DESIGN AND DEVELOPMENT OF A FLIGHT OPERATOR SAFETY AUDIT SYSTEM

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Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently in candidature for any degree.

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STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

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Acknowledgement

This work and the research would not have been achieved without the extraordinary assistance of my supervisor, Associate Professor Ir. Dr. Chin Jeng Feng. His direction, patience, and consistent attention have helped me keep my work on track and motivated to complete the assignment. This research would not have been possible without his unwavering support. I would also want to thank the School of Mechanical Engineering at Universiti Sains Malaysia (USM) for allowing me to be a part of the project team and for giving various assistance throughout the research. They have offered excellent webinars, tutorials, and other resources on thesis writing for the completion of the thesis. Furthermore, I am appreciative for Malaysia Airlines Berhad's participation and input during the project. The kind welcome and helpful suggestions they provided in designing the system for Flight Operation Safety Audit (FOSA) motivated me to learn new things throughout the research. Last but not least, I'd like to express my gratitude to my family and friends for their moral and physical support throughout the research. Their comprehension and encouragement give me the confidence to face the challenges of the research.

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List of Abbreviations

AE	Aeromedical Evacuation
CFIT	Controlled Flight Into Terrain
CORS	Confidential Observations of Rail Safety
COVID-19	Coronavirus Disease 2019
CRM	Crew Resource Management
DAT	Data Analysis Tool
DCF	Data Collection Form
DOSA	Dispatch Operation Safety Audit
EBT	Evidence Based Training
E-R Diagram	Entity Relationship Diagram
FAA	Federal Aviation Administration
FMR	Flight Data Recorder
FOSA	Flight Operation Safety Audit
GUI	Graphical User Interface
ICAO	International Civil Aviation Organization
IDE	Integrated Development Environment
INC	Intentional Noncompliance
iOS	iPhone Operating System
IoT	Internet of Things
KLIA	Kuala Lumpur International Airport
LOSA	Line Operation Safety Audit
LOSA:SP	Line Operation Safety Audit: Single Pilot
MAB	Malaysia Airlines Berhad
MCO	Movement Control Order

Microsoft Power BI	Microsoft Power Business Intelligence
QDR	Quick Access Recorder
SMS	Safety Management System
SQL	Structured Query Language
TEM	Threat and Error Management
TLC	The LOSA Collaborative
UAS	Undesired Aircraft State
US	United States
USM	Universiti Sains Malaysia
VBA	Visual Basic for Applications

Abstrak

Industri 4.0 ditakrifkan sebagai pergabungan antara mesin dan teknologi digital untuk mengawal, meramal dan merancang perniagaan. Salah satu pemboleh Industri 4.0 ialah pendigitalan perniagaan hasil daripada kemajuan teknologi digital seperti Pengkomputeran Awan dan Data Besar dan Analitis. Keselamatan sebaliknya merupakan elemen penting dalam industri penerbangan kerana kebanyakan kemalangan dalam industry ini membawa maut. Line Operation Safety Audit (LOSA) ialah salah satu alat pengurusan keselamatan yang proaktif oleh The LOSA Collaborative (TLC) berdasarkan Threat and Error Management (TEM) untuk mendapatkan dan menganalisis data tingkah laku manusia semasa operasi biasa dan seterusnya mengambil langkah pencegahan sebelum kemalangan berlaku. Dengan menjadikan LOSA sebelum ini sebagai pengalaman, Malaysia Airlines Berhad (MAB) membuat keputusan untuk menjalankan program audit keselamatan dengan nama Flight Operation Safety Audit (FOSA) dan bekerjasama dengan Universiti Sains Malaysia (USM) untuk menghasilkan sistem untuk program tersebut. Pengkajian ini memberi tumpuan dalam menghasilkan sistem yang mesra penggua dan selamat untuk mengumpul, menyimpan and manganalisis data daripada FOSA dengan menggunakan pelbagai perisian perniagaan kejuruteraan dari Microsoft, termasuk Microsoft Excel, dan Microsoft Access.

Abstract

Industry 4.0 is defined as the integration between machines and digital technologies to control, predict and planning for business. One of the enablers of Industry 4.0 is the digitalization of business due to digital technologies such as Cloud Computing and Big Data and Analytics. Safety, on the other hand, is a critical component in the aviation sector, as the majority of flight mishaps are fatal. Line Operation Safety Audit (LOSA) is one of The LOSA Collaborative's (TLC) proactive safety management solutions based on Threat and Error Management (TEM) to acquire and evaluate human behavior data during normal operations and next product countermeasures before occurrence. Using prior LOSA experiences, Malaysia Airlines Berhad (MAB) chose to launch a safety audit program called Flight Operation Safety Audit (FOSA) and work with Universiti Sains Malaysia (USM) to design a framework for the program. This study focuses on the design and implementation of a user-friendly and secure system that collects, saves, and analyzes FOSA data utilizing Microsoft business engineering applications such as Microsoft Excel and Microsoft Access.

Chapter 1 : Introduction

1.1 Overview

This chapter begins with a brief introduction on the research background, include the definition of Industry 4.0, introduction on Visual Basic for Applications (VBA), introduction of the Line Operations Safety Audit (LOSA) and its link to Flight Operations Safety Audit (FOSA) and introduction on process digitalization. The subsequent sections explain on the objectives, problem statement and the scope of the research.

1.2 Research Background

The fourth industrial revolution, or commonly known as the Industry 4.0, is defined as the integration of complex physical machinery and devices with networked sensors and software, used to predict, control and plan for better business and societal outcomes (Hermann et al., 2015). Industry 4.0 was made available by the digitalization of manufacturing and business process due to the advances in digital technologies such as Cloud Computing and Big Data and Analytics. Big Data and Analytics basically refers to a large volume of data that include all variety of data in unstructured or semi-structured formats describing the world from different perspective (Tang et al., 2022). These data provide additional information on the subject of interest, next aiding the organization to form improvement plan on the operation, detect abnormalities in real-time, encouraging new innovations and even being fed into system for machine learning. However, it should be note that a larger volume of data is not the most important part in the industry, instead being able to process the data effectively and accurately by deploying technology and talent is the key to improve the quality of the organization's decision-making. This ability, defined as data analytics capabilities is an important organizational capability that can provide the organization with competitive advantages (Li et al., 2022).

As an initiative step in creating more competitive advantages on their product in this era of digitalization, Microsoft company created Visual Basic for Applications (VBA) that allow users to customize functions and manipulate the user interface features within Microsoft Office software applications (Hyde & Maier, 2006). VBA as a build-in programming language inside Microsoft Office software, for instance Microsoft Excel, Microsoft Access, Microsoft Word and Microsoft PowerPoint allowed business owner to automate routine tasks and conduct analysis and visualization of data within Microsoft Office software, which it became a good option for company to develop customize system as Microsoft Office is a common application available in corporate around the globe.

Accidents in aviation industry often being describe as an “expensive lesson” as these accidents are mostly fatal. Traditionally, reaction measures were adopted by aviation industry where the safety performance data were only obtained via accidents investigations. The reason behind the incident, which was a deadly threat to the aviation industry, will remain uncovered until the accident actually happens. Thus, the investigation will focus on collecting data that describe actions and decisions that failed to achieve the desired outcome, which it is insufficient to allow the industry to fully understand the actual flight performance of the crew that lead to the decision that causes the accident (International Civil Aviation Organization (ICAO), 2002). Line Operations Safety Audit (LOSA) is a program by The LOSA Collaborative (TLC) as an approach towards proactive safety management. The program started in 1991 by the University of Texas Human Factors Research Project with the funding of Federal Aviation Administration (FAA) and was initially to check Crew Resource Management (CRM) performance in aviation sector (International Civil Aviation Organization (ICAO), 2002). As more airlines involved in the program, LOSA undergoes several improvements and eventually evolved into a systematic tool to capture safety data during normal flights operation. The concept of Threat and Error Management (TEM) was added during the development of the program, and the current LOSA can help airlines to monitor flight crew performance, determine organizational CRM strength and weakness, next giving hints to the airline on the part to be prioritize for improvements and hindrance before fatal accidents happens.

