

Bird Strikes in Aviation

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PROJECT DETAILS:

Project Title	Bird strikes in aviation department from 2011 to 2023
Technology	Business intelligence
Project Domain	Transportation and communication
Tools used	Ms-Excel, Jupiter Notebook, Tableau
Programming language used	Python

PROJECT ABSTRACT:

You may be wondering how often birds hit airplanes? After all, planes are too big to miss. Unfortunately, every year, bird strikes cause up to \$1.2 billion in damage to planes around the world. In fact, there are 16000 bird strikes recorded each year in the U.S alone. With increased air traffic, the probability of a bird strike incident is more and the raise in number of reported birds strikes in recent years is a clear indication Most bird strikes results from the animals being stuck into the planes gigantic jet engines. Sadly, these birds get shredded usually. The real danger, however, comes from birds that are big enough to get stuck in the fan. This results in halting the plane's engine. A fan blade can end up displaced into another blade, which engenders a cascading and terrifying failure. Bird strikes can occur at different altitude levels and is highly capable of causing an engine failure which can be fatal at times. This can be mitigate by analyzing the previous year's data.

In this project, occurrence of bird strike incidents in aviation industry is analyzed using a dataset that includes incident location, aircraft type, size of flock, effect on aircraft etc. By analyzing the data collected by Federal aviation authorities and organizations around the world, we can understand the pattern of occurrence and mitigate the risk of a possible bird strike in future. I intend to use tools like Tableau and Tableau prep builder to create a dashboard and represent the data visually.

GOAL OF THE PROJECT:

The goal of the project is to analyze the bird strike incidents that occurred from 2011-2023. For this we have taken real time data from Federal Aviation Administration(FAA). The objective of the project is to perform data visualization analysis on the dataset by using several business intelligence tools.

My goals to visualize, Analysis of warning status unknown and known to the pilots, Airport Id vs density of birds strike, Phase of the flight vs density of bird strikes, Operator vs repair cost , and also visualize visualization during covid lockdown time vs bird strikes , bird strike frequency vs season vs time of the day . Visualizing this data will make it easy for the aviation authorities to understand the patterns in bird

strike occurrences, such as time of year, geographic locations, or specific flight phase where bird strikes are more frequent and take necessary precautions to mitigate these incidents.

TOOLS USED:

- We have used Ms-Excel and python to know the insights of data and to clean the data.
- Used tableau to make data visualizations and creating dashboards.

```
In [2]: 1 df.isnull().sum()
```

```
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INCIDENT_YEAR             0
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...
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NUM_STRUCK                384
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NR_INJURIES              175631
NR_FATALITIES            175701
Length: 86, dtype: int64
```

```
In [3]: 1 df.shape
```

```
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```
In [5]: 1 df.info()
```

```
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Data columns (total 86 columns):
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2   INCIDENT_MONTH        175714 non-null  int64
3   INCIDENT_YEAR         175714 non-null  int64
4   TIME                  121257 non-null  object
5   TIME_OF_DAY           93811 non-null   object
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7   AIRPORT               175714 non-null  object
```

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24	ENG_4_POS	991	non-null	float64
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26	HEIGHT	79076	non-null	float64
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28	DISTANCE	123255	non-null	float64
29	SKY	76874	non-null	object
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71	OTHER_SPECIFY	29543	non-null	object
72	EFFECT	6390	non-null	object
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75	SPECIES_ID	175713	non-null	object
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77	REMARKS	163350	non-null	object
78	REMAINS_COLLECTED	175714	non-null	bool
79	REMAINS_SENT	175714	non-null	bool
80	WARNED	175714	non-null	object
81	NUM_SEEN	51231	non-null	object
82	NUM_STRUCK	175330	non-null	object
83	SIZE	152160	non-null	object
84	NR_INJURIES	83	non-null	float64
85	NR_FATALITIES	13	non-null	float64

dtypes: bool(36), float64(17), int64(3), object(30)

DATA COLLECTION AND INITIAL REVIEW:

- The source of the data for the project is from Federal Aviation Authority(FAA).
- Describe the format of data as received, such as Excel sheets.
- We have noticed that there are many missing values, inconsistent formats some irrelevant columns, etc., in the dataset.

