of 76 serious incidents, which occurred during the approach and landing phase of aircraft operation between 1984 to 1997, were caused by the usage and management error of the auto piloting system. [4] Accident investigators Bruseberg, Johnson, Endsley, Strauch, and Hourizi, have also mentioned the danger of cockpit automation accidents. [5]

Furthermore, according to an analysis of 34 aircraft accident investigation reports concerning automation on the Flight Deck Automation Issues (hereinafter 'FDAI') database, the NTSB's expert investigation, information distributed in media, and other opinions identified that more than one factor out of 20 different automation issues have contributed to the occurrence of an automation-related accident. Further reviews reveal that 11 out of 31 investigation reports show a similar trend. [6]

A group of professionals in the United States of America (hereinafter the 'U.S.') pointed out that commercial aircraft pilots routinely operate an automated jet aircraft managing a complex flight route, but situations which increase task complexity and working loads happen. For instance, when a change of flight route is requested due to traffic, it requires the pilots to correct clearance or vectoring in case of a complex instrument flight wherein the pilots have to abruptly change the data already saved in an automation system or change the plan manually. This increases pilot workload.

At the end of 2013, the Flight Deck Automation Working Group has published recommendations on such problems and other related potential safety issues. This Group also insisted that aircraft pilots are losing their capabilities to manually operate an aircraft because automated manual flight operation skills encroach their manual operation skills. As discussed above, while cockpit automation has various advantages, it also creates a dependence on automation, leading to human errors in exceptional situations.

In this case, while enhanced training solves the problem partially, the key solution lies in the optimal development of automation to support the pilots better. This means that rather than simply supporting perfect automation, another automation design philosophy pursuing a cooperative human-machine interface is required.

As explained above, automation in an aircraft has various advantages. However, studies tell us that it causes various problems such as operational human error, dependency on the system and human error caused by sudden events.

2.3. Human Factor Analysis Classification System

The HFACS, used in this research, has been developed on the basis of the Swiss Cheese model of James Reason. He suggested in the Swiss Cheese model that errors happen out of unsafe acts, preconditions for unsafe acts, unsafe supervision and organizational influence. Shappel and Wiegmann have developed the HFACS by borrowing details and amendments of this Swiss Cheese model. Then, they used the HFACS to analyze aircraft accidents of the U.S. Navy and Marine Corps and through empirical analysis, they discovered four main levels and causal categories within each level, as shown in Figure 2.

