The Study of Aviation Weather Hazards in Thailand

Watana Manon

College of Aviation Development and Training, Dhurakij Pundit University, Bangkok, Thailand
E-mail: watana.man@dpu.ac.th

Abstract

The objectives of this qualitative research were to study types of aviation weather hazards that are harmful to aviation in Thailand and to propose guidelines on the use of meteorological information for flight safety. This study used qualitative research methods that included Purposive Sampling. Informants were divided into 2 groups: (1) meteorological information services; a person who has knowledge and experience in aviation meteorology from the Thai Meteorological Department under the Ministry of Digital Economy and Society, of which offices are located in both central and provincial areas across Thailand, and (2) meteorological information services users; this group consisted of various groups of people, such as Pilots, Flight Operations Officers/Flight Dispatcher, Air Traffic Controllers from various agencies such as Thai AirAsia, Thai Smile Airways, Thai Lion Air, Nok Air, and Aeronautical Radio of Thailand Ltd. The researcher applied data from the interviews and analyzed those data using the Content Analysis method by considering the main and sub-issues to find a conclusion of the research. The research findings showed that the types of aviation weather hazards in Thailand are heavy rain, which will have a dangerous effect on flying such as reducing visibility below 1 kilometer, followed by Cumulonimbus clouds and thunderstorms, turbulence, and gust winds (strong gust wind), as well as the formation of low cloud bases (low ceiling) and low visibility as well. Besides, proposing the guidelines considering the use of meteorological information for flight safety is to improve the meteorological information service system by simply using and completing information with modern innovations for accurate weather observation and forecasting to support the safety of air transportation.

Keywords: *Aviation weather, Weather hazards*

1. Introduction

The aviation industry takes a part in driving economic growth with a large number of social, industrial, tourism, and related activities. Thailand is one of several countries where the aviation industry has played a major part in growing tourist numbers. In 2019, more than 160 million tourists traveled by air through Thailand's airports (Civil Aviation Authority of Thailand, 2020), resulting in more than 2 trillion baht, and tourists traveling by air were due to many reasons such as less time-spent and safer travel than other transport means. Both full-service and low-cost airlines were fully operated, encouraging passengers to have the option to use the service according to their potential. As a result, the number of air passengers had increased in each region, especially passengers from many countries in the Asia-Pacific region with more passengers than the other part of the world.

In Thailand, the number of passengers traveling by air is also increasing, especially at major airports. The number of flights at each of The Airports of Thailand Public Company Limited for the year 2019, with the number of passengers at all 6 airports are Suvarnabhumi, Don Mueang, Phuket, Chiang Mai, Hat Yai, and Mae Fah Luang, Chiang Rai in the 12th period of 2019 (Jan-Dec), the total number of passengers was 142.98 million, 1.8% increased as compared with the same period last year, with 85.82 million international passengers that was increased by 6.1% and 57.18 million domestic passengers, which decreased by 3.6 %. Two airports were reported with decreased passenger numbers: Hat Yai with 3.89 million passengers, a decrease of 8.4%, and Phuket at 18.11 million, 0.6% down. The other four airports showed increased passenger numbers, the highest at Suvarnabhumi at 65.42 million, the second-highest was Chiang Mai with 11.33 million people or 3.1% up, Mae Fah Luang Chiang Rai was 2.92 million, increased by 2.1%, and Don Mueang at 41.31 million people by 1.4 % increased.

Besides, there are airports under the supervision of the Department of Airports (DOA), Ministry of Transport, which are spread across all regions and have a total of 17,921,877 passengers.

Moreover, as the number of passengers using the airports is increasing, the number of flights used to transport passengers will also increase each year. In 2019, the total number of flights operated was 1,045,741 flights (Aeronautical Radio of Thailand, Ltd., 2020), and due to the increased number of flights, there is an increased risk of air transport safety. Data from the Bureau of Aircraft Accidents Archives (B3A) showed that between 2010 and 2019, a total of 8,115 passengers and crew members died in aircraft accidents.