DATA CLEANING:

The data needs to be preprocessed before we do analysis or do visualizations. We used Jupiter notebook python and Excel for cleaning.

- Initial dataset has the records from 1970 to present data. For the better analysis, we have taken most recent data that is from 2011-2023. For this we have filtered the data in Excel sheets.
- To know the number of records, null values or missing values in the dataset, we used Jupiter notebook.
- We have imported the data into Jupiter notebook and performed some operations like `data.head()`, `data.info()`, `data.DType()`. We have imported pandas in python. By using `isnull()` command we can know the missing values. After finding the missing values I have noticed that precipitation has more number of missing values. I have filtered again using Excel for better analysis.
- There are no any duplicate values.

DATASET OVERVIEW:

Bird strikes dataset that we are using to make analysis is from 2011-2023. We have so many features for the analysis in this. Dataset consists of total 86 columns. Let's discuss important feature that we are using for analyses.

1. It has record Id, Which is unique number for every bird strike that happened since 2011 till present. So that easy to take the count of the number of incidents that happened.
2. Data has incident Year, Month, Day, Time and Time of day. These gives the information about when the strike happened and at what time. For the Time of day, It has 4 types. Incident occurs during Dawn or Day or Dusk or Night.
3. It has Airport name and Airport ID and also Operator of the particular flight details.
4. Aircraft Type, Aircraft Make and Model details also given. Along with this we have Engine make and model details.
5. Phase of the flight gives the details of when the bird strike happened. It is either flight is during Approach, Take-off, Climb, Landing Roll.
6. Height, speed and distance of the flight details are there.
7. For weather conditions, Sky type is given if it is wither cloudy, over cloudy or no clouds at all. For precipitation if it is normal or rain or fog etc.,
8. Cost repairs is the economical loss for the damages that caused by the bird strikes. We have other costs also which gives the estimation for loss of revenue, hotel expenses due to flight cancellation, cost of fuel dumped etc.
9. Damage level is the level of damage caused by incident.
 - N – None or no damage
 - M – Minor Damage
 - M? – when the aircraft can be rendered airworthy by simple repairs or replacements
 - S(Substantial) – When the aircraft incur damage or structural failure.
 - D – When the damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.
10. Details of each part damaged is also there.
11. Effect of the birdstrike column gives the information about if there are any precautionary landing, aborted Take-off etc

12. We have the species of the bird details
13. Number of birds stuck when the incident happened
14. If the pilots are warned or no
15. Size of the bird
16. Number of people injured and number of people died

INTRODUCTION:

In the field of analytics one of the most important domains is transportation and communication. Regarding transportation scenarios and the ever-expanding urban areas, the scientific community's two main concerns these days are environmental impacts and safety. Because there is an increase in more number of vehicles and people, these problems are becoming more pressing. Seeking new solutions is reaching a point where available technologies and artificial intelligence, especially MAS, are being recognized as ways to tackle these kinds of problems in a distributed and more appropriate way.

Bird strikes are a huge concern, especially concerning the safety of the passengers and pilots in aircraft. Worryingly, the USA has been experiencing a rise in the number of such accidents. As a result, the FAA has issued guidelines to carry out regular patrols to check on animals, birds, or any wildlife activity around the airport surroundings. The aviation authority also requested the airlines to identify the gaps and strictly implement the required regulations in the vicinity of the aerodrome.

What is Bird Strike?

A bird is often referred to as bird ingestion, bird hit, or bird aircraft strike hazard. It happens when an airborne animal – such as a bat or bird hits a plane. Usually, events happen when an aircraft is flying at a low altitude, mainly during take-offs or landing rolls. It is because aerial animals generally fly at low heights. However, it is not to say that bird strikes don't happen at higher altitude, as the world record for a bird hit at the highest altitude was 11.3 kilometers above the ground.

