Development of a GIS-based Bird Map Application for the Royal Thai Air Force's Aviation Safety Management

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Abstract

This study aimed to assess bird strike risk and develop a GIS-based bird map application to enhance aviation safety for the Royal Thai Air Force. Five risk factors, including bird size, weight, density, activity range, and flight altitude were collected and analyzed using the data from the Royal Thai Air Force Software Center as well as the 6th Wing squadrons. Severity level and probability of occurrence were calculated and used to design a bird strike risk assessment application. The developed application allows users such as pilots and air operators to assess bird strike risk and display real-time maps and images of bird coordinates. This tool can increase safety and reduce bird strike accidents, serving both military and civilian aviation needs.

Keywords: Bird strike, Geographic Information System (GIS), Bird map application

1. Introduction

Bird strike poses significant risks to aviation safety, causing substantial economic and operational losses annually. It was estimated from the civil aviation industry that the incurred cost in aircraft repair due to bird strike was as much as 40 billion baht per year. [1],[2] In the United States, the Federal Aviation Administration (FAA) reported that there were approximately 14,000 bird strike cases per year. [3] The Royal Thai Air Force has faced multiple serious bird strike accidents, such as the 21st Wing F-5F accident. While a pilot was performing an applied tactical flight mission at the Chai Badan air weapon training field in Lopburi, a large bird impacted and break through the cockpit cover. The pilot managed to eject from the fighter aircraft but was seriously injured. This kind of accident emphasizes the urgent need for preventive measures [4–6] due to the fact that aircrafts and aviation personnel are high value resources. Previous research, including the development of a GIS-based bird map application by the Class of 66th Air Force cadets in 2022 [7], had limitations in real-time risk assessment and bird data integration. This study eliminated such limitations through the development of a bird map application which provided precise risk evaluations, and real time data utilization, enhancing aviation safety for both military and civilian operations.

2. Tools and Methods

The objective of the development of a GIS-based bird map application for the Royal Thai Air Force's aviation safety was to study bird strike risk assessment and to develop a bird map application. The Royal Thai Air Force's current system only allows pilots to report and store data in the software center but such data is not further utilized or analyzed. On the other hand, this research analyzed the reported data, assessed the risk and displayed the real time results directly in the application.

The research was conducted with the following tools and methods:

2.1 Tools used in the development of an application for the bird strike risk assessment system

1) Hardware devices, including computers and printers.

2) Data storage software, including Microsoft Word 2020 and Microsoft Excel 2020.

3) Software for developing the applications on the Operation System on Android, including Google Play Store ver. Beta.

4) Android Studio, using JavaScript as the language for writing the bird map application.

5) The database of species and weight of the birds from Don Mueang International Airport.

2.2 Research methods

1) Plan and create a model for the research process to study the risk assessment of a bird strike and develop an application for a bird strike risk assessment system, as shown in **Figure 1**.

2) Study and collect information on the risk factors causing bird strike accidents in the flight training areas and the surrounding areas of the 6th Wing of the Royal Thai Air Force by using the bird sighting statistics from the Royal Thai Air Force Software Center and the information from 6th Wing squadrons.

3) Use the information obtained from the data collection and the study, including the information on bird species which were at risk of bird strike accidents in the area of the 6th Wing of the Royal Thai Air Force to categorize the size of the birds into small, medium and large groups [8] as detailed in **Table 1**.

