論文

The Line Operation Safety Audit (LOSA) as an integral part of SMS in an Airline

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SMS체제 내의 항공사 운항안전 감사 (LOSA) 기능

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ABSTRACT

LOSA는 Line Operations Safety Audit(항공사 운항안전 감사)의 약자이며 기존의 적발 위주의 기존 Line Audit제도와 달리 조종사의 자발적 참여와 철저한 비밀을 유지하며, 처벌 금지 약속을 통하여 참여자가 평소 습관대로 비행할 수 있게 한다. 훈련된 감사관이 이를 소정의 절차서에 의거 조종석에서 관찰하여 실제의 안전취약 및 위협요소, Error를 포착해서 수집하고 텍사스대학 인적요인 연구소에서 분석하여 최종보고서를 작성하여 제도를 개선하는 안전프로그램이다. 제도와 방안을 개선하는 신개념의 선진 운항감사제도로서 안전관리시스템의 대표적인 비행안전 프로그램으로 통상 3~4년을 주기로 실시한다. ICAO, IATA, FAA 및 IFALPA 실행 권고사항으로 현재 약30여개의 항공사가 실시하였다. LOSA는 2009년1월부터 ICAO부속서 6에 의거하여 항공사에서 실행해야 되는 SMS(안전관리 시스템)의 가장 효율적인 Hazard 식별 및 위험 관리도구 중의 하나이다. 본 논문에서는 안전관리시스템의 효과적 도구인 LOSA를 설명하고 항공사내 실행방법을 소개하는데 있다.

Key Words : Threat and Error Management, Human factors, Safety management system, Hazard identification, Risk management, Safety change process

I. INTRODUCTION OF SAFETY

Safety is the state when the risk of harm to persons or property damage is reduced, and maintained at or below an acceptable level through a continuing process of hazards identification and risk management[1].

With the continuous efforts by the aviation society, the accident rate has been significantly declined. In the past it was focused to eliminate risk to zero. No one can guarantee to be absolute safe or free from the risk.

There are needs to manage the risk as low as practicable so the risk could remain in the acceptable region. The hazard in the flight operation can be identified through Line Operation Safety Audit (LOSA) which is one of the effective proactive safety process to manage the risk to an acceptable level in the system.

It is important to understand the accident and incident causation for effective safety management system(SMS). The failure of the defence in the system may cause the accident. The errors and violations which have immediate adverse effect are unsafe acts. The last defences

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in the system are persons in the front line.

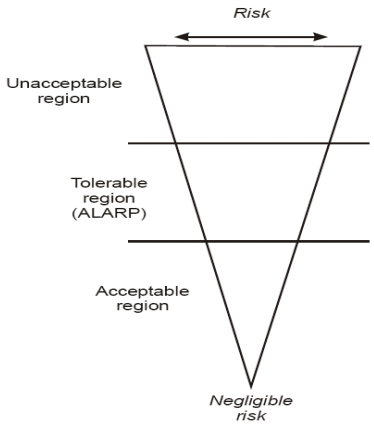

Fig. 1 Tolerability of Risk (ICAO, 2006)

There usually are precursors before the accident occurs. There are good opportunities to prevent tragic accident occurrence when we identify these safety deficiencies and weakness.

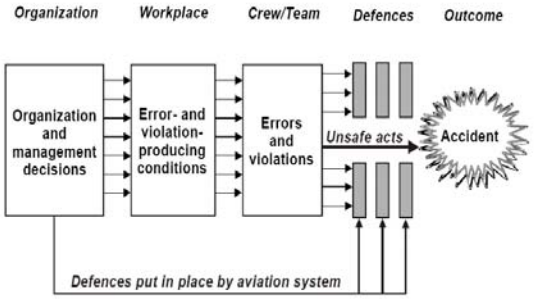

Fig. 2 Accident causation model (ICAO, 2006) Adapted from Prof. James Reason

Henrich's ratio was originally researched for industrial accidents. International Civil Aviation Organization(ICAO) has modified the ratio as above. It shows that for every fatal aviation accident there can be 10 serious accidents, 30 reportable incidents(minor accident) and as many as 600 other

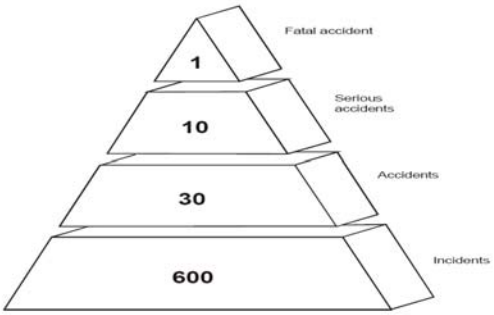

Fig. 3 1:600 Rule (ICAO, 2006)

(non-reportable) incidents.