In Malaysia, LOSA program was first adopted by Malaysia Airline System, then Malaysia Airline Berhad, in 2004, which they joined the ranks of one of the first few to adopt this program. They next conducted the same program each in 2011 and 2017 with the aid of TLC. TLC was in charged in providing training and calibration of observers, data collection tool, data analysis and generate report for the airline. For this year, MAB decided to conduct a similar program without the aid of TLC, with the name Flight Operations Safety Audit (FOSA). FOSA will involve not only Malaysia Airlines, but also two other subsidiaries airlines of MAB, which is FireFly and MASwings together with Universiti Sains Malaysia (USM) as collaboration partner to develop a system for FOSA that will become the base system of the future rerun of the FOSA.

This research focus on the design and development of a user-friendly and secure system that collects, stores and analyse the data from FOSA using various Microsoft business engineering software, include Microsoft Excel and Microsoft Access.

1.3 Objectives

The two main objectives of this research are:

- To develop a system for the Flight Operation Safety Audit (FOSA) of MAB.
- To study and apply the current business engineering software, such as Microsoft Excel and Microsoft Access into real life operations.

1.4 Problem Statement

Safety is the core element in flight operations as accidents in aviation are mostly fatal. Current approaches in aviation safety management are based on accident investigation, which the risks remain uncovered before accidents happened. FOSA in other hand is a proactive safety management tool based on TEM to obtain and analyze human behavior data during normal operations and next produce countermeasures before incident. This research aims to develop a system for FOSA to collect, stores and analyses data using several latest businesses engineering programs, including Microsoft Excel and Microsoft Access.

1.5 Scope of Research

The system will be divided into three parts, which is the data collection form (DCF), database and data analysis tool (DAT). The basic system of DCF and DAT had been created using Microsoft Excel while the database was built with Microsoft Access. Continuous improvement will be done based on feedbacks from MAB users.

Chapter 2 : Literature Review

2.1 Overview

The safety of aircraft depends heavily on the work of pilots. O’Hare (2009) conducted research on the cognitive functions and related performance shaping factors (PSFs) associated with a personally experienced critical in-flight event. Interferences, training, and external environments have been found to play a significant role in more than 20% of aviation accidents and incidents. Kelly and Efthymiou (2019) investigate the human factors that contribute to aviation accidents involving Controlled Flight Into Terrain (CFIT). The longitudinal (2007-2017) study discovered that human factors are the primary cause of CFIT accidents. The most common factors are decision and skill-based errors, as well as communication, coordination, and planning issues.

Assessments of safety culture and safety climate are especially important for reducing aviation accidents, incidents, and hazards. Remawi et al. (2011) used an employee safety survey to examine the relationship between Safety Management System (SMS) and employee attitudes towards unsafe acts in aviation. After SMS implementation, employees are more aware of safety issues. Gerstle (2018) compared aviation and healthcare safety. The article reviewed strategies used by the aviation and healthcare industries to reduce risk and improve safety. The strategies discussed are CRM, TEM, Swiss Cheese Model, Checklists, and Normalization of Deviance. Oster Jr. et al. (2013) reviewed the economic literature relating to aviation safety and identified emerging issues in airline safety. Aviation is the safest mode of commercial transportation, according to the study. The current environment requires a proactive, predictive, and systems-based approach rather than a reactive, incident-based approach. To plan and build an aviation big data platform, Dou (2020) discussed the impact of big data on the aviation industry and ideas and countermeasures. Due to the complexity of the aviation big data system, multilayer network correlation analysis should be used. Chen and Chen (2014) investigated the role of SMS, moral leadership, and self-efficacy in influencing pilots' safety motivation. Organizational factor was SMS, while group and individual indicators were morality leadership and self-efficacy. The effect of fleet managers' morality leadership on pilot safety behaviors is fully mediated by pilots' safety motivation.

2.2 Line Operations Safety Audit (LOSA)

LOSA is one of the safety management methodologies that is becoming more common and is being treated as an industry standard. Klinect et al. (2003) defined LOSA analogous to a "cholesterol check" during routine examination on an airline. LOSA provides a diagnostic snapshot of the safety performance during normal operations. The snapshot allows for a comparison of work-as-done versus work-as-imagined perspectives (Powell, 2021). Like a health check, LOSA does not provide a solution to a problem (Klinect et al., 2003) as it is the airline's responsibility to respond to the results and make changes to the operation. As a result, LOSA is a proactive measure rather than a line check (Earl et al., 2007; Khoshkhoo et al., 2013). LOSA is a non-risk assurance for pilots that covers all deficiencies in the Quick Access Recorder/Flight Data Recorder (QAR/FDR) programme and Line Check methods (Khoshkhoo et al., 2013). LOSA collects threat and error management (TEM) data during normal flight operations and can supplement existing data sources with additional information such as line evaluations, quick access recorders, voluntary incident reports, and accident investigation (Earl et al., 2007). The collected data will be analyzed, classified, and prioritized based on threats, errors, or undesirable states. This information assists in identifying performance gaps, highlighting best practices, and uncovering previously latent critical system anomalies during routine flight operations (Powell, 2021).

Earl et al. (2011) put into practice a single pilot operations variant of the multi-crew LOSA in Australia and New Zealand. According to the findings of the study, threats and errors occurred in roughly equal numbers during the pre-departure phase, descent/approach, and landing phase. This case study also revealed that pilots who verbalized their intentions are more aware and cautious when it comes to cross-checking, resulting in fewer mismanaged procedural errors. Powell (2021) performed LOSA during Aeromedical Evacuation (AE) en route care operations with the goal of analyzing, comparing, and reporting AE system threats, AE crew errors, and undesirable states. The research resulted in the creation of a logic LOSA model for military AE operational settings. Khoshkhoo (2018) customizes LOSA for dispatch operations (DOSA). Cultural activities to inform all steering committee and associated departments, selection and training of observers, design of observation forms, data collection, data processing, and finally report generation are all part of the adaptation. DOSA has successfully detected the capabilities and pitfalls of dispatch operational performances, such as threats and errors. McDonald et al. (2017), on the other hand, adapts LOSA to rail safety under the title Confidential Observation of Rail Safety (CORS). CORS differed slightly from LOSA in that the data collected was limited to TEM and the evaluation of behavioral markers was excluded to avoid a reduction in the program's initial acceptance. The initial results of the adaptation were promising, as it provides insight into the threats and errors that should be avoided, as well as the crew's performance in dealing with such issues.

2.3 Implementation of LOSA based on ICAO DOC 9803

ICAO DOC 9803 (2002) is a LOSA guidelines by International Civil Aviation Organization (ICAO) published in 2002. The document suggested the general steps that should be followed to set up a LOSA program from their experience in US Airways. The first is gathering information to understand the LOSA process, which it was suggested in the guidelines that information could be obtained from sources such as ICAO, The University of Texas and experience from other airlines conducted LOSA. The second step is to obtain interdepartmental support, where representatives from all potentially involved departments should be gathered for briefing to ensure the effective of LOSA and to avoid the feeling of being "threated" from the flight operations and training departments. A "LOSA steering committee" will be formed as the next step of LOSA implementation from the members of these departments, generally include safety, flight operations and flight training department and pilots union. The role of each department in the team are described in the table below.

