論文

The analysis of the line crew performance through the Line Operation Safety Audit (LOSA)

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LOSA실행을 통한 운항 승무원 수행 분석

ABSTRACT

ICAO(International Civil Aviation Organization) Doc 9803의 국제규정에 의거하여 SMS(Safety Management System-안전관리시스템)의 대표적인 비행안전 모니터링 프로그램으로 인정된 신개념의 운항감사제도인 LOSA(Line Operations Safety Audit-항공운항 안전감사)를 항공사에서 실시하여 정상 운항시의 운항승무원을 관찰하여 실제의 안전취약 및 위협요소, Error를 포착하여 텍사스대학 인적요인 연구소에서 작성한 최종보고서의 분석을 통해 제도와 방안을 개선한다. 본 논문에서는 LOSA실행을 통한 승무원들의 위협 및 error의 유형과 발생율, 관리율 및 관리여부를 분석하여 설명하고 항공사내 개선인 SCP(Safety Change Process)를 소개하는데 있다.

Key Words : LOSA, TEM(Threat and Error Management), Human factors, SMS(Safety management system), Hazard identification, SCP(Safety change process)

I. INTRODUCTION

1.1 The definition of LOSA

LOSA stands for Line Operations Safety Audit. It is a flight safety program that analyses human errors in normal operations. Trained pilot observers monitor the normal flights at the observer seat. LOSA is a proactive non jeopardy data collection tool using threat and error management(TEM) as a framework. The observations are strictly confidential, and analysed by the LOSA Collaborative (TLC) and the University of Texas Human Factors Research Project(UTHFRP). [1]

There are many safety related data through accident investigation, incident reports, line checks, and FOQA, these days. The conventional Safety management system(SMS) tools provide what occurs while LOSA explains why the errors happen and how these are managed. With the analysis of crew behaviors through LOSA with TLC and University of Texas(UT), the airlines were able to identify the behaviors of the crew during normal operations. The major objective of LOSA is to measure how the crew manage threats, errors and undesired aircraft deviations in the cockpit on day to day operations. [2]

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1.2 The history of LOSA

The beginning of LOSA was initiated with delta Airlines and UT to check actual line application after the CRM training in 1994. TWA, US Airways and American Airlines followed Delta and conducted CRM audits with UT.

The 1st TEM based LOSA was developed in collaboration with Continental Airlines in 1996. The follow-up LOSA at Continental Airlines in 2000 after the improvement provided the proof of concept for LOSA as a proactive safety tool. [3]

1.3 LOSA as an integral part of SMS

The human performance less than optimum caused the majority of the accident and incident. The LOSA and TEM are integral parts of a SMS. The hazards can be identified through LOSA. The LOSA is the primary tool to develop countermeasures to human error for monitoring normal operation.

Now we know these threats, errors and how these were managed through LOSA from TLC, the management set targets for enhancement. and making efforts to improve the system and focus the area needed be trained and the procedures to be amended to reduce the risk effectively. [4]

The propose of this paper is to introduce the implementation of LOSA of a sample Airline "Z" according to ICAO DOC 9803 and the analysis of the data in the airlines using LOSA with TLC .

II. TEM

TEM is the basic tool to capture day to day operation of the crew performance for LOSA. The schematic enable us to understand how the threats effect on errors. It helps to comprehend the flow of management on threats and errors.

There are at least one threats on most normal flight. The mismanaged threats that contributes to a crew error and UAS. LOSA takes a view that errors will occur, because of human limitation. Most training were focused on minimizing errors before we adopt the TEM concept.

It is very useful to find out the threats and errors chain from the schematic of threat and error for pilots to trap and avoid these threats and errors more effectively when we identify and understand them through the schematics and analysis of LOSA.