Aviation accidents, especially those of airline passengers, are caused by many factors such as human error, mechanical factors, management factors such as aviation safety management, air traffic management, and other important factors uncontrolled by humans. However, it is possible to avoid confrontation, which is the environmental factor (Thanyapawee, 2016) that creates many losses of life and property to the world's aviation industry each year, especially in Thailand, which locates in the tropical zone and has coastal areas. The high humidity, along with quite hot air temperature, causes severe weather that is always dangerous to flying, such as thunderstorms, hailstorms, heavy rain, strong wind gusts, thick fog, and low ceiling/low visibility. These hazards cause harm or delays for taking off and landing of the aircraft. The United States is damaged by weather conditions directly or indirectly by millions of baht per year. The proportion of severe weather conditions that resulted in an accident involving the aircraft made the researcher interested in studying the aviation weather hazards in Thailand.

Several accidents in Thailand were caused by severe weather, such as the accident of Thai Airways flight TG261 from Bangkok to Surat Thani at around 8.00 PM on December 11, 1998. The Airbus A 310-300 was approached to Surat Thani Airport during the Depression "Jill" covering the area. The aircraft crashed to the ground, killing 101 people and seriously injuring 45 people, and only 45 survived (Ranter, 2013). Another incident was one-two-go airliner flight OG269 from Don Mueang Airport to Phuket Airport. On September 16, 2007, around 4:00 PM, an MD-82 with 123 passengers was running out of the runway during strong gust winds and heavy rain, resulting in 90 killed and 41 injured (Ministry of Transport, 2009).

Therefore, for air transport from airports to airports in different regions of the country, it is necessary to provide weather information for the departure, destination, and alternate airports for flight planning and safety of each flight since weather factors are one of the factors that affect the safety of air travel and must be studied and prepared as completely as possible on each flight.

As mentioned above, the researcher was interested in studying aviation weather hazards in Thailand that will affect the safety of all flights to airports in each region, and need to know types of weather hazards such as turbulence, thunderstorm, low ceiling/low visibility, low-level wind shear, as well as the complete and adequate information to help relevant parties such as weather forecasters, flight operations officer/flight dispatcher, and air traffic controllers who provide information and advises the pilot who controls the aircraft to make a decision and fly during severe weather conditions to ensure safety, efficiency, and economy.

2. Objectives

1) To study the types of aviation weather hazards that are harmful to aviation in Thailand
2) To propose the guidelines for the use of aviation meteorological information for flight safety

3. Materials and Methods

To research Aviation Weather Hazards in Thailand, the researcher has established a research methodology or research process by using a qualitative research process, which consisted of

- Documentary Research
- In-depth interview

In this respect, the researcher set out the framework and scope of the research methodology and the key reasons for applying the above-mentioned methodology to conduct this research, which is summarized as follows:

3.1. Research Method

To determine the methodology for this research, the researcher has established a methodology by using qualitative research processes including the process of studying and analyzing data from documentary research and in-depth research processes for applying the above-mentioned methodology or research processes to conduct the following summarized research.

3.1.1 Documentary Research

To determine the methodology by using qualitative research processes with document research, the researcher initially conducted research processes based on the methodology by studying and analyzing data from documents or documentary research by reviewing concepts, theories, and literature related to aviation weather hazards in aviation. The definition of aviation weather conditions that are dangerous to fly consists of

1) Concepts related to aviation meteorology
2) Meteorological elements (Thongtaptim, W.,& Manon, W.,2019)
3)Weather hazard conditions that are dangerous to fly
4) Related Research
5) Research conceptual framework

In relation to the implicit considerations of philosophical concepts. The meaning of weather hazard conditions that are harmful to aviation has been carried out in studies from academic papers, research papers, and academic articles relating to extreme weather hazards in aviation, including various types of domestic and academic documents from abroad as well as academic information obtained through electronic media searches or websites.

(1) Concepts related to aviation meteorology included Aviation History and Theory History of the International Civil Aviation Organization, aviation safety practices and recommendations, and standards and guidelines for aviation meteorological data.

(2)Aviation meteorological elements included Aviation meteorological information containing the composition of meteorological compounds in accordance with the International Civil Aviation Organization and World Meteorological Organization, including surface wind, visibility, present weather, clouds, temperature and dew point temperature, and pressure (International Civil Aviation Organization, 2010).

(3) Concepts of extreme weather hazards in aviation included Turbulent, Icing, Cumulonimbus clouds, and heavy rain.