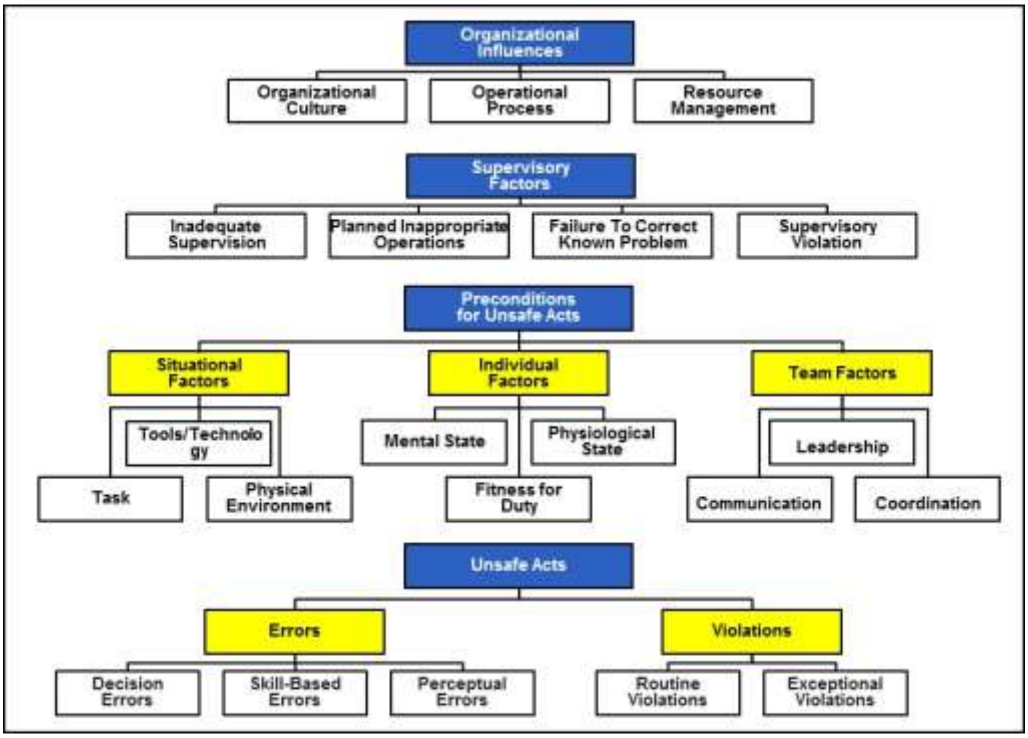

Figure 2. Human Factors Analysis and Classification System [7]

This research chose the HFACS to analyze accident cases because this model includes recently studied and reported human error. Especially, this model divides unsafe acts clearly into errors and violations. Errors are further divided into judgement, technical and awareness parts concerning the background of an occurrence. Violations are further divided into ordinary violation including intentions of a person and exceptional violation including inevitable circumstances.

Furthermore, the HFACS categorizes all automation-related errors and systematically divides them into four categories which allow us to review their interactions and causality. In other words, this classification model eases not only the classification of automation accidents but also provides the systematic approach to decrease accidents.

Another reason that this research chose the HFACS is that it pays attention to fundamental factors such as the role of supervisors and organizational influence. These factors have been typically ignored by research on human error in the past. Since these factors are fundamental in relation to cockpit automation, this study has chosen this system as a tool for analysis.

2.4. Case Study: Aircraft Automation Accident

2.4.1. Case Analysis: Asiana Airlines

According to Wiener and Curry's technical report published in 1980, very specific and common problems with the use of automated devices are failure of automatic equipment, automation induced error compounded by crew error, crew error in equipment setup, crew response to a false alarm, failure to heed automatic alarm, failure to monitor and loss of proficiency. [8] To tackle these causes, they highlighted the acquisition and retention of skills, know-how for monitoring of complex systems, appropriate action towards alerting and warning systems, and research on psychosocial aspects of automation.

Asiana Airlines' accident happened also due to the pilots' excessive automation reliance without proper understanding of the automation system. It was found that the pilot flying disconnected the autopilot and moved the thrust levers to idle, which caused the autothrottle to change to the hold mode. On this mode, autothrottle does not control airspeed. Afterwards, the pilots inadequately monitored the airspeed and altitude.

Probable causes and contributing factors are as stated below;

Table 1. Probable Causes and Contributory Factors of the Asiana Airlines Accident

Probable Cause	. the flight crew's mismanagement of the airplane's descent during the visual approach . the flying pilot's unintended deactivation of automatic airspeed control . the flight crew's inadequate monitoring of airspeed . the flight crew's delayed execution of a go-around
Contributory Factor	. the complexities of the autothrottle and autopilot flight director systems that were inadequately described in Boeing's documentation and Asiana's pilot training . the flight crew's nonstandard communication and coordination regarding the use of the autothrottle and autopilot flight director systems; . the pilot flying's inadequate training on the planning and executing of visual approaches . the pilot monitoring/instructor pilot's inadequate supervision of the pilot flying .flight crew fatigue which likely degraded their performance

2.4.2. Similar Cases to Asiana Airlines Accident

FDAI has presented three similar cases related to the autothrottle. [9]

- **Runway Excursion accident of MD-83, Kajaani Airport, Finland (1994):** Air Liberte Tunisie F-GHED aircraft DC-9-83(MD-83) slideslipped off the runway while landing at Kajaani airport in Finland. The captain did not realize that the autothrottle was engaged during go-around and unintentionally pushed TOGA switches.
- **Runway Excursion accident of Air France Flight 072, B747-400, Tahiti Faa'a Airport, French Polynesia (1993):** Air France Flight 072 overran the runway and fell into a lagoon due to inappropriate use of the autothrottle. Since this accident various developments on procedures and technologies have been made.
- **Runway Excursion accident of World Airways Flight 30H (1982):** World Airways Flight 30H has landed at the point where it is 2,500ft away from the edge of the runway. This accident was caused due to mismanagement of the autothrottle during the landing phase.