It could be indicators of potential serious safety problems in the organization when there are many un-reportable incidents. These will eventually lead to an accident if these are not managed.

When we know these errors and threats in the real world through proactive safety management tool like LOSA, we could identify risks in the system on normal line operation and the airlines may investigate why the errors and undesired aircraft state happen and how these can be managed systematically.

The propose of this paper is to introduce the safety monitoring tool of LOSA according to ICAO DOC 9803 and ICAO SMS Manual 9859, and the implementation in the airline.

II. SAFETY MANAGEMENT SYSTEM(SMS)

2.1.1 The cycle of SMS

The primary purpose of SMS is to identify hazards and control risks, and there are methods to identify report and analyze hazards. There must be procedures to manage risks so that these risks could be

dealt within standardized manner. There should be on-going program to evaluate the actions in the system, so this cycle could flow automatically. Here is an example of systematic process as above produced by ICAO. The safety cycle starts with identifying hazards when there are hazards in their environment, then takes actions through the control options and risk communication.

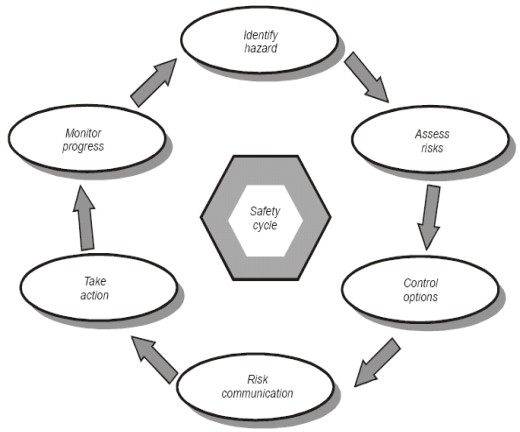

Fig. 4 Safety cycle (ICAO 2006)

2.1.2 The process of safety management

There are unidentified latent unsafe conditions on our daily operations. The airlines collect data on these conditions to analyze the hazards. There are reports, audits, checks, flight operational quality assurance (FOQA), and LOSA in the system to collect data. Safety management is based on evidences, so it requires actual data to identify hazards.

If there is no data, then it is only an opinion. The priorities of unsafe conditions can be set to reduce the risk once the data are analysed. The airlines can assign responsibilities to implement these actions, then evaluate the situation if these unsafe condition is managed

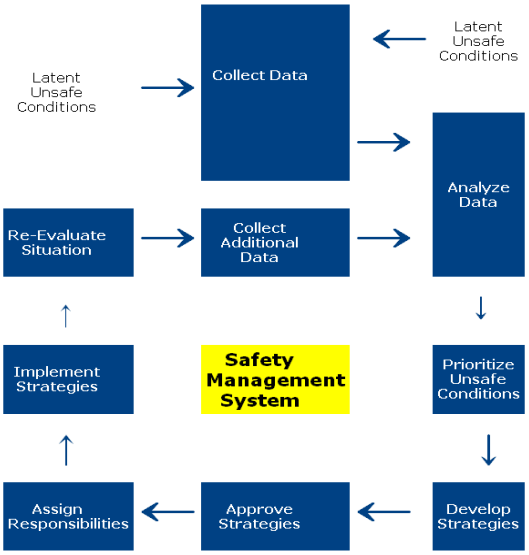

Figure. 5 SMS Process (ICAO 2006)

to an acceptable level. This is the continuous loop which guard the safety of the organization systematically.