Related research included studies on extreme weather hazards in aviation, as well as guidelines for actions to reduce the risk of severe weather.

3.1.2 In-depth Interview

To determine the methodology using qualitative research processes with in-depth interviews, this research has established a methodology process. The structure of the questions was semi-structural interviews or guided interviews, that are, uniformly structured interviews or open-ended interviews, which are flexible and open methodology or keywords used to guide interviews. In other words, open-ended questions with keywords were drafted along with the characteristics of flexible questions and were ready to modify the wording of the questions to be consistent with each participant in the research or interviewer in each situation or with a changing environment. Academics and individuals who are important or involved in the security of all aviation industries, whether an aviation meteorological information provider or a user of the Aviation Meteorological Information Service, answer in-depth interview questions. The in-depth interviews provided diverse information in different dimensions and practical facts, including depth and width dimensions concerning promoting the participation of individuals who conduct in-depth interviews.

3.2. Populations and samples used in research

To determine the methodology by using qualitative research procedures, the population and samples were defined from meteorological information providers and users of meteorological information services to know the implications of philosophical concepts as well as concepts and processes or mechanisms regarding the effects of aviation weather hazards. The researcher used a purposive random selection process and manually selected the samples to obtain the information from the qualitative research process and continued to process the data leading to the discovery.

The Qualitative Research defined the populations and samples for in-depth interviews from meteorological information providers and users of meteorological information services during August-November 2020 as follows:

3.2.1 Samples: Meteorological information provider

The samples were Meteorological information providers, including 6 experts from the Thai Meteorological Department.

1) Aeronautical Meteorology Division, 1 meteorologist
2) Northern Meteorological Center, 1 meteorologist
3) Northeastern Meteorological Center, 2 meteorologists (Upper and Lower region)
4) Southern Meteorological Center, 2 meteorologists (East Coast and West Coast)

3.2.2 Samples: Meteorological Information User

The samples from the users of the meteorological data service consisted of 19 persons who used meteorological information as well as:

1) 8 Pilots from Thai AirAsia, Thai Smile Airways, Thai Lion Air, and Nok Air (2 pilots per airline)
2) 4 Flight Operations Officer/Flight Dispatcher from Thai AirAsia, Thai Smile Airways, Thai Lion Air, and Nok Air (1 Flight Operations Officer/Flight Dispatcher per airline)
3) 7 Air traffic controllers from Aeronautical Radio of Thailand Ltd., which located at Don Mueang Air Traffic Control Tower, Suvarnabhumi Air Traffic Control Tower, Chiang Mai Air Traffic Control Tower, Khon Kaen Traffic Control Tower, Ubon Ratchathani Traffic Control Tower, Hat Yai Air Traffic Control Tower, and Phuket Air Traffic Control Tower.

The researcher established the criteria for selecting samples for use in the qualitative research through in-depth interviews with key criteria for determining the sample selection as follows.

1) Individually available samples with knowledge and understanding of the provision of meteorological information in accordance with the standards prescribed by the International Civil Aviation Organization(ICAO) and the World Meteorological Organization (WMO).
2) Samples with characteristics are individuals who use meteorological information services in accordance with the standards prescribed by the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO).

3.3 Research Tools

Regarding appropriate tools for determining this methodology, the researcher has established a process by using qualitative research. Documentary Research is a tool used to collect information and is based on academic papers, textbooks, and various types of research, including information from electronic media research or information obtained from internet websites. To use it in the process of establishing the basics of academically integrated knowledge on aviation weather hazards, first of all, it is important to lead to the creation of tools that can be used in the process of effective academic data collection.

Another tool used to collect information based on qualitative research is an in-depth interview that designs the structure of questions that can be used in semi-structured interviews or guided interviews, which are unconstitutional interviews of clear questions. It is a research process that results in flexible and open questions, especially for individuals who are knowledgeable and skilled or specialize in subjects that are conducting research procedures. This process provides opportunities for knowledgeable and skilled people to do. You can express your opinions in a variety of ways. The researcher or interviewer can conduct the interview and can inquire, follow, and sort out the facts or subtleties that are important and interesting in each point of the answer. The in-depth interview allows for the acquisition of diverse data in different dimensions and practical facts, including the depth and dimension of the subject in which the research process is conducted.