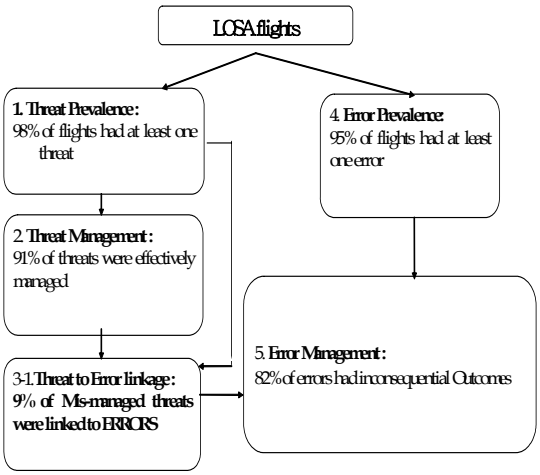

Fig 1. The schematic of threat and error

III. THREATS

3.1 Definition

Threats increase the risk of the flight. Threats are events or errors occurred outside of the flight crew's influence, but have to be managed to keep safety. Errors caused out

side of the cockpit crew are considered as a threat. Threats require the attention and management of the cockpit crew in order to maintain adequate safety margins. [1]

3.2 Threat Analysis

3.2.1 Threats profile

There are external threats and airline threats. Around 2/3 were external threats and 1/3 were airline threats.

The table shows the threats which must be managed for safe flights.

Table 1. The percentage of flights with one or more threats -Airline Z

Threat		Percent of flights with Threats
All threats		98%
External threats	ATC	70%
	Adverse Weather	55%
	Other Environmental Threat	38%
	Airport Condition	36%
Airlines threats	Aircraft Malfunction / MEL Item	29%
	Cabin	25%
	Airline Operation Pressure	24%
	Ground / Ramp	13%

3.2.2 The most frequent threats

Most frequent threats are ATC, adverse weather, and other environmental threats such as terrain and the congested radio contact.

Table 2. The percentage of frequent threats -Airline Z

Threats	Percent of all threats
ATC	29%
Adverse weather	17%
Other environmental	12%
Airport condition	11%
AC malfunction	9%

3.2.3 Threats by phase

There are airline threats like delays and aircraft malfunction which are related within the airline and environmental threats like weather and air traffic control(ATC) which occur outside the airline even before the departure. 41% of the threats occurred before taking off and 31% occurred during approach and landing.

Around 41% of environmental threats occur in Des / App / Land and 76% of airline threats occur in pre - departure according to LOSA data of Airline Z. These facts are shocking that so many threats occur even before the aircraft has departed. The airlines are making efforts to improve safety on these threats.

Table 3. The threats by phase Airline Z

Phase of Threat	Percent of Threats
Pre-departure / Taxi-out	41%
Takeoff / Climb	14%
Cruise	9%
Descent / Approach / Land	31%
Taxi-in / Park	5%
Total	100%

3.3 The management of the threats

There are around nine percent of all threats that are mismanaged, the frequent threats are ATC, weather, and aircraft threats. This data shows that the management of the threats are higher than

the comparison airlines, and it is still needed to train how to manage these threats more effectively.

The ATC, adverse weather, and aircraft malfunction /MEL related threats show problematic among all threats in terms of the management.

It is recommended to reduce the threats specially related with weather. The airline may focus on utilizing the weather radar, and anti icing equipment.

Table 4. The mismanagement of threats- Airline Z

threats	Mismanagement %
All threats	9% of all threats
ATC	12% of flights with mismanaged threats (difficult to meet clearances and late changes from ATC)
Adverse Weather	12% of flights with mismanaged threats
A/C malfunction/MEL	5% of flights with mismanaged threats

IV. ERRORS

4.1 Definition

Error is an action or inaction by the cockpit crew that leads to deviations. Errors tend to reduce margin of safety and increase the probability of the accidents or the incidents. [1]

4.2 Error analysis

4.2.1 Error profile

The crews encountered on most of the flights. Around 30% of errors are intentional noncompliance (Violations). There were 26% of AC handling errors, 64% of procedural errors and 10% of communication errors. We could observe crew make most errors on procedural errors than aircraft handling errors.