There are various factors that can tell the level of damage that has been caused due to a bird hit. These factors range from speed difference, size and weight of the aerial animal.

What happens when bird hits?

In the recent of bird strike, Birds usually collide with either the forward facing edges of an aircraft, which include wings, jet engine, or the plane's nose cone. The birds may hit the windshield or canopy of fighter jets which may result in cracking. Dangerously, such cracks can sometimes disrupt air pressure, which ought to be maintained inside the cabin and may result in the loss of altitude or other flight related problems.

This may be extremely dangerous when a bird hits the turbine directly and get caught in engine. In such a situation. The struck bird can cause disruption in the motion of the fan blades leading to the failure of the engine to a certain extent.

Across the world, aviation authorities have been attempting to bring measures to prevent aerial animals from coming close to planes. To start with, they have experimented with predatory birds' sound recording and cartridge scalers that produce loud bands and flashes of light. However, according to experts, these measures are not long-term in nature, and the birds get used to the sounds.

EXISTING PRECAUTIONS AND PRECAUTIONS TO BE CONSIDER:

Existing FAA precautions are wildlife hazard management at airports, Reporting and collection of data, Aircraft design standards, Research and development, Air traffic control guidelines.

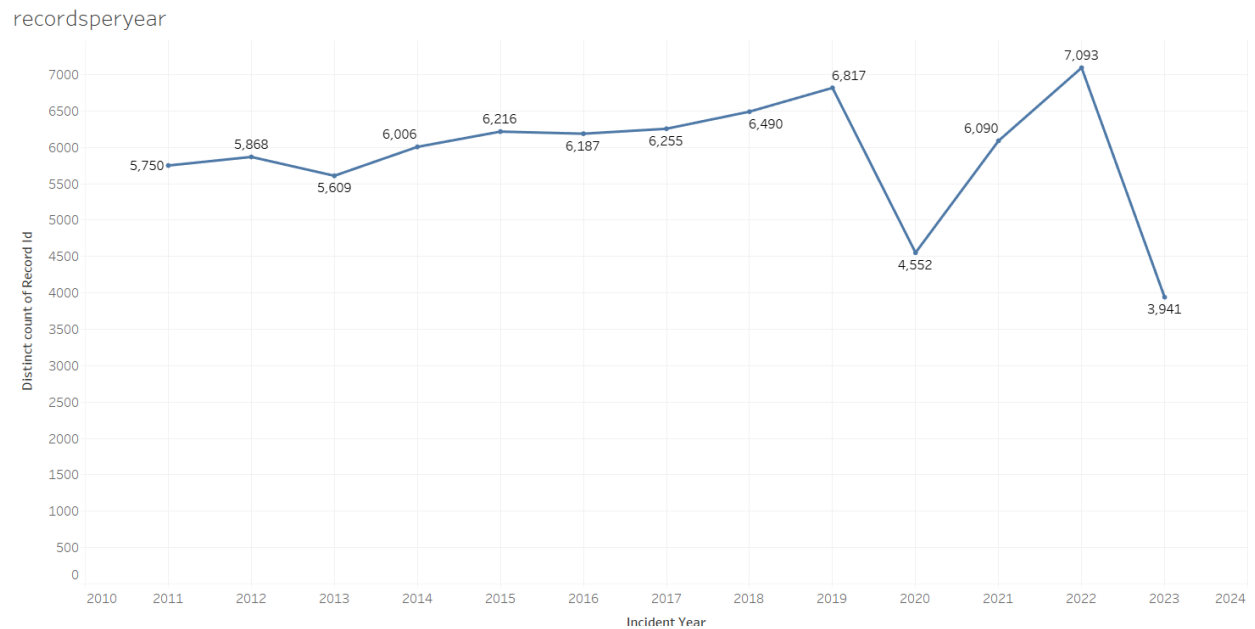
Additional measures to consider are Advanced technology integration such as incorporating advanced radar and detection systems to alert pilots and air traffic controllers of bird flocks in real-time. Flight operation adjustments such as adjusting flight schedules or routes, especially during migration seasons or times of day when bird activity is high.