4. Results and Discussion

Research on aviation weather hazards in Thailand is qualitative research, which aims to study the types of aviation weather hazards that are harmful to aviation in Thailand and to propose the guidelines for the use of meteorological information for flight safety. The researcher studied factors related to aviation

meteorological information from operational stakeholders, including weather information providers, meteorologists, and users of the information services. A total of 25 samples provided an insight into the operations involved in providing or using the Meteorological Information Service, which provides data collection tools, including open-ended questionnaires that can summarize and analyze data.

4.1 Summary of findings

According to the study, the researcher summarized the findings for a given purpose.

4.1.1 Results of analyzing the general data of key informants

Of 25 interviewees, 16 were males (64.0%) and 9 were females (36.0%). 7 samples (28.0%) aged between 26-30 years old, 6 samples (24.0%) aged between 31-37, 5 persons (20.0%) aged between 38-45, 3 person (12.0%) aged between 46-50, and 4 persons (16%) aged 50 or over.

The key contributors had 19 undergraduate degrees (76.0%), six of them graduates (24.0%). The samples consisted of 4 operational meteorologists (16%), 2 professional meteorologists (8.0%), 4 Pilot in Command (16.0%), 2 Senior First Officer (8.0%), 2 Junior First Officer (8.0%), 2 Senior Flight Operations Officer/Flight Dispatcher (8.0%), 2 Flight Operations Officer/Flight Dispatcher (8.0%), 2 air traffic control managers (8.0%), 3 air traffic control officers level 2 (12.0%), and 2 air traffic control officers level 1 (8.0%). 5 persons who provide important information had 5 years of experience in each group of work (20.0%), Followed by 9 persons (36.0%) of 6-10 years, 8 persons of 11-15 years (32.0%), and 3 persons of over 16 years (12.0%).

4.1.2 Analysis of the types of extreme weather that are harmful to aviation in Thailand and guidelines for the use of meteorological data to ensure the safety of aviation operations (National Weather Service, 2021).

1) Types of aviation weather hazards in Thailand

According to the findings, the types of aviation weather hazard in Thailand and to propose guidelines on the use of meteorological information for flight safety, it was found that the weather was more likely to be severe, and most likely in the rainy season, which is a strong southwestern monsoon, and often occurs during the summer storm, often with severe weather and dangerous flight hazards (Akande,2013. For the kind of extreme weather conditions that are dangerous to fly in Thailand, details are shown in Figure 1.