2.5. Automation Related Human Error Analysis

2.5.1. FDAI Automation Related Human Error Types

The database of FDAI contains 34 aircraft accidents, 8 Aviation Safety Reporting System incidents, and 63 research reports as on 20 November 2013. This research has reported 94 potential issues from the above database. The analysis result is categorized per frequency as shown on Table 2 below.

According to these reports, excessive dependence and blind trust on an automation system has been recorded as the most frequent cause of potential automation accidents.

Table 2. FDAI Automation Human Error Types

Issue Contents	Frequency
understanding of automation may be inadequate	6
pilots may over-rely on automation	5
pilots may be overconfident in automation	5
situation awareness may be reduced	4
automation may not work well under unusual conditions	4
pilots may be out of the loop	3
displays (visual and aural) may be poorly designed	3
mode awareness may be lacking	3
automation may demand attention	3
training may be inadequate	3
mode selection may be incorrect	3
controls of automation may be poorly designed	2
vertical profile visualization may be difficult	2
manual skills may be lost	2
behavior of automation may not be apparent	2
insufficient information may be displayed	2
inter-pilot communication may be reduced	2
protections may be lost though pilots continue to rely on them	1
interface may be poorly designed	1
automation may be too complex	1
pilots may lack confidence in automation	1
manual operation may be difficult after transition from automated control	1
cross checking may be difficult	1
automation may lack reasonable functionality	1
database may be erroneous or incomplete	1
automation information in manuals may be inadequate	1
crew assignment maybe inappropriate	1
pilots may under-rely on automation	1
cultural differences may not be considered	1
company automation policies and procedures may be inappropriate or inadequate	1

2.5.2. Aircraft Automation Accident Case Study of Beth Lyall

Similar to what had happened with Asiana Airlines in 2013, excessive dependence on an aircraft automation system may play a significant role in the decreasing situational awareness and coping mechanism of pilots in case of sudden outbreaks. In order to analyze the impact of such a new cause, this research reviewed an existing study of Beth Lyall, which focused on the FDAI database. Lyall analyzed ten aircraft accidents that are related to an automation system and human factors from the FDAI database to classify the results as shown in Table 3.

According to the analysis, the most common human error type in these ten accidents is insufficient understanding of the aircraft automation system. [10].

Table 3. Human Error Occurrence Frequency per type (Lyall)

Types	Frequency
Lack of understanding of the system	5
Improper performance of an automation device in an abnormal situation	4
Inappropriate design in visual/audio device	3
Inappropriate choice of pilots (in a mode selection)	3
Situation awareness of pilots	3
Lack of awareness in selection of a mode	3
Lack of information	2
Inappropriate habit in the use of an automation system	2
Insufficient design in a control panel of an automation device	2

2.5.3. HFACS and Automation Related Human Error

This research does not analyze cases using the categorizations of Lyall and of FDAI. One characteristic of the classification of Lyall and FDAI with regards to the accidents related to automation is that it is an ad-hoc and incomplete classification. Factors are classified based on the frequency of the occurrences. This means that if an event has occurred because of a new factor that has not been defined, for instance, the table will require revision afterwards. Therefore, this research does not particularly use the classifications of Lyall and FDAI for analysis.

YounChul Choi and others have suggested a new standard for classification of errors. This standard is developed based on the presence of intention.[11] Following such research, this study has added detailed categories into the existing HFACS in order to clearly, practically and empirically analyze and categorize human error related to automation. The added details are shown in Table 4 below. In the group, each factor has been given a code. For organization influence 'O' is given. For supervisor, 'S', for preconditions, 'P' and for unsafe acts, 'A' was given. A code number is given to each item in Level 3 by 10's (110, 210, 310). For Level 4, code numbers are given to each sub-category by a single number(111, 211, 311). Such codes and numbers are given in order to establish an efficient structure for analysis, but do not have any specific numeric meanings.