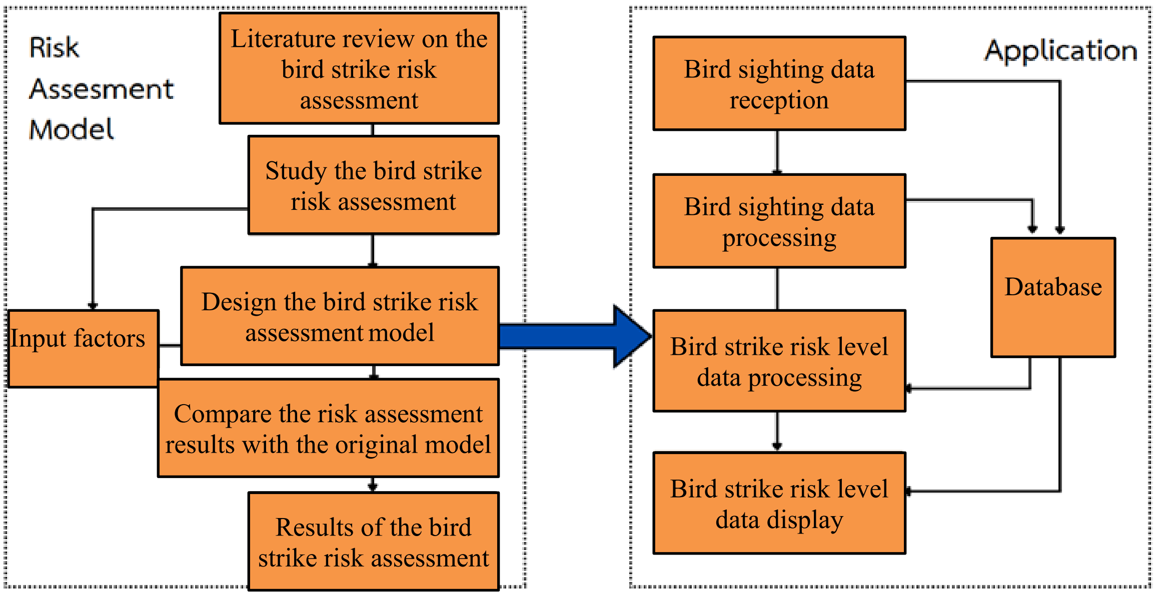

Figure 1 Research Process

4) Use the data to analyze the risk level using the calculation formula based on the research of [8] as follows:

4.1) Calculation of the probability of occurrence (Likelihood) in Eq. (1)

$$\text{Likelihood} = (CC + RCFH + ARR) \times 100 / 3 \quad (1)$$

Where CC is the density coefficient of bird clusters (Cluster Coefficient), RCFH is the risk coefficient of the height at which the birds fly (Risk Coefficient of Flight Height), ARR is the activity range risk coefficient and N is the number of birds found at the time of notification.

Consideration of the density coefficient of bird clusters (CC), when comparing the N value or the number of birds found at the time of notification, is shown in **Table 2**. [9]

Table 1 Sizes and Weights of the Birds Used in the Assessment of Danger to an Aircraft

Type/Size	Weight	Size
small	< 300 grams	small and very small
medium	300–1000 grams	small to medium, medium, and medium to large
big	1000 > grams	large and very large

Table 2 Comparison of the Density Coefficients of Bird Clusters

Number of birds (N) [birds]	Density Coefficient of Bird Clusters (CC)
$N > 100$	1
$100 \geq N > 20$	0.5
$20 \geq N \geq 3$	0.2
$3 > N \geq 1$	0

Consideration of the risk coefficient of the height at which the birds fly (Risk Coefficient of Fight Height) or RCFH value using the data compared with the height at which the birds fly (H) is shown in **Table 3**. [9]

Table 3 Comparison of the Risk Coefficients of the Height at Which the Birds Fly.

Height (H) [m]	Risk Coefficient of Flight Height (RCFH)
$H > 100$	0.1
$100 \geq H > 50$	0.5
$50 \geq H > 30$	1
$30 \geq H > 5$	0.5
$5 \geq H$	0.1

Consideration of the activity range risk coefficient or ARR values by comparing the ARR values with the distance data within the airport's air operation area (kilometers) is shown in **Table 4**. [9]

Table 4 Comparison of the Coefficients of the Activity Range of Birds

Risk Coefficient of the Activity Range of Birds	
Within the air operation area	0.9
Within 4 kilometers around the airport	0.6
Within a distance of 4 to 8 kilometers around the airport.	0.3

An example of the calculation for the probability of occurrence (Likelihood) from the data collected on September 25th, 2023 at 10:00 a.m. inside the 6th Wing area found a group of 10 scaly-breasted munias at a height of 200 feet. They were found at a distance of 2.50 kilometers from the 6th Wing, which was inside the airport's air operation area. The bird's weight was 14 grams and the highest weight ever detected was 8,900 grams. The statistics from the past 90 days recorded the highest number of birds found in one sighting, totaling 200 birds.

From the above database, the values for substituting the variables in the formula can be defined as follows:

The number of birds found at the time of notification (N) = 10 birds

The maximum number of birds ever detected in one sighting (N Max) = 200 birds

The height of 200 feet at which the birds fly (H) = 60 meters.