Table 2.1 General roles of each department based on ICAO DOC 9803.

Department	Role
Safety Department	• Administrator of LOSA.
Flight operations and training departments	• Provide information on the area to concentrate. • Provide needed personnel. • Implement action plan from LOSA.
Pilots union	• Ensure support from the pilots. • Disseminate the results of the LOSA and inform pilots of any company decisions as the results of the LOSA.

The steering committee will identify the problem after the formation. Tips from ICAO DOC states that they should try to avoid working on many aspects at a time while the decisions should be based on data but not only instincts. Next step will be determining the number of segments to be observe. Based on the document, the number of flights that will be observed is a function of the number of people who will act as LOSA observers. This information will then use to form goals and action plan for the program which includes schedule audit dates, select observers and schedule training dates. The period for observation should not be available for an extended period as the result may be inaccurate. As for the criteria of observer, they should be among those who is familiar with the airline's procedures and operations and be able to occupy the cockpit jump-seat and capture data without being obtrusive and overbearing. The suggested period for training is two days, mainly focus on the method to fill in the rating forms using examples. Feedback should be provided to the observers periodically to reinforce well done area and improve the other area.

Chapter 3 : Research Methodology

3.1 Overview

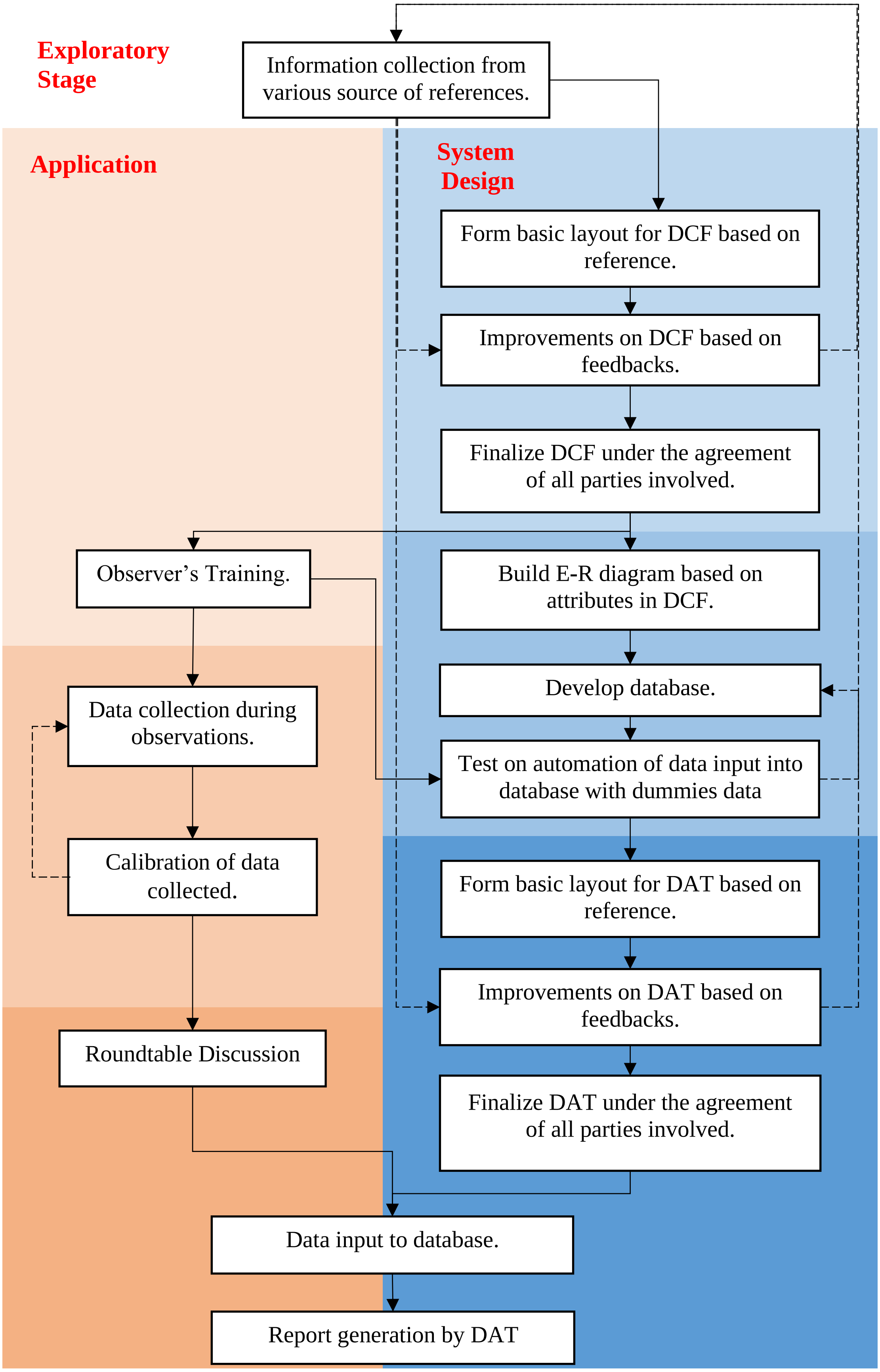


Figure 3.1 Flowchart for this research.

3.2 Information Collection on the Project

The primary goal of the study was to create a system to collect, store, and analyze data from observations of FOSA 2022 that include three airlines under MAB: Malaysia Airlines, FireFly and MASWings. Thus, the first step was gathering information from MAB as well as other sources such as ICAO DOC 9803, a sample DCF from Malaysia Airlines' LOSA 2017, a sample DCF from FireFly's LOSA 2017, a sample report from MAB's LOSA 2017, and a list of codes and abbreviations for LOSA 2017 on the requirements of the system to be developed.

EXAMPLES OF THE VARIOUS FORMS UTILIZED BY LOSA

LOSA Observation Form — EXAMPLE

Observer Information

Observer ID (Employee number)	*3059*
Observation Number	*#1*

Crew Observation Number (e.g., "1 of 2" indicates segment one for a crew that you observed across two segments)	*1*	Of	*1*

Flight Demographics

City Pairs (e.g., PIT-CLT)	*PIT - LAX*			
A/C Type (e.g., 737-300)	*B-757*			
Pilot flying (Check one)	CA		FO	*X*

Time from Pushback to Gate Arrival (Hours:Minutes)		*4:55*	
Late Departure? (Yes or No)	*Yes*	**How late?** (Hours:Minutes)	