Table 5. New HFACS for Automation Related Human Error Analysis/Categorization

Level 1	Level 2	Level 3
O. Organizational influences	O100. Resource management	O110. Maintenance resources
		O120. Field resources
		O130. Operator support
		O140. Acquisition resources
		O150. Informational resources/support
		O160. Tool availability
		O170. Equipment availability

	O200. Organizational culture	O210. Strong safety culture
		O220. Employee evaluation process and promotion concerns/potential
		O230. Perception of equipment
		O240. Perception of company
		O250. Perception of owner
		O260. Perception of supervisor
		O270. Harmony or disruption within the work unit
		O280. Different culture
	O300. Operational process	O310. Operations tempo/workload
		O320. Procedural guidance
		O330. Program management
		O340. Program oversight
		O350. Program and policy risk assessment
		O360. Policy makers in touch
S. Unsafe supervision	S100. Inadequate supervision	S110. Supervision oversight inadequate
		S120. Local training issues/programs
		S130. Supervision policy
		S140. Supervision-personality conflict
		S150. Supervision-lack of feedback
		S160. Supervision-modeling from previous exposure and experience
	S200. Planned inappropriate operations	S210. Ordered or mislead beyond capability
		S220. Crew/Team make up and composition
		S230. Limited experience
		S240. Lacking proficiency
		S250. Authorized unnecessary hazard
	S300. Failure to correct a known problem	S310. Personnel management
		S320. Operations management
	S400. Supervisory violations	S410. Supervision-lacking disciplinary enforcement
		S420. Supervision-making policy on the run
		S430. Directed the violation
P. **Pre-condition**	P100. Environment	P110. Technological environment
		P120. Physical environment
	P200. States of operator	P210. Physical/Mental states
		P220. Adverse mental states
		P230. Adverse physiological states
	P300. Personal factor	P310. Crew resource management
		P320. Self imposed stress

Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
A. Unsafe acts	A100. Skill-based	A110. Slip	A111. Attention failures	Instruction, omission, reversal,

	errors			misordering, mistiming
		A120. Lapse	A121. Memory failures	Omitting planned items, place-losing, forgetting intentions
	A200. Decision errors	A210. Mistake	A211. Rule-based mistake	Misapplication of good rule, Application of bad rule
			A212. Knowledge-based mistake	Many variable forms
	A300. Perceptual errors	A310. Perceptual error	A311. Error due to misperception	
	A400. Violation	A410. Violation	A411. Routine violations	
			A412. Exceptional violation	
			A413. Acts of sabotage	

2.5.4. FDAI Source Analysis using the HFACS

In order to analyze automation-related human factors in a systematical order, this research reviewed 94 FDAI, and the results are as follows.

- **Unsafe acts (A: Action):** As shown in Figure 3, *rule-based error* happens most frequently, with *slip* coming in second and the others – *lapse* and *knowledge-based mistake*, less frequently. As rule based errors are typically made by skilled persons, it is possible to conclude that this error is highly related to excessive dependence and trust on automation.

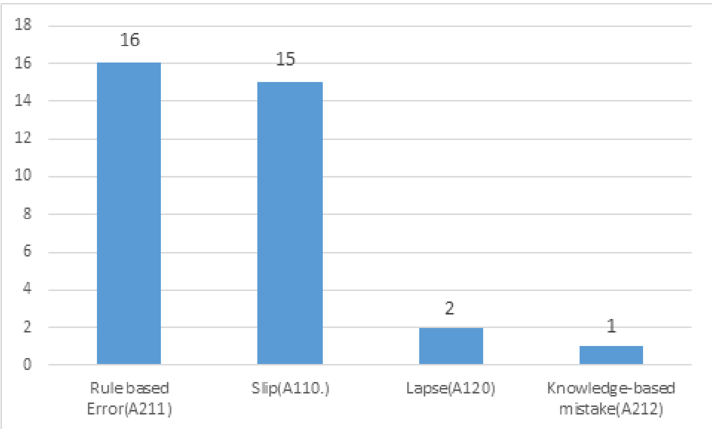

Figure 3. Frequency of the Occurrence of Unsafe Acts (A)

- **Preconditions for unsafe acts (P):** *Technological environment* (P110) is the most frequent factor among others in preconditions for unsafe acts as shown in Figure 4. This factor is related to design errors of an automation system or limits of automation systems.