The distance the birds were found at 2.50 kilometers (within the airport's air operation area)

The weight of a scaly-breasted munia = 14 gram

The maximum weight of the bird found within the area = 8,900 grams.

From the aforementioned data compared with the values in **Tables 2–4**, the values of CC, RCFH and ARR can be obtained as follows:

The density coefficient of bird clusters (CC) = 0.2

The risk coefficient of flight height (RCFH) = 0.5

The risk coefficient of the activity range of birds (ARR) = 0.9

Consequently, the probability of occurrence (Likelihood) in Eq. (1)

results in the likelihood of = (0.2 + 0.5 + 0.9) × 100 / 3 = 53.33

4.2) Calculation of the severity of occurrence in Eq. (2)

$$\text{Severity} = (\%N + \%W) \times 100 / 2 \tag{2}$$

Calculation of the %N value or the comparative number of birds, using the data on the number of birds found at the time of notification (N = 10 birds) and the greatest number of birds ever found in 1 day (N Max = 200 birds), from the risk assessment formula, the %N = number of birds found at the time of notification/the greatest number of birds ever detected in 1 time is 10/200 = 0.05. The calculation of the %W value or the bird's comparative weight, by using the weight of the scaly-breasted munias (W = 14 grams) and the maximum weight of the bird found in the area (the maximum W of birds found in the area = 8,900 grams), from the risk assessment formula, it is determined that %W = weight of the scaly-breasted munias / Maximum weight of birds found in the area = 14/8900 = 0.0015

Therefore, the value of the severity of occurrence (Severity) is (0.05 + 0.0015) × 100 /2 = 2.575

4.3) Comparison to determine the risk value

After obtaining the probability of occurrence (Likelihood) and the severity of occurrence (Severity), the next step was to compare the probability of occurrence and the severity of occurrence as shown in **Table 5**.

Table 5 Comparison of the Probability and the Severity of Occurrence

Probability of occurrence	0–14	15–29	30–49	**50–69**	70–100
	very low	low	moderate	**high**	very high
The severity of occurrence	**0–3**	4–6	7–13	14–39	40–100
	very low	low	moderate	high	very high

From **Table 5**, the probability of occurrence (Likelihood) was equal to 53.33, which could be interpreted that the likelihood of the bird strike incident was high.

As for the severity of occurrence (Severity), it was equal to 2.575, indicating that if a bird strike incident occurs, the severity would be low or very low.

The next step was to compare the probability and the severity values in **Table 6** to express the result in terms of a risk value.

Table 6 Comparison of Risk Values

Comparison to Find the Risk Value		The Severity of Occurrence				
		very high	high	moderate	low	**Very low**
Probability Of Occurrence	very high	3	3	3	2	2
	high	3	3	3	2	**2**
	moderate	3	3	2	1	1
	low	2	2	1	1	1
	very low	1	1	1	1	1

Risk level 1 means there is a low risk of causing a bird strike accident.

Risk level 2 means there is a moderate risk of causing a bird strike accident.

Risk level 3 means there is the highest risk of causing a bird strike accident.

From **Table 6**, the result of the calculation was Risk level 2, meaning there was a moderate risk of causing a bird strike accident. Pilots should exercise caution while flying.

5) Prepare a map showing the risk levels in the form of geographic information technology as a step to bring in the information which the research team has studied and collected, to apply to the bird map application.

6) Design a bird map application program and analyze the results.

7) Conduct testing to find errors and make final improvements.

8) Write a research report and present the research results.

3. Results

The study found that there were five main factors contributing to bird strike risk. The first factor was the number of the colliding birds. The higher the number of birds, the higher the impact on the aircraft. The second factor was the weight of the bird which was directly related to the severity values. The greater the weight of the bird, the greater the force of impact. The third factor was the bird's flight altitude which had a direct effect on the bird strike risk based on the data from the International Civil Aviation Organization (ICAO). [10] ICAO defined bird's flight altitude of 40 meters as the critical risk zone. The closer the bird fly to the critical risk zone, the higher the risk value. The fourth factor was the density coefficient of the bird cluster which expressed the behavior of the birds flying in flocks. The higher frequency the birds fly in flocks, the higher the possibility of a bird strike. Naturally, birds instinctively fly in flocks. When one flock flies by, the rest will intuitively join the cluster and follow the flock leader. In addition, flying in a large flock also prevents the following birds from dodging the aircraft in time. The fifth factor was the bird activity range during the flight phases. Approximately 80% of bird strike occurs during takeoff, climb, approach and landing. [10] The higher number of birds near the operation area (the distance of 8 kilometers around the airport), the more likelihood the bird strike. All five factors were analyzed and compared in the risk assessment table.