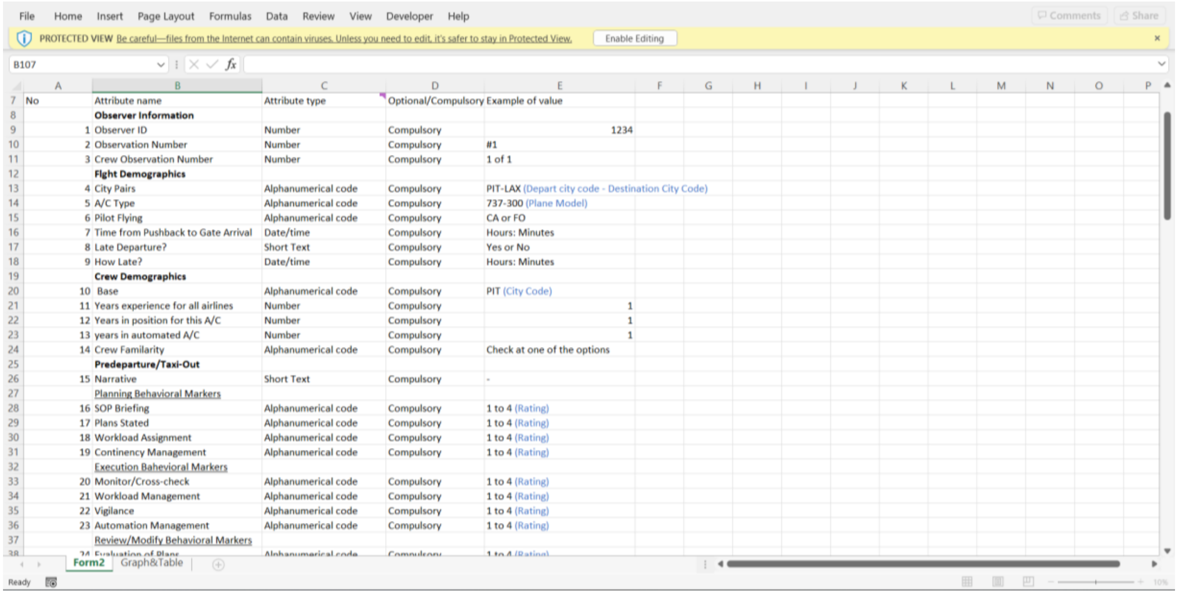
Crew Demographics

	CA	FO	SO/FE	Relief 1	Relief 2
Base	*PIT*	*PIT*			
Years experience for all airlines	*35*	*5*			
Years in position for this A/C	*7*	*1 month*			
Years in automated A/C (FMC with VNAV and LNAV)	*12*	*1 month*			

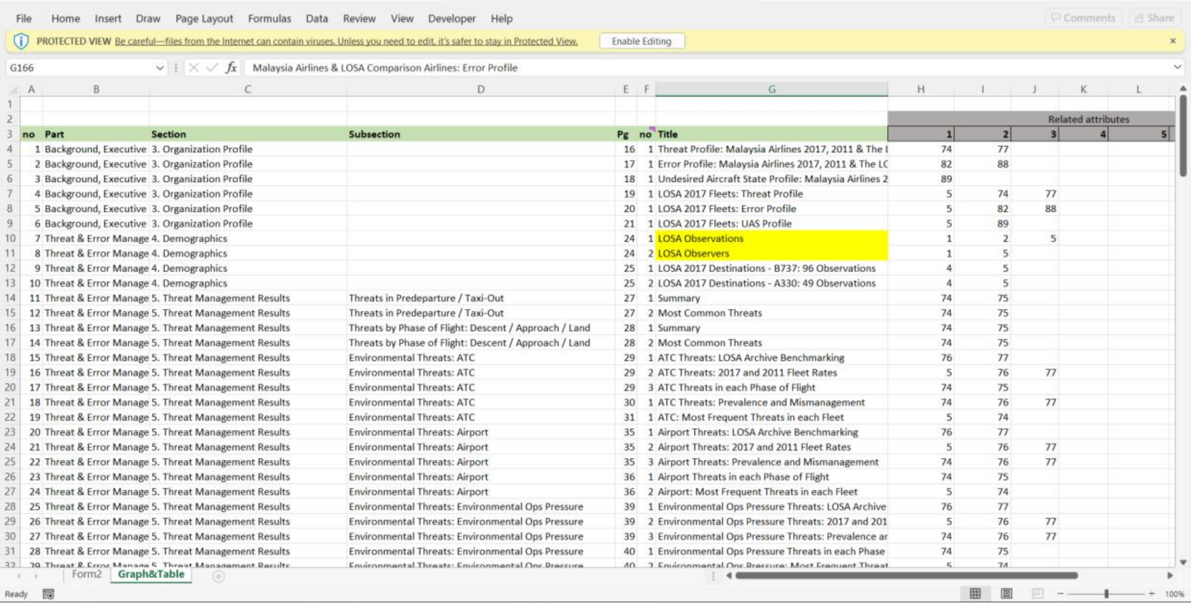
Crew Familiarity (Check one)	**First LEG the crew has EVER flown together**	
	First DAY the crew has EVER flown together	
	Crew has flown together before	*X*

Figure 3.2 Sample DCF obtained from MAB. (International Civil Aviation Organization (ICAO), 2002)

All the samples of DCF and report collection were studied and compared, at the same time, discussions were made with representatives from MAB on their preference to build a more customized forms and reports. To facilitate database development, an Excel spreadsheet with all of the questions and sample answers from the sample DCF was created with the attribute type and example of value filled in was determined. The graph and tables in the sample report too had been analyzed and the details were tabulated in an Excel spreadsheet that listed down the related attribute of each table in the report as a base for report design.



No	Attribute name	Attribute type	Optional/Compulsory	Example of value
	Observer Information			
1	Observer ID	Number	Compulsory	1234
2	Observation Number	Number	Compulsory	#1
3	Crew Observation Number	Number	Compulsory	1 of 1
	Flght Demographics			
4	City Pairs	Alphanumerical code	Compulsory	PIT-LAX (Depart city code - Destination City Code)
5	A/C Type	Alphanumerical code	Compulsory	737-300 (Plane Model)
6	Pilot Flying	Alphanumerical code	Compulsory	CA or FO
7	Time from Pushback to Gate Arrival	Date/time	Compulsory	Hours: Minutes
8	Late Departure?	Short Text	Compulsory	Yes or No
9	How Late?	Date/time	Compulsory	Hours: Minutes
	Crew Demographics			
10	Base	Alphanumerical code	Compulsory	PIT (City Code)
11	Years experience for all airlines	Number	Compulsory	1
12	Years in position for this A/C	Number	Compulsory	1
13	years in automated A/C	Number	Compulsory	1
14	Crew Familarity	Alphanumerical code	Compulsory	Check at one of the options
	Predeparture/Taxi-Out			
15	Narrative	Short Text	Compulsory	-
	Planning Behavioral Markers			
16	SOP Briefing	Alphanumerical code	Compulsory	1 to 4 (Rating)
17	Plans Stated	Alphanumerical code	Compulsory	1 to 4 (Rating)
18	Workload Assignment	Alphanumerical code	Compulsory	1 to 4 (Rating)
19	Continency Management	Alphanumerical code	Compulsory	1 to 4 (Rating)
	Execution Bahevioral Markers			
20	Monitor/Cross-check	Alphanumerical code	Compulsory	1 to 4 (Rating)
21	Workload Management	Alphanumerical code	Compulsory	1 to 4 (Rating)
22	Vigilance	Alphanumerical code	Compulsory	1 to 4 (Rating)
23	Automation Management	Alphanumerical code	Compulsory	1 to 4 (Rating)
	Review/Modify Behavioral Markers			
24	Evaluation of Plans	Alphanumerical code	Compulsory	1 to 4 (Rating)