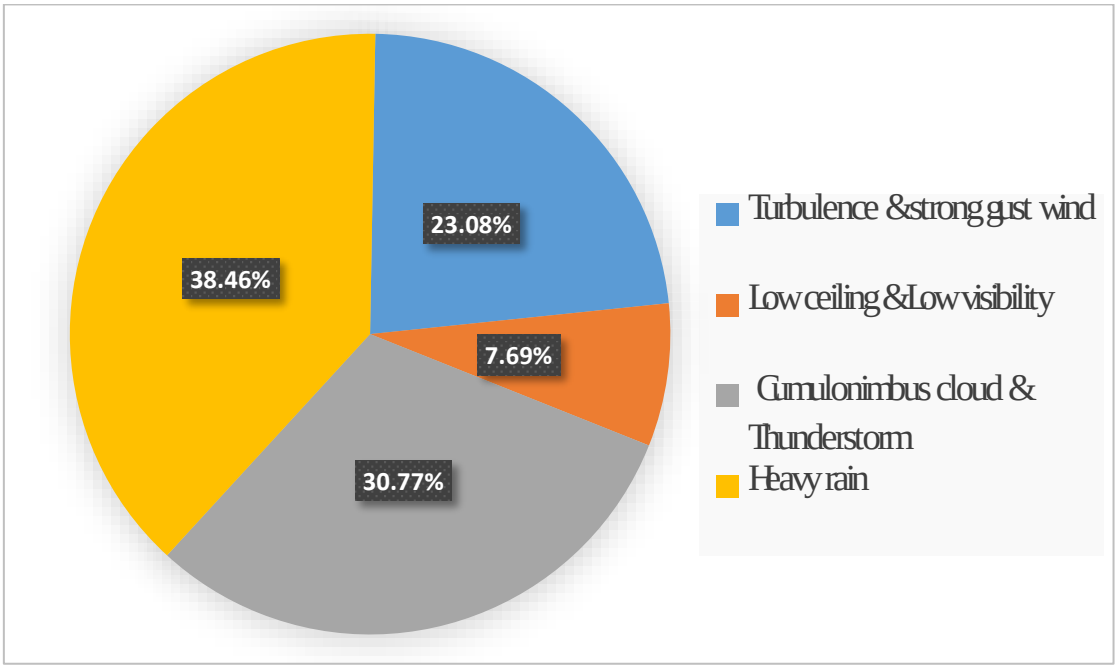

Figure 1 Types of aviation weather hazards in Thailand

The main informants are aviation-related operators, both service providers, and meteorological information users, who must continuously monitor weather data at all times of their duties, so they must know what kind of weather conditions occur during the duty period and how severe they are (Jordi et al., 2017).

(1) Heavy Rain

Up to 38.46% occurs and there will be severe weather conditions such as visibility reduced by the severity and size of the raindrop. Sometimes visibility can decrease below 1 kilometer and caused wet runway conditions, which can be dangerous to aircraft take-off and landing. In Thailand, heavy rainfall typically occurs in a very short period, except for heavy rains during tropical cyclones moving over Thailand.

(2) Cumulonimbus cloud and thunderstorm

Summer and rainy seasons in Thailand have often a chance that various meteorological elements are suitable and cause cumulonimbus clouds if it continues to grow into a thunderstorm, but every Cumulonimbus cloud may not grow into a thunderstorm.

Important informants had the opportunity to track meteorological data for use in aviation operations to ensure safety. If there is a flight in the area, a smooth air current is usually encountered, and subsequently, the Cumulonimbus cloud develops into a thunderstorm, which causes severe weather conditions such as lightning, thunder, gusts, turbulent air currents, wind shear or microbursts, as well as heavy rain and hail.

(3) Turbulence and Strong Gust Wind

The flow of air currents often changes direction or speed continuously both low and high altitude in all seasons. When the air current is swirling or ripple in the atmosphere either horizontal or vertically, it is called turbulence for strong gust wind is a strong wind that occurs suddenly for a while, most often in common with thunderstorms, 23.08% of all informants, separated by the type of turbulent air current, are the most wind shear currents, 76.2%, second to convective turbulence, 19.0%, and 4.8% by mechanical turbulence, where turbulent air currents caused by wind shear usually occur while a thunderstorm is in the mature stage, which has a severe downdraft and is dangerous while an aircraft is at a low altitude, such as when taking off or landing.

(4) Low Ceiling and Low Visibility

The weather that results in low cloudy skies is when the sky is covered by a large number of clouds (Overcast Sky), especially when covered by low clouds such as stratus clouds or Stratus Fractus, which are a few hundred feet above the ground. It can also cause drizzle, sometimes this cloud is also caused by the lifting of the fog, which results in low visibility, especially when the aircraft is landing, resulting in decreasing visibility. Pilots samples have an opinion on this issue 7.69% of the low ceiling and low visibility to be dangerous aviation weather in Thailand.

According to key informants, it is important to know what kind of weather conditions are occurring in Thailand and which can cause flight hazards. Therefore, to ensure aviation safety for commercial aircraft that must serve passengers. Each airport has standard operating procedures (SOPs) in low visibility procedures (LVP). To prepare, be aware of hazards, and create safety for aircraft, vehicles, and storage of ground-based equipment. If the road has a surface visibility value below 550 meters, the authorities must control and limit the allowing of vehicles to cross the runway and taxiway. However, if the visibility of the airport is less than 300 meters, all aircraft can not take off or land. The airport is closed, which complies with weather minimum flight control rules.

2) Guidelines for the meteorological information users to ensure safety in aviation operations

Aviation meteorological information comes from meteorological elements such as surface observations, upper-air observations, radar, and meteorological satellite data to integrate information for weather forecasting, which means anticipating weather conditions as well as natural phenomena that occur over the coming period to maximize air transportation by exchange weather information with each other through the Global Telecommunication System (GTS), and Thailand has been designated as the communications hub of Southeast Asia region.