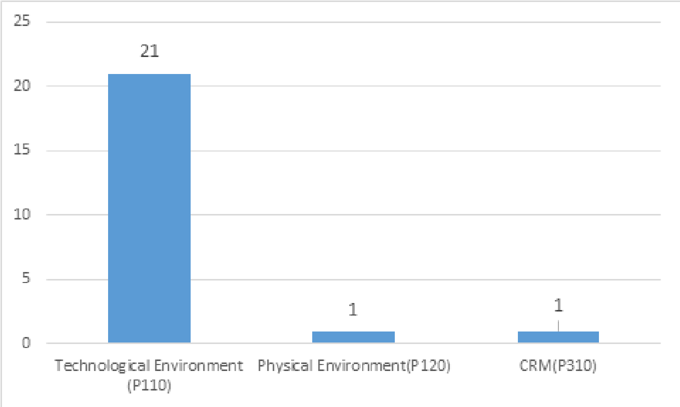

Figure 4. Frequency of the Occurrence of Preconditions For Unsafe Acts (P)

- **Unsafe supervision (Supervision):** As shown in Figure 5, *local training issues/programs* have shown the highest frequency as an accident cause among other unsafe supervision causes. This means that automation procedures as well as lack of training contribute to an accident. Additionally, *crew resource management* as well as limited experience are identified as causal factors with a very low frequency.

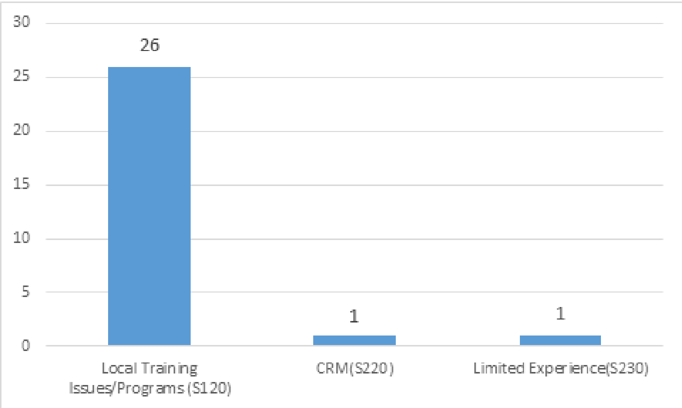

Figure 5. Frequency of Occasion of Unsafe Supervision (S)

- **Organizational Influence (O : Organization):** As seen in Figure 6, the most frequent factor in *Organizational Influence* is '*different culture*'. This indicates that in an automation system designing phase, each State's cultural factor has not been considered which in turn has an impact on the education training system and standards of procedures. Also, *informational resource/support and perception of company* have been identified with a low frequency.

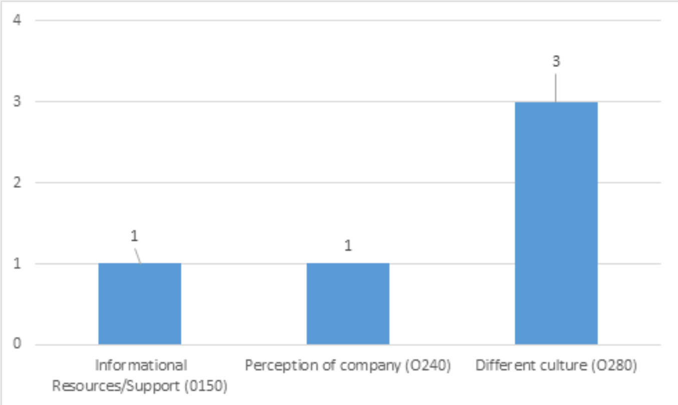

Figure 6. Frequency of Occurrence: Organizational Influence (O)