no	Part	Section	Subsection	Pg	no	Title	Related attributes 1	2	3	4	5
1	Background, Executive	3. Organization Profile		16	1	Threat Profile: Malaysia Airlines 2017, 2011 & The L	74	77			
2	Background, Executive	3. Organization Profile		17	1	Error Profile: Malaysia Airlines 2017, 2011 & The LC	82	88			
3	Background, Executive	3. Organization Profile		18	1	Undesired Aircraft State Profile: Malaysia Airlines 2	89				
4	Background, Executive	3. Organization Profile		19	1	LOSA 2017 Fleets: Threat Profile	5	74	77		
5	Background, Executive	3. Organization Profile		20	1	LOSA 2017 Fleets: Error Profile	5	82	88		
6	Background, Executive	3. Organization Profile		21	1	LOSA 2017 Fleets: UAS Profile	5	89			
7	Threat & Error Manage	4. Demographics		24	1	LOSA Observations	1	2	5		
8	Threat & Error Manage	4. Demographics		24	2	LOSA Observers	1	5			
9	Threat & Error Manage	4. Demographics		25	1	LOSA 2017 Destinations - B737: 96 Observations	4	5			
10	Threat & Error Manage	4. Demographics		25	2	LOSA 2017 Destinations - A330: 49 Observations	4	5			
11	Threat & Error Manage	5. Threat Management Results	Threats in Predeparture / Taxi-Out	27	1	Summary	74	75			
12	Threat & Error Manage	5. Threat Management Results	Threats in Predeparture / Taxi-Out	27	2	Most Common Threats	74	75			
13	Threat & Error Manage	5. Threat Management Results	Threats by Phase of Flight: Descent / Approach / Land	28	1	Summary	74	75			
14	Threat & Error Manage	5. Threat Management Results	Threats by Phase of Flight: Descent / Approach / Land	28	2	Most Common Threats	74	75			
15	Threat & Error Manage	5. Threat Management Results	Environmental Threats: ATC	29	1	ATC Threats: LOSA Archive Benchmarking	76	77			
16	Threat & Error Manage	5. Threat Management Results	Environmental Threats: ATC	29	2	ATC Threats: 2017 and 2011 Fleet Rates	5	76	77		
17	Threat & Error Manage	5. Threat Management Results	Environmental Threats: ATC	29	3	ATC Threats in each Phase of Flight	74	75			
18	Threat & Error Manage	5. Threat Management Results	Environmental Threats: ATC	30	1	ATC Threats: Prevalence and Mismanagement	74	76	77		
19	Threat & Error Manage	5. Threat Management Results	Environmental Threats: ATC	31	1	ATC: Most Frequent Threats in each Fleet	5	74			
20	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Airport	35	1	Airport Threats: LOSA Archive Benchmarking	76	77			
21	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Airport	35	2	Airport Threats: 2017 and 2011 Fleet Rates	5	76	77		
22	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Airport	35	3	Airport Threats: Prevalence and Mismanagement	74	76	77		
23	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Airport	36	1	Airport Threats in each Phase of Flight	74	75			
24	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Airport	36	2	Airport: Most Frequent Threats in each Fleet	5	74			
25	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Environmental Ops Pressure	39	1	Environmental Ops Pressure Threats: LOSA Archive	76	77			
26	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Environmental Ops Pressure	39	2	Environmental Ops Pressure Threats: 2017 and 201	5	76	77		
27	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Environmental Ops Pressure	39	3	Environmental Ops Pressure Threats: Prevalence ar	74	76	77		
28	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Environmental Ops Pressure	40	1	Environmental Ops Pressure Threats in each Phase	74	75			
29	Threat & Error Manage	5. Threat Management Results	Environmental Threats: Environmental Ops Pressure	40	2	Environmental Ops Pressure: Most Frequent Threat	5	74			

Figure 3.3 Excel spreadsheets that listed down the questions and graphs in the sample DCF and report. The full tables are included in Appendix.

3.3 Design of Data Collection Form

A basic layout based on Malaysia Airlines' LOSA 2017 DCF was first created on Microsoft Excel VBA to help MAB visualize the DCF. To build a more customize form for FOSA 2022, modifications and improvement were made on a continuous basis through feedback from user and discussions among the representatives of various parties and department that involved in the project.

In the early stages of DCF development where there are still many rooms of modifications on the DCF, online meetings were conducted every day to update the progress and obtain feedbacks from the individuals involved. A duration of five weeks was taken to finalize the layout and question to be included in DCF, which the improvements started to focus on optimizing user experience and reducing user’s error in filling in the DCF. The frequency of online meetings was reduced to once every fortnight to update the development of the system. A total 30 significant improvements were done since the formation of basic layout on 13th of August 2021 until the latest modifications on the 27th of May 2022. The final DCF consists of nine main sections for data collection and additional four sections for reference. The nine main sections include Demographics, Threat Management, Error Management, five Flight Phases, and Overall Evidence Based Training (EBT) Ratings while the four reference sections include the revised Threat Codes List, Error Codes List, Undesired Aircraft States (UAS) Codes List and EBT Competency Rating List.

Demographics sections were separated into three sub-sections: Observer Information, Flight Demographics and Crew Demographics. Observer Information record the information of the observer, Flight Demographics record the information of the flight, while Crew Demographics record information of the pilot of the flight. To speed up observer’s process when filling in the form and to ensure error-free data, most of the answer are in the form of drop-down lists, option buttons, checkboxes, or limit to only numerical value inside the answer spaces by utilizing VBA. Below are some error-free precautions taken:

1. For certain numerical value answer, an error message will pop-out and the invalid answer will change to red when incorrect format was filled into the answer space as a reminder for the user.

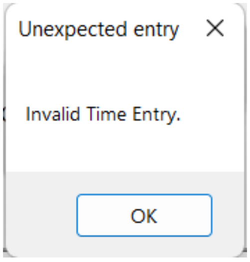


Figure 3.4 Error message to remind the user.

Figure 3.5 Answer change to red when an invalid answer was filled in.

2. Some of the numerical values will be formatted automatically.

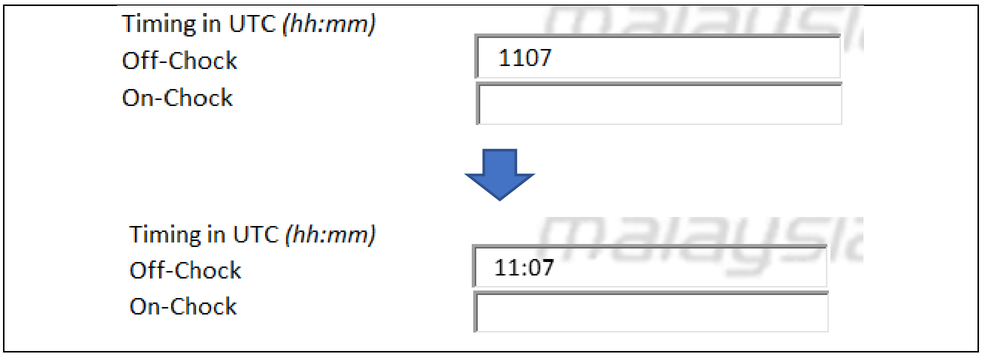


Figure 3.6 The answer converts to format "hh:mm" automatically.