2.2 Description of LOSA in ICAO SMS manual DOC 9859(ICAO, 2006)

Hazards could be identified through proactive safety process like flight data analysis(FDA), LOSA and Normal operation safety survey(NOSS). Organizations with proper safety oversight adopt the method such as FDA and LOSA to capture of data which reflect actual day-to-day performance. One of the method of monitoring normal operations on the flight deck is LOSA using threat and error management(TEM) model, and provide airlines with important view into the threats and errors. Line crew with previous experience need refresher training for TEM through LOSA. Some airlines conduct safety surveys at regular intervals, and during the significant change, or the introduction of a major new safety

features[2].

ICAO endorsed LOSA as the primary tool to develop countermeasures to human error in aviation operations for monitoring normal flight operations. LOSA monitors normal operations for accident prevention. LOSA facilitate hazard identification through the analysis of actual performance during the flight and identifies threats of aviation safety in order to understand human performance and human behavior. LOSA provide data to the airline on how the system manages threats, operational risks and errors committed by crew. LOSA also provide the data of successful behavior and the failure of the safety system. These successful outstanding performances can be used for the crew resource management (CRM) training[1].

The airlines may use LOSA which is one of the best SMS tool to identify hazard and to manage the risks of the line crew on normal operation as a part of the SMS implementation before the accident happen. The airlines can operate LOSA within the SMS system effectively when SMS process are documented and monitored regularly.

III. LOSA

3.1 WHAT IS LOSA?

The human performance less than optimum caused the majority of the accident and incident even though there has been continuous effort of the aviation industry to improve the safety. LOSA is a proactive data collection system on crew and system performance to capture these performance which is less than optimum 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[3].

LOSA provides why errors happen and how the crew manage these errors while other conventional SMS like FOQA may provide only what happened. The other safety tools are using data from failed performance such as accident and incident while LOSA provides positive feed back, success story that can be reinforced and trained. Pilots may learn how to manage flights not only from mistakes but also from good examples that have been managed successfully.

The trust from the line pilot on LOSA is the key for successful LOSA. When there are pilots who does not trust LOSA, they will show fake performance instead of the natural performance in the cockpit according to the LOSA collaborative(TLC).

LOSA provides numbers of threats and errors in detail in comparisons with other fleets and airlines so the managers may identify why those happened to improve the SMS and the flight environment.

3.2 THE PURPOSE OF LOSA

The LOSA and TEM are integral parts of a Safety Management System (SMS). LOSA has shown its success on the major improvement on many areas including the riskiest phase called the blue box, which is the busiest phase during approach and landing.

The first Threat and Error Management LOSA was developed in 1996 in collaboration with Continental Airlines. When they measured second LOSA in 2000, they found many improvements in checklist usages, unstable

approaches and these were confirmed by FOQA data[4].

3.3 10 LOSA CHARACTERISTICS(ICAO)

There are 10 characteristics of LOSA according to ICAO DOC 9803. If there are not these characteristics, the requirement of LOSA recommendations can not be met [4].

1) Jump seat observation during normal flight
2) Anonymous and confidential data collection
3) Voluntary flight crew participation
4) Joint management, pilot association sponsorship
5) Safety targeted data collection form
6) Trusted and rained observers
7) Trusted data collection sites
8) Data cleaning round tables
9) Data-derived targets for enhancement
10) Result feed back to line pilot

3.4 SAFETY CHANGE PROCESS(SCP)

3.4.1 TYPICAL SCP ACTIONS (ICAO, 2002)

1) Modifying procedures or implementing new ones.
2) Redefining operational philosophies and guidelines
3) Arranging specific training in error management and crew countermeasures.
4) Reviewing checklist to ensure relevance of the content and then issuing clear guidelines for their initiation and execution.
5) Defining tolerances for stabilized approaches, as opposed to the "perfect approach" parameters promoted by existing standard operation procedure (SOP)[2].

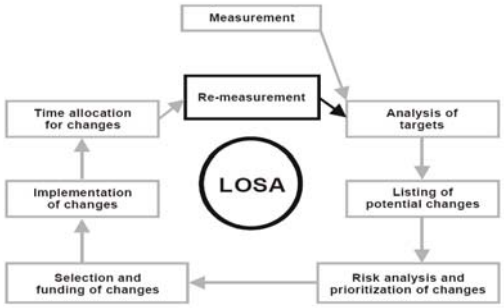

Fig. 6 The safety change process(SCP), (ICAO 2002)

3.5 TEM

Continental Airlines uses TEM as an integral part of a Safety Management System. Continental Airlines uses Monitoring and Crosschecking skills in their flight operations to manage threats and errors[5].