Engine design innovations such as more bird-resistant engines and testing aircraft components under more rigorous conditions simulation bird strikes.

In order to take all these precautions, it's critical to regularly identify patterns so that we can identify and analyze the locations of frequent bird strikes using various features.

EXPLORATORY DATA ANALYSIS:

1. Number of records Vs Incident years:



The visualization shows the number of bird strike incidents reported each year from 2011-2023. We have taken a distinct count of record id to get the count of total bird strike incidents for each year. Incident year is taken on the columns. We have plotted a trend line chart for finding the increasing trend or decreasing trend over the time.

Trends:

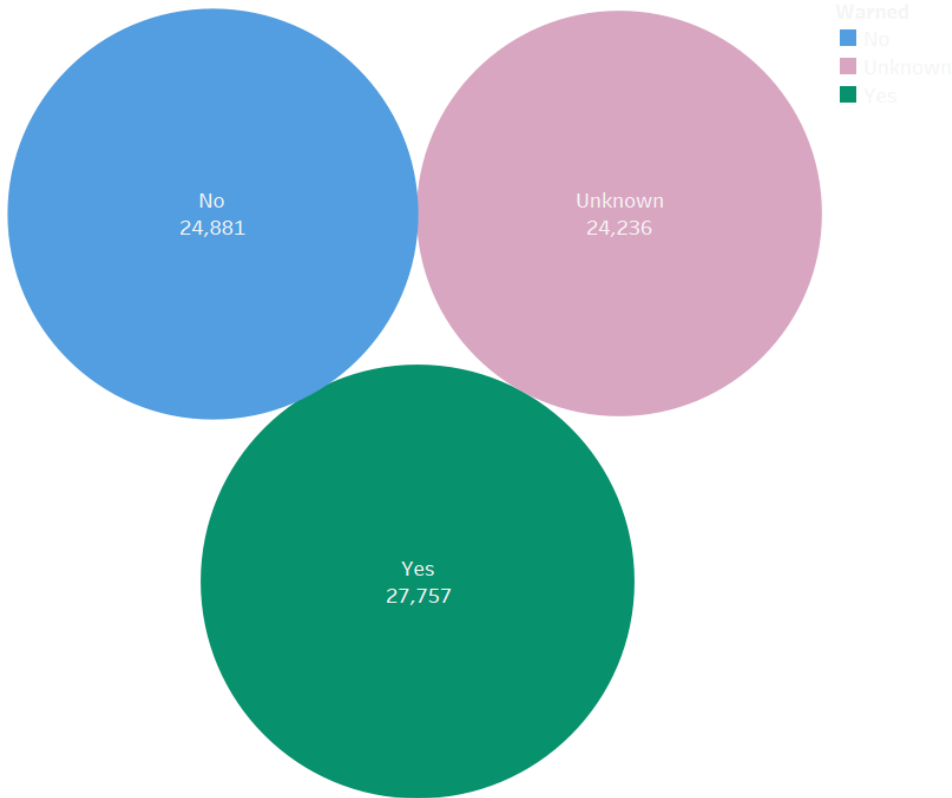
- There is an overall fluctuation in the number of bird strikes per year from 2011-2023.
- From 2011 – 2019 there is a significant increase in the number of incidents that occurred.
- From 2019-2021 you can see a dip in the graph. This is because of the covid crisis over that period. The number of flights in operation has decreased so the bird strike encounters also decreased.
- Then again after 2021 we can see an increase in trend line. We have data information available till 2020 only.

Recommendations:

Based on the analysis of these trends, Bird strike mitigation can be done by following some strategies at airports such as habitat management, avian radar systems, and pilot training programs.