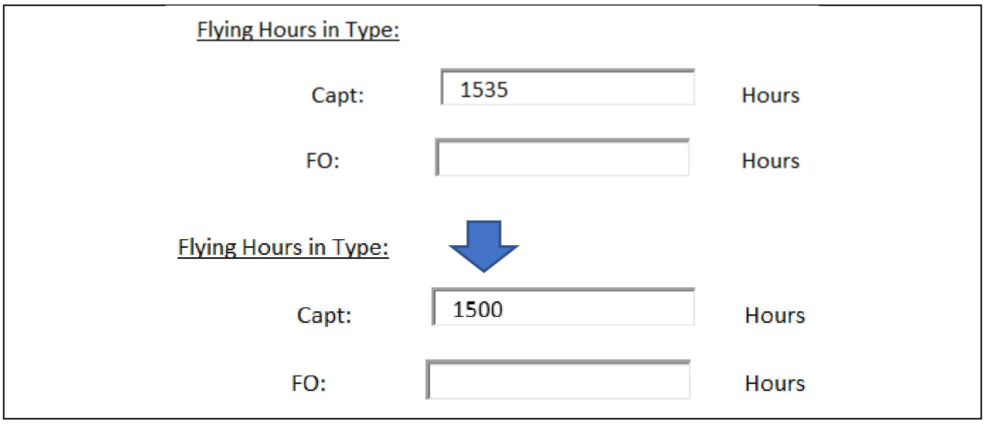


Figure 3.7 The answer round-off to the nearest one hundred automatically.

3. Sections that will only enable when the previous question are true.

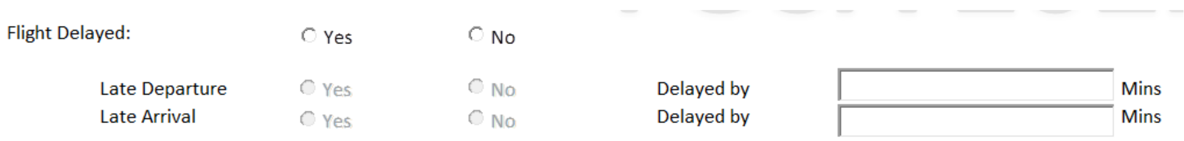


Figure 3.8 Late departure and Late Arrival will only enable when Flight Delayed are true.

Threat Management and Error Management section consist of tables that allows user to record threat and error observed during flight where it only allows any modification on data using the “Add New Threat/Error”, “Edit Threat/Error” or “Delete Threat/Error” button on the upper section of the page. A pop-out sub-form will appear when “Add New Threat/Error” or “Edit Threat/Error” button was clicked to allow user to do modifications on the data. An error message will appear when observer add or edit a data entry with blank required field.

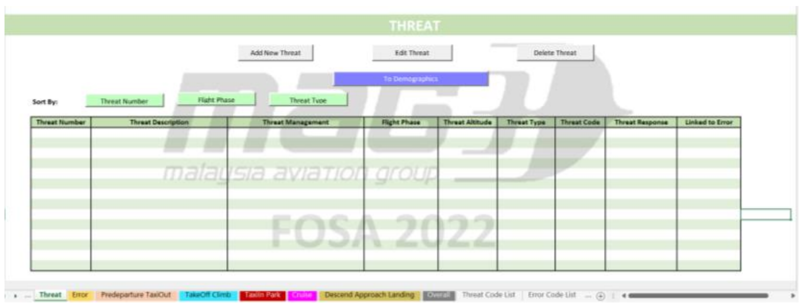


Figure 3.9 Threat table.

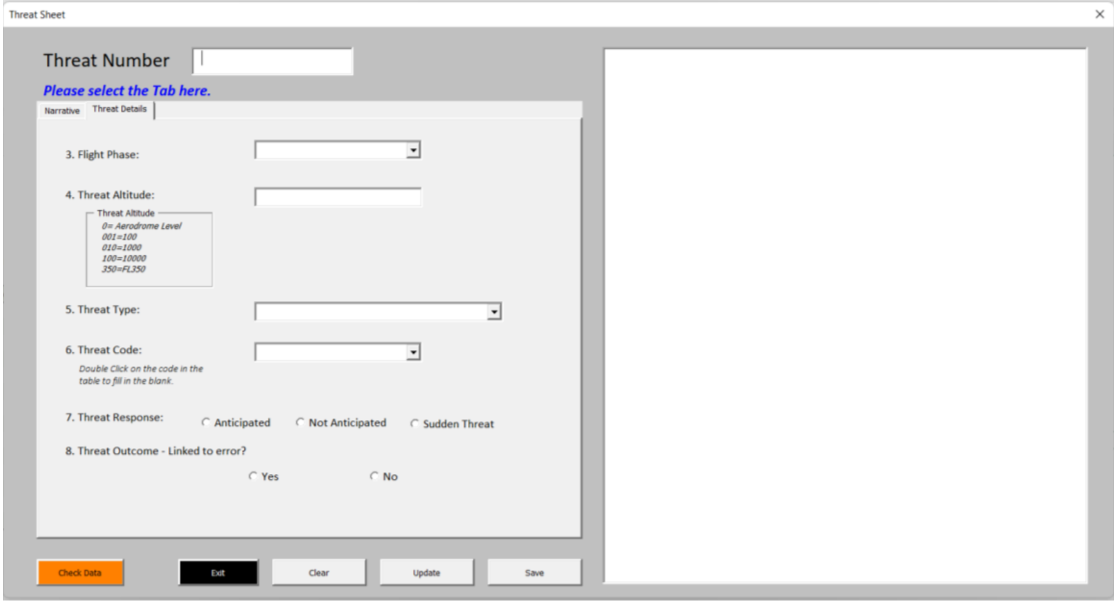


Figure 3.10 Pop-out Forms for threat, the blank space in the right will show list of Threat Code with description.

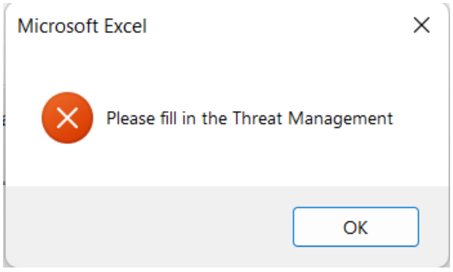


Figure 3.11 Error message to ensure all required field are filled.

The five Flight Phases include Predeparture/Taxi-Out, Take-Off/Climb, Cruise, Descend/Approach/Landing and Taxi-In/Park. Flight phases section contain a narrative space to allow observer to describe pilot's performance during the flight phase. "Add New Threat/Error" were included inside the section to ease the observer when they discover any error or threat when filling in the narration space. There is a "Check Data" button as well where a pop-up window that connect to the table in the Threat and Error Management tables as reference for the observer.

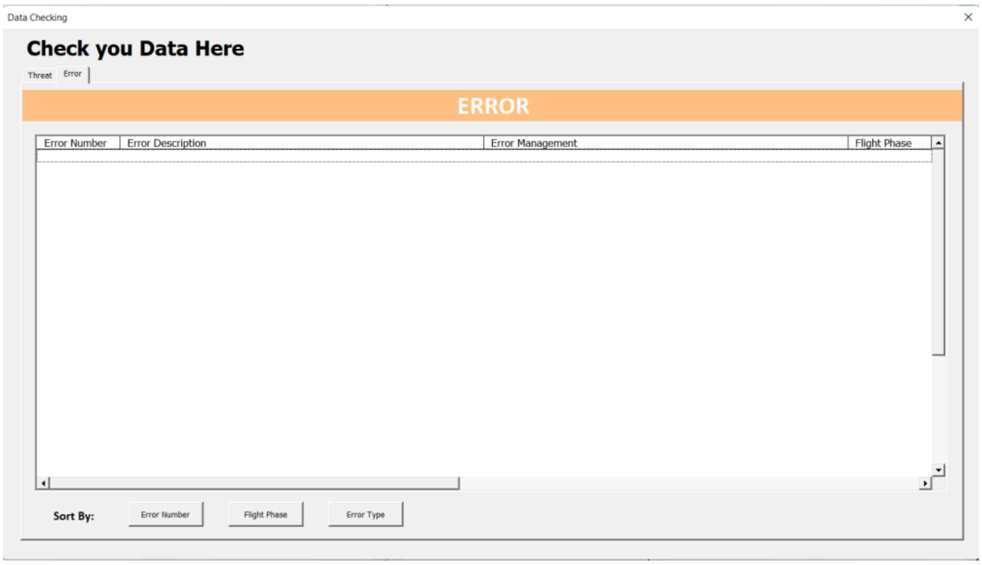


Figure 3.12 Pop-up windows to check data.