2.6. Comprehensive Results of the Analysis using the HFACS Model

The comrehensive results of the analysis using the HFACS and specific classification codes, *local training issues/programs* have shown the highest frequency, which is 26, as an accident cause. Also, *technological environment*, among other causes under preconditions for unsafe acts has shown the second highest frequency, which is 21. *Rule-based error*, which belongs to the unsafe acts category and *slip* categorized as a *skill-based erro*r have shown high frequencies. Detailed analysis on these specific categorized factors, which are under *unsafe acts*, *preconditions of unsafe acts*, *unsafe supervisions* and *organizational factors*, is meaningful because it enables detailed reviews for cockpit automation-related human errors and it helps us consider countermeasures.

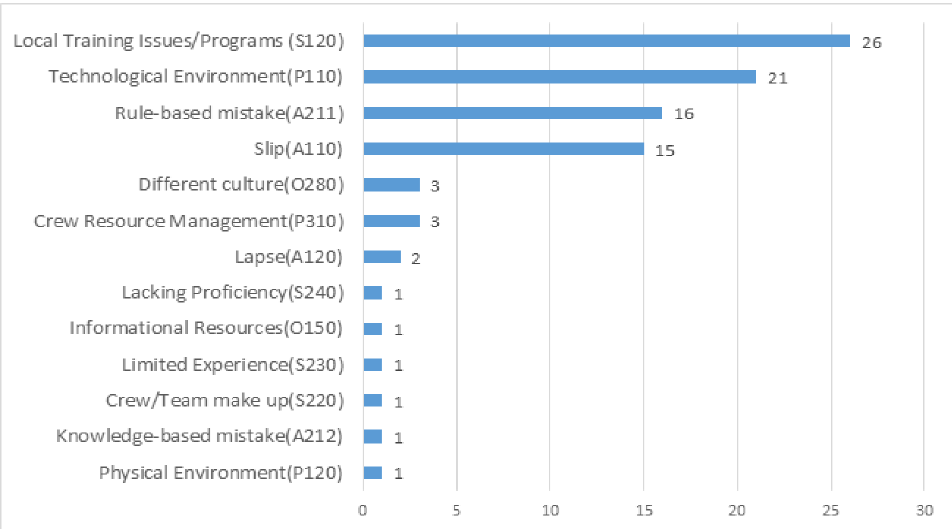

Figure 7. Comprehensive Results of Automation-Related Human Error Analyzed by the HFACS

A comparison between the accidents and the results of the analysis have given us a lesson. The lesson is that unclear understanding of the automation procedures, lack of education, and excessive trust and dependency are the common causes in various accident cases, including the Asiana Airlines accident. This teaches us that early education might have prevented this type of accidents.

In existing research, Stephen and others have confirmed that particular types of human error occur due to declined pilot performance in connection to automation.

[12] Research conducted by the Federal Aviation Administration of the U.S. in 2013 has also suggested that in order to overcome performance decline of pilots, training on coping with automation is necessary. [13]

On the other hand, most studies and legal frameworks suggest that conformity with standards of procedures is the fundamental measure to prevent pilot error.

However, this may create a misunderstanding that all automation-related accidents are caused only by pilot acts and that if imperfect pilot acts are all eliminated, all accidents will become preventable, so that full-automation is the answer by removing pilots from the cockpit. [14]

Nevertheless, it should not be forgotten, that in the cockpit, together with automation, cooperation synergy of a captain and co-pilots can possibly prevent an accident. It is also important to review supervision, which may mediate and control pilots' individual acts, cultural difference and organizational influence.

3. Conclusion

Air travel is the most significant, international and fastest mode of transport. An accident in this transport industry can create a loss of aircraft and human lives. Also, one accident might not only damage passengers' lives, but it may also trigger inter-State conflicts.

The initial purpose of developing cockpit automation was to decrease human workloads and to prevent accidents. However, as there are multiple accidents caused by automation-related pilot errors, there is the need to resolve this issue arising out of automated systems. One example of such issues may be the Asiana Airlines accident. This accident occurred due to a typical pilot error because of a lack of understanding of the device used. Prevention of this type of accident requires us to analyze similar cases in detail.