As a result of this research on meteorological information usage guidelines for aviation safety. There are issues from key informants that show the problems or obstacles to the meteorological information service process. The data service agency has limited personnel, which data services are sometimes untimely, adequate air monitoring equipment for missions and telecommunications systems that support meteorological

transmission are sometimes unstable. Whilst, the problems or obstacles related to the meteorological information service process which system was found to be corrected, keep the information up to date relatively slowly, the weather warning system is not real-time, radio contact is often obscure, and the weather tracking system also has a device for incomplete use. Therefore, by providing information from key informants to guide the user of meteorological information for safety in aviation operations, that included:

(1) The meteorological information service system has been made to be easy and complete.

(2) Radio system has been upgraded due to meteorological information does not allow interference.

(3) There are always discussions between service providers and users of meteorological information services to understand each other.

(4) Update the information to match the current weather conditions and the weather forecast meets the required standards.

(5) Modern innovations are implemented for accurate weather monitoring and weather forecasting for aviation safety.

4.2 Discussion information

Since this research is qualitative, the researcher took the findings from the interviewers. A total of 25 cases was analyzed and used as a guide to discussing the results.

According to key informants, meteorological information is important information that affects aviation operations, which focuses on safety first, depending on the type of extreme weather conditions that are harmful to aviation. The data is collected by the Thai Meteorological Department, which weather center operate in different regions, which is considered to be a group of carriers that require knowledge and experience including weather observation and weather forecasts to advise meteorological information users, That have knowledge and experience depends on the mission of the data using such as the pilot, flight operations officer/flight dispatcher, and air traffic controllers.

Both service providers and weather information services have an average working experience of 6-10 years, (36.0%) of key informants since both providers and meteorologists must be knowledgeable and experienced in meteorology, creative, capable of analyzing and well interpret data, that use to make decisions for flight operations based on their assigned missions. The priority is safety, followed by the efficiency of aviation operations, and finally, the cost-effectiveness of each flight. Therefore, to plan the flight of each flight, it is necessary to have accurate, fast, and timely meteorological information from the data provider with knowledge and experience, that can take that information to assembled in flight planning accurately and efficiently. The meteorological information can be used routine weather observation, special weather observation, terminal aerodrome forecast, radar observation, satellite observation, temperature, and wind aloft, including significant weather charts can be used to properly and appropriately analyze the types of extreme weather conditions that are harmful to each flight, That also has an affects the risk of incidence or accidents of aircraft operations.

In addition to service providers and users, meteorological data users know the types of extreme weather conditions that are harmful to aviation in Thailand, such as cumulonimbus clouds and thunderstorms, turbulent air currents and strong wind gusts, and low cloud bases and low visibility, the key informants also presented guidelines for using meteorological data to ensure safety in aviation operations. The key points that will affect the use of guidelines are mentioned that the system for receiving and sending meteorological data should be an easy-to-use system and have complete information on the needs of both pilots. flight operations officer/flight dispatcher, air traffic control officer. The information must be prompt, accurate, and timely. If significant data changes are made, they must be updated according to climate change, as well as radio wave system improvements, weather reports, and weather forecasts do not disrupt by other radiofrequency.

The devices used for weather monitoring and weather forecasting must be accurate. If damaged, it will affect the information that the user must use in flight planning and flight operations decisions to ensure maximum safety. There are guidelines for formulating strategies to make the most efficient service or use of meteorological information services. Integrating aviation meteorological information service such as the Thai Meteorological Department, and for the user such as airlines, Aeronautical Radio of Thailand Ltd., and government sector that responsible for overseeing meteorological information standard, including management of transfer systems, and meteorological information is also exchanged around the world.

Therefore, the Civil Aviation Authority of Thailand, The Ministry of Transport, to meet the needs of the user units and meet the standards of the World Meteorological Organization and the International Civil Aviation Organization, must aim to ensure the safety of air transportation.