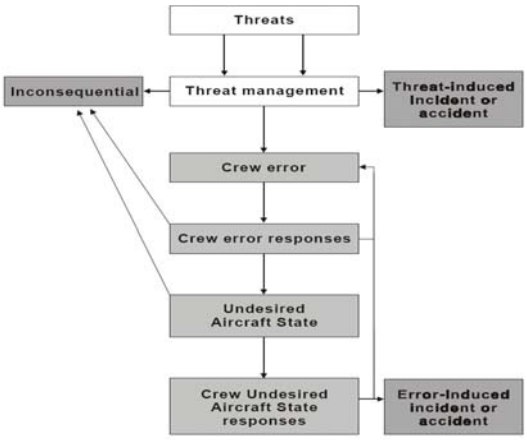

Fig. 7 The threat and Error management model (ICAO 2002)

3.5.1 THREATS

Threats are events or errors happened outside the flight crew's influence, but need to be managed to keep safety. Threats increase the risk during the flight regarding safety. Errors caused out side of the cockpit crew are regarded as a threat. The table shows that the most flights face threats on day-to-day operations and must

manage threats.

Table. 1 The threats result of 4500 flights, 25 LOSAs[5]

threats per flight	average 4.2
seven or more threats per flight	17% of flights
Flights with no threats	Only 3%

There are lots of airline threats such as delays and aircraft malfunction and environmental threats such as weather and air traffic control(ATC) even before taking off.

Table. 2 The threats by phase of 4500 flights, 25 LOSAs [5]

Phase of flight	Percentage of threats
Predeparture/ Taxi-out	40% of all threats (73% of all Airline threats occur during Predeparture/Taxi-out)
Descent/ Approach/ Land	30% of all threats (43% of all Environmental threats occur , while occur during Descent/Approach/Land).
The frequent threats	weather, ATC, terrain, traffic, airport conditions

Table. 3 The mismanagement of threats- 4500 flights, 25 LOSAs[5]

threats	Mismanagement rate
All threats	10% of all threats
Aircraft threats	13%
ATC threats	12% (difficult to meet clearances and late changes from ATC)
Adverse Weather	11%

There are around ten percent of all threats are mismanaged the frequent threats are aircraft, ATC and weather threats. The ATC related threats show most problematic among all threats[5].

3.5.2 ERRORS

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

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. There are average 3 errors per flight according to the table2-1. Over 80% of flights in LOSA had crew errors.

Table. 4 The error result of 4500 flights, 25 LOSAs[5]

Error per flight	average 3
seven or more threats per flight	17% of flights
Flights with no observable errors	20%

Thirty percent of all errors occur during pre-departure and taxi-out when crews preparing their departure , and it must be easier to manage these error than the errors in the air. It is noted that the forty percent of all errors occur during Descent/Approach/ Land, and this phase should be focused for the error management.

Table. 5 The errors by phase of 4500 flights, 25 LOSAs [5]

Phase of flight	Percentage of Errors
Predeparture/ Taxi-out	30% of errors occur during Predeparture/Taxi-out
Descent/ Approach/ Land	40% of all observed errors
The frequent errors	Checklist errors, Call-out cross-verification errors

Table. 6 The mismanagement of errors -4500 flights, 25 LOSAs [5]

Errors	Mismanagement rate
All errors	25% of all errors
Additional error	6% of all errors lead to another error
Errors result directly in an undesired aircraft state.	19% of all errors to UAS
Descent/Approach/ Land	55% of mismanaged
Manual handling/flight control errors	36% of all mismanaged errors.
Automation	16% of all mismanaged errors.
System/Instrument/ Radio errors	16% of all mismanaged errors.
Checklist errors	5% of the mismanaged errors
Crew-ATC communication errors	3% of the mismanaged errors

Over 25% of all errors are mismanaged errors that leads to an additional error or undesired aircraft states. Most often mismanaged errors are Aircraft handling during hand flying, this should be dealt with priority to manage errors. It could be useful improving automation policy and procedures since the mismanagement rate of the automation error is also 16% as system . 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. The pilots make errors on checklist because they are not trained for normal procedures since most training is focused on handling abnormal situation. 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[6].