Table 5. The percentage of flights with one or more errors -Airline Z

Error		Percent of All Errors
A/C Handling Error	System / Instrument / Radio	29%
	Automation	29%
	Manual Handling / Flight Control	28%
	Ground Navigation	6%
Procedural Error	SOP Cross-Verification	43%
	Callout	33%
	Other Procedure Error	30%
	Briefing	26%
	PF / PNF Duty	26%
	Documentation	24%
	Checklist	22%
	ATC	10%
	Pilot to Pilot Communication	1%

The pilots are trained to trap and avoid errors. However, pilots make errors in the cockpit, because we are human and human is not perfect. LOSA helps in detecting errors in normal flight so we can learn from them.

4.2.2 The most frequent errors

Most frequent errors are cross-verification, call-outs, other procedural errors as PF making own automation changes and external communications.

Table 6. The percentage of frequent errors -Airline Z

Errors	Percent of all Errors
Cross-verification	15%
Callouts	10%
Other procedural error	10%
External communication	10%
Automation	9%

4.2.3. Errors by phase

Thirty percent of all errors occur during pre-departure and taxi-out when flight deck crews are preparing for the departure. It is important to provide the system to minimize committing these errors since it maybe easier to reduce the errors than the ones in the air.

It shows that the thirty nine percent of all errors occur during Descent /Approach /Land. This phase could be focused for the error management training for stabilized approaches.

Table 7. The errors by phase of airline Z

Phase of Flight	Percent of Errors
Pre-departure / Taxi-out	30%
Takeoff / Climb	17%
Cruise	7%
Descent / Approach / Land	39%
Taxi-in / Park	7%
Total	100%

4.3 The management of the errors

The pilots are trained to minimize errors in te cockpit. The analysis of TLC tells us that the crew commit these errors in normal flights, so we can set up the system to train the crew and making procedures to manage these errors when provided data. The mismanagement rate of errors is 18% which is lower than the averages of the comparison airlines. [4]

Most often mismanaged errors are Aircraft handling during hand flying, system/ instrument/radio and automation errors. Around a little less than half of the errors went undetected. This is taken care with priority to manage errors. It is useful improving automation policy and procedures considering the threat conditions.

This data shows that the management of the errors are better than the comparison airlines, and it is still needed to train how to manage these errors more effectively. It is very helpful to use the data compared with comparison airlines provided by TLC, because this tells to an airline where they stand regarding safety.

It should be focused for pilots to train on ground school and in the simulator to handle system such as anti-icing, radar, and altimeter settings for system/instrument/radio.

Table 8. Mismanagement of errors- Airline Z

Errors	Mismanagement rate
All errors	18% of all errors
Manual handling	35% of all mismanaged errors
System/instrument /radio	18% of all mismanaged errors
Automation	13% of all mismanaged errors

V. UNDESIRED AIRCRAFT STATES

5.1 Definition of UAS

The Undesired aircraft states(UAS) is a flight crew induced aircraft state that reduces safety margins significantly. If we do not manage the UASs properly, these can be developed to an accident.

Some examples of undesired aircraft states are incorrect a/c configurations, vertical deviations of altitude, lateral deviations of heading, speed too high, speed too low, or abrupt aircraft handling.

There are several UAS types such as aircraft handling, ground navigation, incorrect aircraft configurations. The examples of aircraft handling are vertical, lateral or speed deviations. The examples of incorrect aircraft configurations are incorrect systems, and automation configurations. When an UAS is linked an additional error it is mismanaged UAS. [1]

5.2 UAS Analysis

5.2.1 Top 5 UASs

Table 9. Top five UAS - Airline Z

UAS	% of UAS
Incorrect aircraft system configuration	24% of all UAS
Speed deviations	13% of all UAS
incorrect A/C configuration(flight control, brakes)	10% of all UAS
incorrect automation configuration	10% of all UAS
Taxi handling/Navigation	9% of all UAS

5.2.2 UAS by phase

It is noted that the sixty one percent of all UAS occur during Descent/Approach/Land, most of them are mismanaged.