The Overall section too contains a narrative space for the observer to describe the overall performance of the pilot. A table that contains the list of EBT ratings and its description are provided at the right side of the section. The table will show the details of the competency selected to ease the observer.

3.4 Training of Observers

The total one training were carried out and it takes a total of three days. The number of participants include 13 pilots from FireFly, 9 from MASwings and 20 from Malaysia Airlines. The trainers selected for the training are generally experienced pilots, are the trainers for pilots, are CRM instructors and attended training in LOSA as observer before. As for preparations, an introductory video was taken in simulators from the perspective of the observers to show to the trainees what will they need to do. Several videos that show how threat and error are managed or mismanaged were also prepared as example for the trainees. A guideline on the features of DCF is also distributed to the trainees as handouts.

The first day of the training generally covers the introduction on the program, include safety briefing, introductory video, introduction on data collection tool, TEM and EBT competencies. The second day of the training went into more details on threat and error management where the videos were shown to the trainees for discussion to strengthen the concepts and memory. The final day of the training started with the recap of yesterday and more videos of managed and mismanaged error and threat were shown to trainees and quizzes were done to further plunge the concepts into the trainee's memory. The session then moved the focus to UAS, most common mistakes on DCF, example of good and bad narratives for the flight phases and the calibration schedule.

Figure 3.13 Photo taken during observer's training.

3.5 Observation

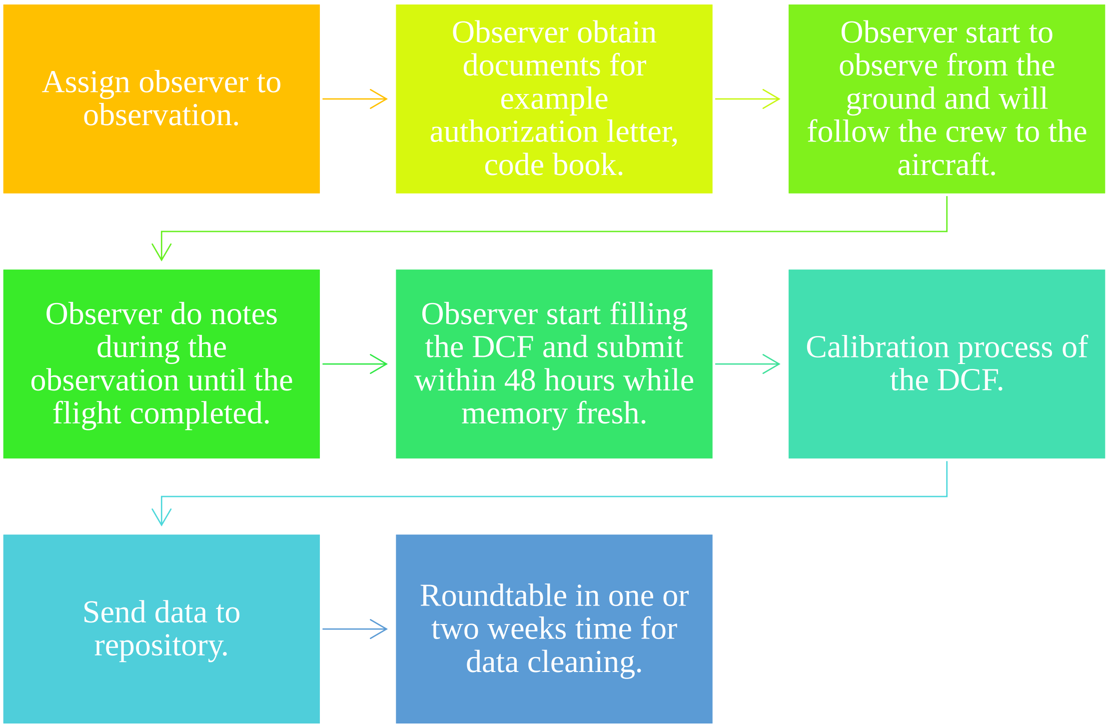


Figure 3.14 Process flow of observation.

Certain criteria need to be fulfilled to be registered as a FOSA observer. The observer needs to be currently flying in the aircraft to be observe and need to have minimum 300 hours of experience on the aircraft. Line pilots are to be chosen, which they must not currently hold any position as trainer, management, senior pilot in the sense that they not doing involved in some work or projects within the company. This is to avoid 'angelic performance' of the pilot which may affect the result. The FOSA observation should capture normal performance of the pilot to obtain that are reasonable. For current FOSA, 22 observers were chosen, however, two of the observers failed to report to the observation due to COVID-19.

There are some rules that should be follow by the observers during the observation. First, observer has to ask permission from the crew before start. Next the observer should not participate into the conversation between crews during the flight but only observing the crews until the flight completed. Thirdly, the observer should not give any feedback to crew even though the crew asking for it. The submission of DCF should be within 48 hours after the flight and the further amendments during the calibration on the DCF need to be done within 7 days after reporting in KLIA.

Malaysia Airlines done their observation of the first two sectors in February and subsequent sectors in March until June which covered for about 200 sectors. Observation reports were de-identified as pilot name, date of flight and aircraft registration number were not collected. Only the sector, aircraft type, pilot experience in hours and year on the fleet were recorded for analysis purpose.

3.6 Roundtable Discussion

Figure 3.15 Process flow of roundtable discussion.

A "correct" observation should be in accordance to laid down policies within the operation manual. The operation manual is the guide for the pilot on the correct action and the timing of the action, as well as the reason behind every action. Thus, the observation results should be aligned with the policies and procedures within the operation manual. Another characteristic of a "correct" observation is it should not be ambiguous. The action much be either right or wrong. As for the evaluator in the roundtable discussion, they should understand the aim and the goal of the project and also should be experience pilot in senior position, either holding position within training department or fleet department.

The discussions usually take one working day, which consist of two sessions and will be done physically to ensure effectiveness and within the timeline. There is no specific requirement on how many evaluators are needed per observation, however, a minimum of one representative from each department are required when doing roundtable discussion.