3.5.3 UNDESIRED AIRCRAFT STATES

Undesired aircraft states(UAS) is a flight crew induced aircraft state that clearly reduces safety margins. The undesired aircraft states is as close to an accident. Mismanaging these undesired aircraft states may lead to an accident.

Over 19% of the mismanaged errors lead to an undesired aircraft state according to table3-1. 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.

The only 5% of the flights out of unstable approaches which is 5% of UAS execute go-around. The pilots have tendency to continue the approach and landing even they know they are not in the stable approach criteria.

About 30% of the UAS was connected with the unmanaged threats. This is why the management of threats are important since the threats are the precursors to the accident.

Table. 7 The errors by phase of 4500 flights, 25 LOSAs [5]

UAS per flight	0.33
Incorrect aircraft system configuration	20% of all UAS (they occur on 9% of flights)
Speed deviations	16% of all UAS
lateral/vertical deviations	13% of all UAS (occur on 9% of flights)
incorrect automation configuration	13% of all UAS (occur on 9% of flights)
unstable approach	5% of flights
connected from unmanaged threat	30% of all UASs

To identify these threats can be done with LOSA while it could be difficult to identify the threats through accidents and incidents[6].

IV. IMPLEMENTATION OF LOSA DATA COLLECTION IN AN AIRLINES

4.1. THE MAJOR STEPS OF IMPLEMENTING LOSA [2]

4.1.1 FORMING INITIAL DEVELOP TEAM

It is quite useful to form initial develop team to get information and organize the committee. The committee should maintain close contact with The LOSA Collaborative, TLC to set up the LOSA.

4.1.2 GATHER IN FORMATION

The preparation team may visit or contact other airlines to benchmark LOSA for the preparation. LOSA archive is willing to share the information to achieve safer environment with the collaboration efforts. It is also useful to obtain and share the experience at the ICAO LOSA and TEM conference each year.

The airlines which have completed LOSA are able to implement the safety change process according to the final report with specific findings of LOSA data and comparisons that gives managements which area should be focused to be improved in detail and what direction they should train the crew to minimize the occurrence of threats, errors and undesired aircraft states.

4.1.3 IDENTIFY WHAT TO LOOK AT

The LOSA committee of the Airlines may hold several meetings to identify weak areas by studying and discussing the FOQA data, continental reports, crew interviews and evaluation of the training and simulator checks. The representatives from each related department including safety, training, standards, , and quality can make the presentation of the safety status. The committee may discuss the good and bad points of the flight operations to focus LOSA.

4.1.4 DETERMINE HOW MANY SEGMENT TO OBSERVE

TLC calculates the number of the segments depending on the size of the operations in an airline and the size of the LOSA. UT and TLC determine the number of the LOSA flight

segments needed for the airline based on the daily departures and the size of LOSA. It requires more segments for full LOSA with comparisons of other fleets.

4.1.5 SCHEDULE AUDIT DATES, SELECT OBSERVERS AND SCHEDULE TRAINING

It is important to coordinate with flight operation regarding the status of the pilot scheduling. The committee should contact TLC on regular basis to schedule LOSA dates. It is required for the TLC to conduct LOSA that the union and the management of the company make the written agreement for LOSA.

There are some conditions that observers must meet. Observers must be trust worthy. Observers should be able to understand and communicate with the instructors from TLC during the observer training in English, and write the narrations of the observation report in English. Observers must be able to keep the information he/she acquired during the observation in confidential. Besides, observers should have basic the computer skills which he will use to write the report with. Both company and the pilot union should be satisfied with the selection of observers and involved on the selection of the observers and this built trust among the line pilots with the advice from TLC.

4.1.6 CONDUCT OBSERVER TRAINING

It usually takes three to five days for the observer training. The observer training consists of the TEM training, Introduction of LOSA observer forms, Categories and codes of the threats and errors, Observation, Calibration of observation, and Feed back by TLC and University of Texas Human Factor researchers. It is quite useful to select observers in advance to train for the basic TEM background knowledges, standards, the terms in English and basic computer skills.