The GIS-based bird map application called HAWK EYE was created. The application could be accessed through Google Play store on mobile phones with Android operating system. The application could receive and display the bird's coordinates, assess the bird strike risk level, and display basic information of each of the reported bird species in the form of maps and images, as shown in **Figure 2**. Pilots and air operators could easily report bird sightings and acknowledge the risk level displayed in colored circles indicating the risk level in each area. The reported data would also expand the database. The development of the prototype bird map application was supported and coordinated by the Royal Thai Air Force and the civil aviation agencies.

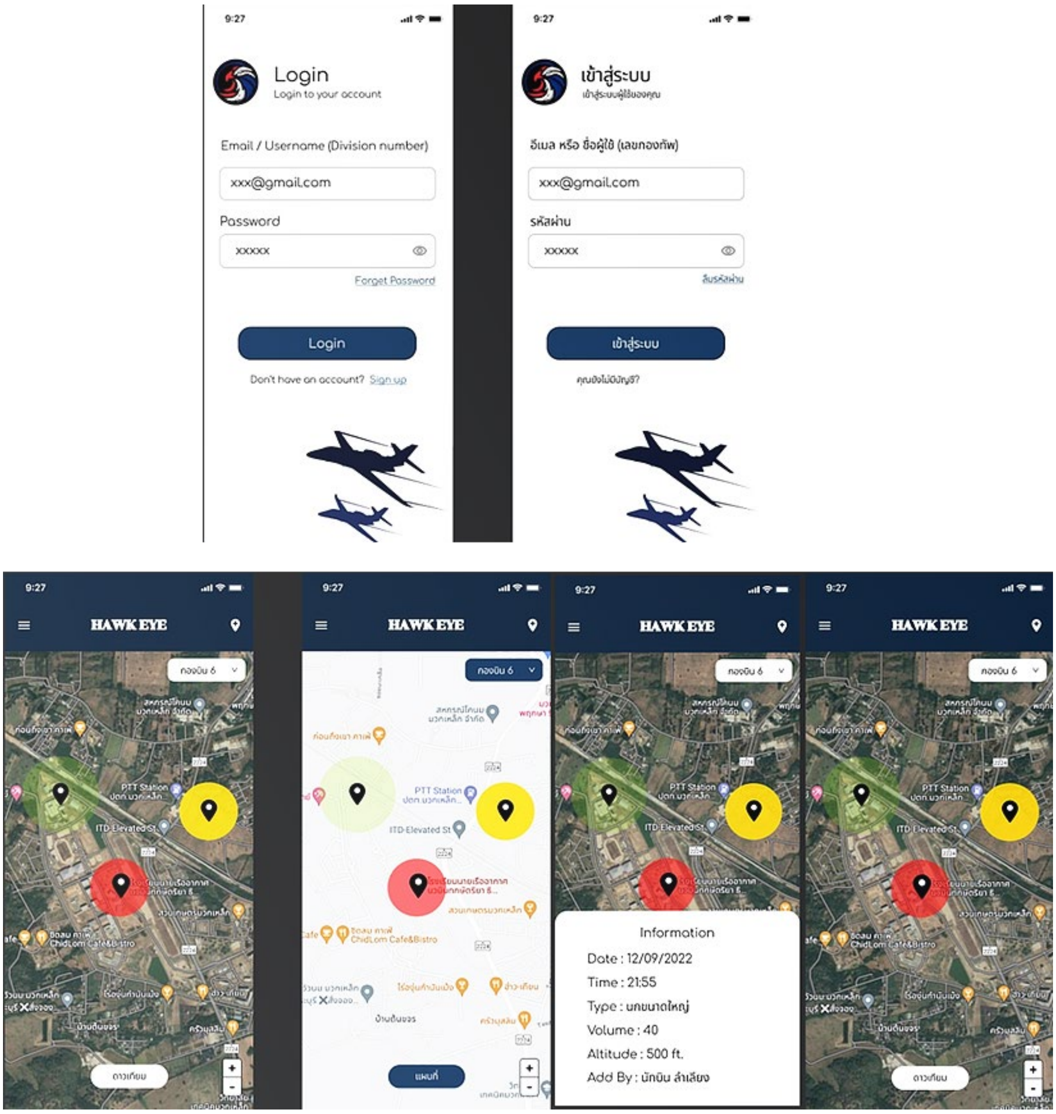

Figure 2 A Picture of the Use of the GIS-based Bird Map Application.