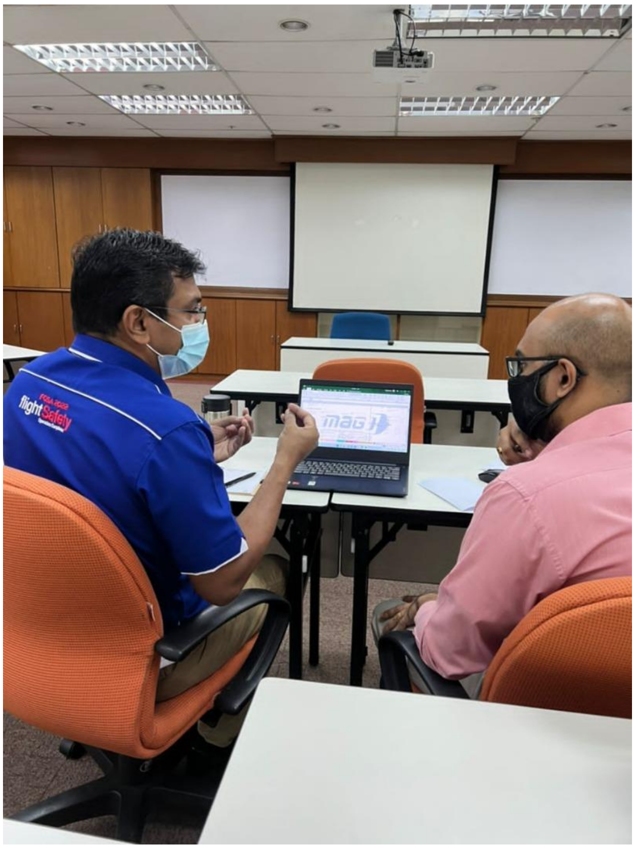


Figure 3.16 One-to-one calibration session during roundtable discussion.

3.7 Design of Database

3.7.1 Database Development

FOSA stores the collected information in a relational database. A relational database is a database that stores and makes data points connected to one another available. It is based on the relational model which represents data in tables. Each row in a relational database is a record with a unique key. The columns of the table carry data attributes, and each record typically includes a value for each attribute, making it simple to construct links between data points.

The entity relationship diagram was identified first in order to build the database, as shown in Figure 3.17. Briefly describe, trained observers make observations on selected flights. During the observation, information on the incidence of error, threat, and UAS is recorded in addition to the flight and pilot details. Error and threat are interconnected, and their causal links are highlighted anytime such information is offered in the observation. When compared to errors and threats, UAS is more of a result of the former elements. To assist further analysis, any error, threat, or UAS detected is classified using predefined categories.

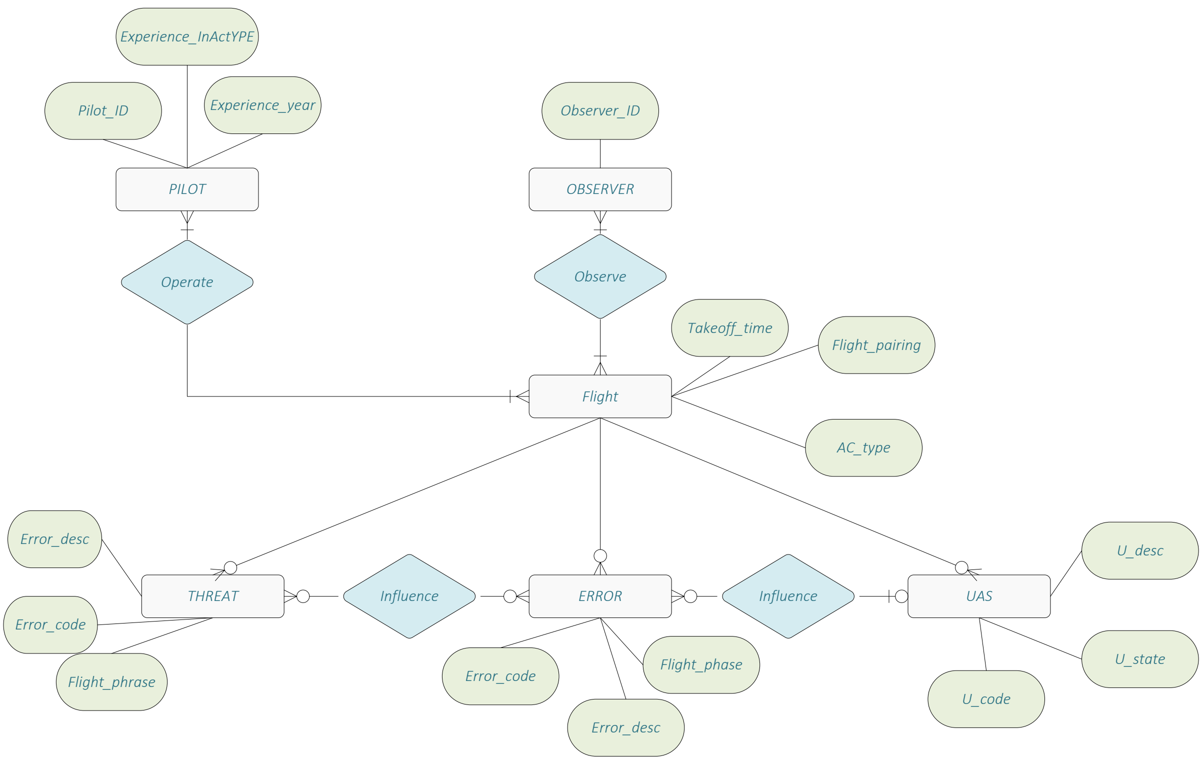


Figure 3.17 E-R diagram (only maximum 3 attributes are shown per entity).

3.7.2 Database Object Identification

Based on the E-R diagram (Figure 3.16), database objects were identified. The main database object is flight where observation will be made. Therefore, a table named TbObservation is constructed. During the observation, detected threats and errors will be recorded, and multiple recordings are possible. Consequently, two tables, TbThreatManagement and TbErrorManagement are built. One error at most will lead to a UAS, therefore a separate table to keep UAS triggered by an error is not required, as the information can be treated as attribute(s) to TbErrorManagement.

3.7.3 Normalization

Next, these three tables underwent normalization process. Normalization is the process of arranging a database so that the tables are connected where appropriate and flexible for future development. Normal forms are sets of rules that are employed in normalization. If the database architecture adheres to the first set of rules, it is regarded to be in the first normal form, or 1NF. The database is considered to be in the third normal form, or 3NF, if the first three sets of normalization rules are obeyed. The normalized tables are presented in Figure 3.17. Because there was no repeating information in any of the tables, they are said to be in their first normal form (1NF) already.

Taking the tables to their second normal form (2NF) entails determining the primary keys and ensuring that the fields in the tables are connected. Each table's primary keys are identified. For example, ObID is the primary key for TbObservation, while ErrorLogID is the primary key for TbErrorManagement. Both primary keys are long-integer auto-numbers that generate a counter that is automatically increased. To convert the tables to the third normal form (3NF), the tables were evaluated to determine if there were any more fields that could be broken down further and were not dependent on a key. As mentioned, information categorization facilitates data analysis. To meet the 1NF, three additional tables, namely TbThreat, TbError and TbUAS are built to store this information (categories and their description). Pilot information, such as years of experience (in flight or aircraft type), is provided in the TbObservation as the status of the pilot is collected when the observation is made. The third normal form is usually sufficient for removing redundancy while yet allowing for flexibility and expansion.

One-to-one connections, one-to-many relationships, and many-to-many relationships are all types of table relationships. A key appears just once in a linked table in a one-to-one relationship. Keys from one table appear several times in a related table in a one-to-many relationship, whereas the primary key in the second table appears many times in the first table in a many-to-many relationship. The many-to-many relationship of ten presents complications in real examples of normalized databases, thus many-to-many relationships should be broken down into a succession of one-to-many relationships. According to the definitions above, most relationships are one-to-many: One record (observation) in TbObservation collects various threats (TbThreatManagement) and errors (TbErrorManagement); the same threat/error code (TbThreat or TbError) may apply to several records of threats (TbThreatManagement) or errors (TbErrorManagement) (TbErrorManamgent). As the information provided is for reference purposes, TbStation data is informally linked to TbObservation.