Table10. The UAS by phase of airline Z

Phase of Flight	Percent of UAS
Pre-departure / Taxi-out	12%
Takeoff / Climb	14%
Cruise	9%
Descent / Approach / Land	61%
Taxi-in / Park	4%
Total	100%

5.2.3 The management of the UAS

The 5% of flights in UAS did not executed go-around when it is not stabilized. The pilots seemed continuing their approach for landing when they are not in the stable approach criteria.

There were about 36% of the UAS which was related with the threats that were mis-managed. This data tells us the management of threats should be focused for training and checks to reduce the occurrence of UAS.

VI. CONCLUSIONS

The LOSA helps management the directions to train and set up the system for crew to manage threats, avoid committing errors, manage their errors, and undesired aircraft states with final report which was provided by TLC through LOSA data collection. The LOSA committee of Airline Z is implementing the safety change process with the analysis of identified threats and errors as follows.[5]

The final report shows that the management of threat and errors of Airline Z is in the leading group among the comparison airlines, however there are lots of rooms to

improve specially the error detecting area and managing major threats such as weather, aircraft, and ATC. Around 25% of the flights had a mismanaged threat that lead to a crew error or undesired state. This rate shows how the management of the threats is critical to reduce the errors.

The training and check should be focused on improving the standard briefing procedures and philosophy to enhance managing threats . The examples of the briefing errors are incorrect or incomplete take-off, departure or approach briefings. The pilots make errors on checklist and briefing because they are not trained for normal procedures since most training is focused on handling abnormal situation. [6]

The mismanagement rate of the ATC communication is three percent, this occurred when there is a mismanagement of ATC threats. This tells us to focus on handling ATC threats before errors happen. The most frequent ATC related threats are challenging clearance, late changes, difficult languages and difficult to meet clearances. It is very helpful to have regular meetings and close contacts with ATC agency to share how to manage weather threats with the help of ATC weather radar and ATC threats with the help of controllers.

The airlines must improve to reduce the threats such as aircraft malfunctions, application of MEL(Minimum equipment list) and weather before departure since most airline threats occur before taking off.

The airline A makes effective efforts to reduce the flights that make more errors then others through improving error detection ability by ground and simulator training, introduction of special airport, scheduling system improvement considering the difficulties of the mission, TEM training, and leadership training because the leadership has strongest relationship with the error management.

The result of LOSA indicates that the error detection rate should be enhance since around the half of the errors went undetected. The ares which should be focused for enhancing the error detection are monitor, cross-check, the management of workload, automation and taxiway/ runway.

It is noted during the SCP that intentional noncompliance errors should be focused to reduce since it is very difficult to monitor during the check-ride because the crew behave very well to show perfect flight according to the SOP(standard operation procedures) not to fail the evaluation. The major intentional noncompliance errors are PF makes own FMC(flight management computer) changes, performing checklist from memory, flight without appropriate Jeppesen charts, omitting the altitude callouts, and performing the after landing checklist item before leaving the active runway.

The crews make errors on the taxiway and runway management which were not focused on training since most training were mainly related on flight training rather than groung operation.

Most mismanaged errors occur during manual handling of the aircraft when they fly manually. The Airline Z is amending the procedures that the manual flying should only be flown in low threat conditions and in light workload periods.

The crew must be trained to execute missed approach in the simulator and flight, and the Airlines must encourage the company culture that the crews must go around at any unstable approaches criteria without hesitation.

The airlines are setting up effective TEM

training with practical 6 generation CRM instead of theoretical CRM courses with LOSA data. The Airlines Z uses TEM as an integral part of a SMS(Safety Management System)manual and uses monitoring and crosschecking skills in the flight operations to manage threats and errors effectively.

The accident occurs when there is not proper defence according to reason's accident causation model. Airlines Z identifies these hazards and manages risks through LOSA within SMS continuously rather than implementing it independently in an Airline. Airline Z has standardized reporting, investigating and FOQA system to use TEM as basic analytical tool, so all these can be compared one another. [5]

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