Pursuant thereto, this study has added specific categories to the existing HFACS and analyzed 94 potential automation cases of FDAI. According to the analysis, under the category of unsafe acts, *rule-based error* happened most frequently. Among other *technical-based errors*, *slip* happened the second most. As *rule-based error* typically happens to skilled persons, it indicates excessive dependence and trust on automation. Under the category of *pre-condition for unsafe acts*, technological environment has shown the highest frequency. This cause shows error in the design of automation systems and the general limitations of automation systems. In connection to this, *flight crew resource management* has also shown a high frequency. It means that *flight crew resource management* may be useful for overcoming the limits of an automation system. In the category of *unsafe supervision*, *local training issues/programs* has been the factor with the highest frequency. This factor is related to a lack of understanding of automation procedures and of training. Some of the subcategorized factors such as *crew resource management* and *lack of experience* were also encountered. In the *organizational influence* category, *cultural differences* were the cause with the highest frequency. Lack of consideration of each State's culture may lead to different approaches to the development of training systems and standards of procedures, which can raise issues. Furthermore, *informational resource/support* as well as perception of company have been found as influencing factors.

The comprehensive results of this analysis have proved that pilots should properly understand automation systems in aircrafts. As current standardized education systems are not designed to help pilots actively cope with automation systems, it is urgent to introduce a new concentrated training system such as AOP or ATOP, which enable concentration trainings for all pilots after analyzing the individual weaknesses of pilots.

On the one hand, this study is an accomplishment as a new approach to analyze and categorize cockpit automation itself and related human errors by drawing detailed factors of the HFACS model, instead of the existing frequency analysis. On the other hand, a limitation of this research is that the accident data used are restricted to FDAI. Therefore, in the future, airlines data collection on the basis of present status analysis as well as surveys can help enrich a follow-up research that may help provide more realistic recommendations and creating a rapport with pilots in the field.

References

[1] Boeing, Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations, 1959–2016, **(2017).**

[2] H.W. Orlady and L. Orlady, "Human Factors in Multi-Crew Flight Operations", Taylor &Amp; Francis Ltd., **(1997)**.

[3] E. E. Geiselman, C. M. Johnson and D. R. Buck, "Flight Deck Automation Invaluable Collaborator or Insidious Enabler?", Human Factors Applications, vol. 21, no. 3, **(2013)**.

[4] B. Lyall, "Human Factors: Safety and Automation", Research Integrations, **(2007)**.

[5] Flight Deck Automation Issues-Accident Analysis <http://www.flightdeckautomation.com/accidentstudy /accident-analysis.aspx.

[6] Flight Safety Foundation, ALAR Briefing Note 1.2– Automation, **(2000)**.

[7] S.A. Shappell, S. A. and D.A. Wiegmann, "FAA-The Human Factors Analysis and Classification System-HFACS", **(2000)**.

[8] E.L. Wiener and R.E. Curry, "Flight-Deck automation: Promises and Problems – NASA-TM-81026", **(1980)**.

[9] Flight Deck Automation Issues. <<http://www.flightdeckautomation.com/fdai.aspx>>.

[10] B. Lyall, "Human Factors: Safety and Automation", Research Integrations, **(2007)**.

[11] Y.C. Choi, Y.K. Kim and C.Y. Kim, "A Study on Detailed Categorization and Empirical Analysis of Human Error", Journal of the Korean Society for Aviation and Aeronautics, vol. 10, no. 1, 9, **(2002)**.

[12] S. M. Casner, R.W. Geven, M.P. Recker and J. W. Schooler, "The Retention of Manual Flying Skills in the Automated Cockpit. Human Factors", The Journal of the Human Factors and Ergonomics Society, vol. 56, no. 8, **(2014)**.

[13] J. Stewart, "The Gradual Creep of Technology Could Soon Mean that Aircraft No Longer Need a Pilot at the Controls", BBC Future, **(2014)**.

[14] O. Brooksby, "Aviation Fatalities: Most are Caused by Human Error", <<http://olsonbrooksby.com/blog/2013/10/aviation-fatalities-most-are-caused-by-human-error-2/>>.