4.3 Research Feedback

According to the study, the severity of the weather is dangerous for flying. There is an increasing trend of violence. The frequency of aviation weather hazards is increasing, especially in Thailand that located near the equator. The western part of the country is adjacent to the Bay of Bengal and the Indian Ocean, and from the lower part of the central region down and east adjacent to the Gulf of Thailand, it is a hot and humid area. This is a factor that can result in the likelihood of severe weather conditions, for example, heavy rains, and have a chance of tropical cyclones such as depressions, Tropical Strom, and typhoons that is likely to cause cumulonimbus clouds or thunderstorms and turbulent air currents. Therefore, the services and use of meteorological information services are essential for such information to be accurate, prompt, and timely.

4.3.1 Meteorological information providers, including Aeronautical Meteorology Division, Northern Meteorological Center, Northeastern Meteorological Center, and Southern Meteorological Center, across all regions, must provide information by measuring meteorological elements such as surface wind direction and speed, dew point temperature, and airport's pressure, as well as weather analysis, terminal aerodrome forecasts, routine weather observation, weather charts for aviation, and severe weather warnings in accordance with international standards. Precision and accurate air monitoring equipment by the standard is regularly calibrated.

4.3.2 Meteorological information distribution through the aviation communications network must be regularly monitored to avoid disruptions, which will affect the use of information for delayed flight operations. It was not in time for consideration when severe weather occurred at the airport.

4.3.3 Users of meteorological information, including airline operators, air traffic services providers, airport operators must be knowledgeable in such information and able to interpret it accurately and timely to use the information for operational purposes. Air Traffic Management notification of aviation weather conditions to aircraft, including alerting ground operators within the airport (airside) to be aware of the dangers of thunderstorms and lightning, etc. This is in accordance with the Manual of Standard Aeronautical Services and related sectors such as the Thai Meteorological Department and The Civil Aviation Authority of Thailand.

4.3.4 Meteorological information providers need to have the knowledge and understanding of the mission of flight operations, and air traffic control for the needs of using meteorological information for air navigation, in accordance with international standards of the World Meteorological Organization and the Civil Aviation Authority of Thailand, and to understand the behavior of other operators such as pilot, flight operations officer/ flight dispatcher, which is an important role to use the most complete and perfect meteorological information.

5. Conclusion

According to the study, the severity of the weather is dangerous for flying. There is an increasing trend of violence, and the frequency of aviation weather hazards is increasing, especially in Thailand that located near the equator. The western part of the country is adjacent to the Bay of Bengal and the Indian Ocean, and from the lower part of the central region and eastern part adjacent to the Gulf of Thailand, it is a hot and humid area. It is a factor that can result in the likelihood of severe weather conditions, for example, cloudy sky, heavy rain, and a chance of tropical cyclones forming such as Tropical depressions, Tropical storms, and typhoons, which is likely to cause Cumulonimbus clouds or thunderstorms and turbulent air currents. Therefore, the service and use of meteorological information services are essential to be accurate, prompt, and timely.

5.1 Meteorological information providers, including of Aeronautical Meteorology Division, Northern Meteorological Center, Northeastern Meteorological Center, Southern Meteorological Center, have to provide information by measuring meteorological elements such as surface wind direction and speed, visibility, clouds amount, dew point temperature, and pressure, as well as weather analysis, terminal aerodrome forecast, routine weather reports, weather charts for aviation, and significant weather warnings in

accordance with international standard that precision and accurate weather monitoring equipment with the standard and regularly calibrated.

5.2 Meteorological information distribution through the aviation communications network must be regularly monitored to avoid disruptions, which will affect the use of data for delayed flight operations. It was not in time for consideration when severe weather takes place at the airport.

5.3 Users of meteorological data, including airline operators, air traffic services agencies, airport operators must be knowledgeable of information and able to interpret it accurately and timely to use the information for operational purposes, air traffic management, notify the aviation weather conditions to aircraft, including alerting ground operators within the airport (airside) to be aware of the dangers of thunderstorms and lightning, which is in accordance with the Manual of Standard Aeronautical Services and related agencies such as the Thai Meteorological Department and The Civil Aviation Authority of Thailand.

5.4 Meteorological information providers need to have knowledge and understanding of aviation operations, flight operations, and air traffic control to understand the needs and necessities of using meteorological information for air navigation.