4.1.7 AUDITS

The LOSA data collection takes one to two months depending on the size. The audit schedule are usually selected randomly.

4.1.8 ANALYSE AUDIT FINDING

The TLC and UT analyse the findings and clean the data if they were invalid. The airlines form the safety change process, SCP committee to analyse the final report from the TLC and start to investigate the area they should improve.

4.1.9 PROVIDE FEED BACK TO SYSTEM AND CARRY OUT IMPROVEMENT TO SYSTEM

The airlines give feedback to the system and the SCP committee carry out the improvement. It is important not to focus on the individual but on the system such as the organization, training, procedures, philosophies, checklists, call-outs, evaluation, equipments, and others.

4.1.10 DEVELOP ENHANCED POLICIES, PROCEDURES AND A SAFER ENVIRONMENT

The SCP committee can develop enhanced policies, procedures, safer environments together with the related department through the review and analysis of the final report and the raw data.

4.2. COMMITTEE

The support from other department is very important to have successful output from LOSA. The LOSA Committee members are usually from safety, standards, flight operations, QA, training department and pilot union.

It is needed to get support from committee members for the preparation and promotion of LOSA to pilot for their participation. It is also great to have aviation psychologist, researchers from aviation universities, ATC, and regulators from Civil aviation safety authority(CASA) to be part of the special committee members for the benefits and their professional support. The committee may make posters and stickers to promote the LOSA for active participation of the line pilots. The committee can give brief introduction at the recurrent ground school training.

4.2.1 PILOT ASSOCIATION

Pilot association takes a part in the LOSA Steering Committee, making LOSA a joint project between the airlines and the pilot association. It gives great advantages for building trust from the line pilots to fly as usual to show the natural performance. Pilot association and the Airlines can guarantee the confidentiality, non-punitive and voluntary participation to the pilots with the written agreement from the company as TLC requires. This will surly make line pilot to open their cockpit doors to the observers to show their actual operations naturally.

It is important to explain pilot association that LOSA is not the another form of line check to discipline proposes. The committee may show the document from The International Federation of Air Line Pilots' Associations(IFALPA) and encourage pilot association to contact other Air Line Pilots' Associations(ALPAs) and LOSA experienced airlines as TLC advised[3,4].

V. CONCLUSIONS

Reason's accident causation model explains the accident occurs when the weaknesses are present but the other defence are not functioning properly. Airlines could maintain safety by identifying these hazards and managing risks continuously through LOSA within SMS which is an organised approach to maintain safety. ICAO Annex 6 require aircraft operator must implement SMS by 31 Jan 2009. (ICAO, 2006) It is effective to operate LOSA as a integral part of SMS rather than implementing it independently.

The airlines must reduce airline threats before taking off since most airline threats occur during predeparture and taxi-out phase such as aircraft, weather and ATC threats specially as difficult to meet clearances and late changes from ATC.

The pilots should be trained detecting errors and the airline should reduce the errors of the crews in 17% of flights who make seven or more threats per flight while 20% of flight do not get involved with any errors. If the airline make effective efforts to reduce this 17% of the flights who makes most errors through training improvement, introduction of special airport, fairing, 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 management should make efforts to reduce

30% of the errors occurred on ground.

Most frequent mismanaged errors are manual handling of the aircraft, and pilots make errors almost whenever they fly manually because of increased workloads. The automation policy and procedures should be improved and the manual flying should be flown only when the workload is light and in low threat conditions. The pilots should be trained to handle system error related with anti-icing, radar, altimeter settings, the normal procedural errors as checklist usages and monitoring.

The frequent undesired aircraft states are incorrect a/c configurations, altitude, heading, speed , or abrupt aircraft handling. Executing missed approach should be encouraged and trained so the crews must go around during the unstable approaches. It is important to focus by the management to reduce the UAS since the threats are the precursors to the accident.

The airlines could set up effective TEM training according to LOSA data provided exact threats and errors within the organization with narratives and raw data with metrics and comparison with other airlines.

LOSA is the integral part of the SMS and advise the area needed be trained and the procedures to be amended to reduce the risk effectively. It is quite important to get the management evolvement for the active support, promoting LOSA to the pilots for the natural performance and request the supports from the pilot association to provide safer system for the crew.

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