Figure 2 shows the use of the bird map application which the research team has developed for convenient information input and comprehensive risk evaluation. Data access rights has been implemented, including the bird sighting database storage.

4. Discussion and Summary

4.1 Discussion of the results

The research found that by using the weight data of various bird size models, it could provide similar or equal risk value to the calculated risk value which used the actual and exact bird data, including the weight and species, as mentioned in the research conducted by the Air Force Cadets Class of 66th. [7] However, in real situations, air operators have little time to observe the birds in the entirety. They could only estimate and categorize into different sizes. Actual bird information could easily be integrated in the bird map application for convenient usage and estimation error could also be reduce.

4.2 Summary

This research assessed bird strike risk and developed a GIS-based bird map application to enhance aviation safety for the Royal Thai Air Force. The application used a database of the bird's basic information and its coordinates to assess the risk on aircraft operations whereby the research results could be summarized as follows.

1) The results on the bird strike risk found that the main factors included the bird size, weight, density, activity range, and flight altitude. These factors were analyzed to measure the level of severity and the probability of occurrence, and used to design a bird strike risk assessment application.

2) The resulting bird map application prototype called HAWK EYE was developed. The application is a public use software available for civilian usage and it can be accessed from Google Play Store on Android mobile phones. The application includes the database of the reported bird coordinates and the risk assessment for aircraft operations displayed in the form of maps and pictures. Database update depends on pilots and air operators to continuously and consistently record and report the data via the application.

5. Acknowledgments

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6. References

[1] Thai PBS. "What is bird strike, why does it crash planes." thaipbs.or.th. https://www.thaipbs.or.th/news/content/311099 (accessed Mar. 10, 2025).

[2] Thaiarmedforce. "What is bird strike." facebook.com. https://www.facebook.com/thaiarmedforce/posts/430518138537724 (accessed Mar. 10, 2025).

[3] Naewna. "Frequency of bird strikes on aircraft?." naewna.com. https://www.naewna.com/inter/850385. (accessed Mar. 10, 2025).

[4] The Civil Aviation Authority of Thailand (CAAT). "What is Bird Strike?." facebook.com, https://www.facebook.com/photo.php?fbid=665067592329740&id=100064795145989&set=a.307294851440351 (accessed Sep. 15 2023).

[5] K. Chatniti. "Bird Strike." aavn-school.ac.th. https://shorturl.asia/vqBtH (accessed Feb. 10, 2022).

[6] Thai PBS Sci & Tech. "Know bird strike, Why it is dangerous to aircraft, How to prevent it." thaipbs.or.th. https://www. thaipbs.or.th/now/content/1619 (accessed Mar. 10, 2025).

[7] Online Newstime. "Bird Map App, excellent research of Air Force Cadets, Navaminda Kasatriyadhiraj Academy, helps pilots be safe on bird-free flight paths." onlinenewstime.com. https://shorturl.asia/KmeZf (accessed Sep. 15, 2023).

[8] Transport Canada, "Elements of Risk," in *Airport Wildlife Management Bulletin - TP 8240 - No. 38: Appendix B*, Ottawa, Canada: Transport Canada, 2020. Accessed: Feb. 10, 2022. [Online]. Available: https://tc.canada.ca/en/aviation/publications/airport-wildlife-management-bulletins-tp-8240/airport-wildlife-management-bulletin-tp-8240-no-38/airport-wildlife-management-bulletin-tp-8240-no-38-appendix-b#4-3

[9] Y. Hu, P. Xing, F. Yang, G. Feng, G. Yang and Z. Zhang, "A birdstrike risk assessment model and its application at Ordos Airport, China," *scientific reports*, vol. 10, 2020, Art. no. 19627, doi: 10.1038/s41598-020-76275-z.

[10] International Civil Aviation Organization (ICAO). (2014). Bird Strike. [Online]. Available: https://www.icao.int/MID/Documents/2014/Wildlife%20and%20FOD%20Workshop/Risk%20Reduction%20program%20-%20GACA.pdf