In accordance with the international standards of the World Meteorological Organization and the Civil Aviation Authority of Thailand to acknowledge the behavior of other operators such as pilots, flight operations officer/ flight dispatcher who have an important role with the most complete of meteorological information.

5.5 Limitations of Research

This research is qualitative based on information from the interviewees. The study focused only on the types of aviation weather hazards that are harmful to aviation in Thailand, as well as the guidelines for the use of meteorological data to ensure the safety of aviation operations by collecting data from questionnaires that the key informants responded to following the designed questionnaires. It was found that some of the information provided by key informants had not been thoroughly implemented or no measures had been taken seriously in Thailand operations. For example, Pilot Report (PIREP), which reports weather conditions encountered by aircraft during flight, should alert other pilots to meteorological phenomena that are dangerous to fly following requirements and notify air traffic control officers to assist with flight guidance, as well as notify weather authorities and other ground units following the requirements. The authority that directs aviation meteorological services is the Civil Aviation Authority of Thailand who regulates the standard of the World Meteorological Organization and the International Civil Aviation Organization must be strictly implemented.

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7. References

Aeronautical Meteorology Division. (2019). *Principle Knowledge of Aviation Meteorology*, Retrieved June 29, 2020, from http://www.aeromet.tmd.go.th

Akande, S. (2013), Aviation Weather Hazards. Retrieved 12 June 2020, from https://www.reseachgate.net.

Airport of Thailand Public Company Limited.(2019). *Annual Reports 2019*, Retrieved October 5, 2020, from http://airportthai.co.th

Bureau of Aircraft Accidents Archives.(2020). *Aviation Accidents and Incidents*. Retrieved June 29, 2020, from https://baaa-acro.com/crash-graph. created [min]=2010-01-01&created [max]=2019-12-31

Center for Science Education, (2020), *Cloud Types*, Retrieved May 20, 2020, from https://www.zmesscience.com/science/type of clouds/20.5.2020

Chaithayawat,T.(2016).*Aircraft Crash and Aviation Business*, Master of Economics.Program of Business Economics, Thamasart University
Civil Aviation Authority of Thailand, (2020).*Overview Thai Aviation Industry in 2019*, Retrieved September 25, 2020, from https://www. Caat.or.th
Department of the Airport, (2020), *Airports of DOA*, Retrieved September 30, 2020, from http://airports.go.th/th/content/
International Civil Aviation Organization, (2014). Definitions and Usage Notes, *Commercial Aviation Safety Team*, 3 Aviation Weather Hazards
International Civil Aviation Organization, (2010).*Meteorological Service for International Air Navigation*, Retrieved September 10, 2020, from http://www.icao.int
Kumar,R & Kumar.A, (2013), Bad weather and aircraft accidents, *Current Science*, *104* (3), pp.316-325
Mazon, J., Rojas, J. I., Lozano, M., Pino, D., Prats, X. and Miglietta, M. M. (2017), *Influence of meteorological phenomena on worldwide aircraft accidents, 1967–2010.* Retrieved June 27, 2020, from https://rmets.onlinelibrary.wiley.com/
Ministry of Transport, (2009), *Aircraft Accident Final Report, One-Two-Go Airlines Flight 269*, Retrieved June 1, 2020, from https://www.en.wikipedia.org.
National Weather Service. (2021). *Aviation Weather Hazards Safety*. Retrieved July 2, 2020, from https://www. Weather.gov
Rafer, N. (2012). Altimeter setting and terminology, Retrieved 21 June 2020, from https://www.Slideserve.com/rafer
Ranter, H. (2013). *Aircraft accident Airbus A310-204 HS-TLA Surat Thani Airport.* Retrieved December 17, 2020. from https://www. Aviation safety.net
Serving the General Aviation Community. (2020). *Airplane Ground Schools*. Retrieved June 30, 2020, from https://www.discriptor and weather phenomena
Thitprasert, S. (2015). *Case Study of Electronic Parts Import Company*, Master of Science Program, Faculty of Logistics, Burapha University Office of Natural Resources and Environmental Policy and Planning National Report No. 2, Service Center Academic Affairs of Chulalongkorn University
Thongtaptim, W., & Manon,W. (2019). Using of weather elements in flight operations management. *Proceeding in CATC National Research Conference 2019*, Bangkok, Thailand.