2. Warning issued to the pilots:

Warning issued to pilots



Warned and distinct count of Record Id. Color shows details about Warned. Size shows distinct count of Record Id. The marks are labeled by Warned and distinct count of Record Id. The data is filtered on Record Id, which keeps 76,874 of 76,874 members.

Type Of Graph:

Bubble graph is used to analyze if the warnings to the pilots are issued or not. In this case, each bubble indicates the warning was issued to the pilot or warning not issued to the pilot and the incidents where its unknown if a warning is issued.

You can observe that warnings issued 'Yes' are 27757, warnings issued 'no' are 24881 and warning status 'unknown' are 24236.

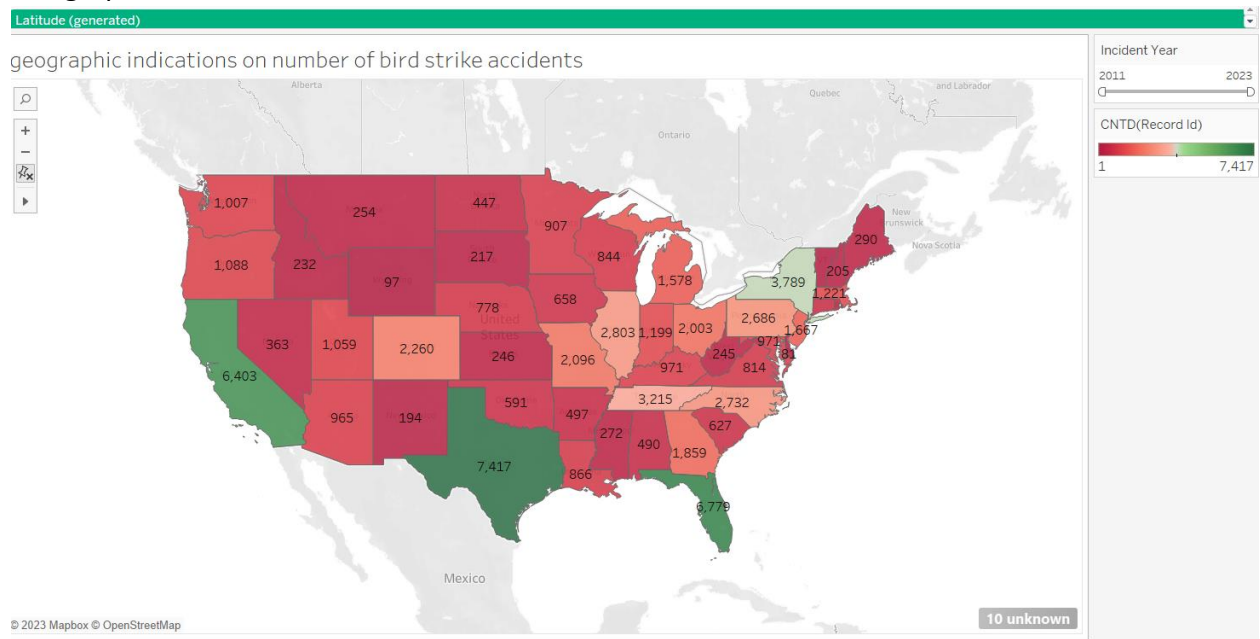
Analysis:

The number of incidents where warning status is unknown are significantly equal to the warnings issued. There appears to be decent degree of knowledge and responsive to possible birds trike threats when recognized, as evidenced by the fact that the number of events when warnings were provided is highest.

Recommendations:

- Enhance reporting methods to alleviate the large number of unknowns, improve the reporting, methods and make sure that warnings are regularly documented.
- Data interpretation for safety actions analyzes the effectiveness of the warnings using the data.
- Technology enhancement, where the technology detects the birds activity and issue accurate warnings.

3. Geographic indications on number of bird strikes:



Type Of Graph:

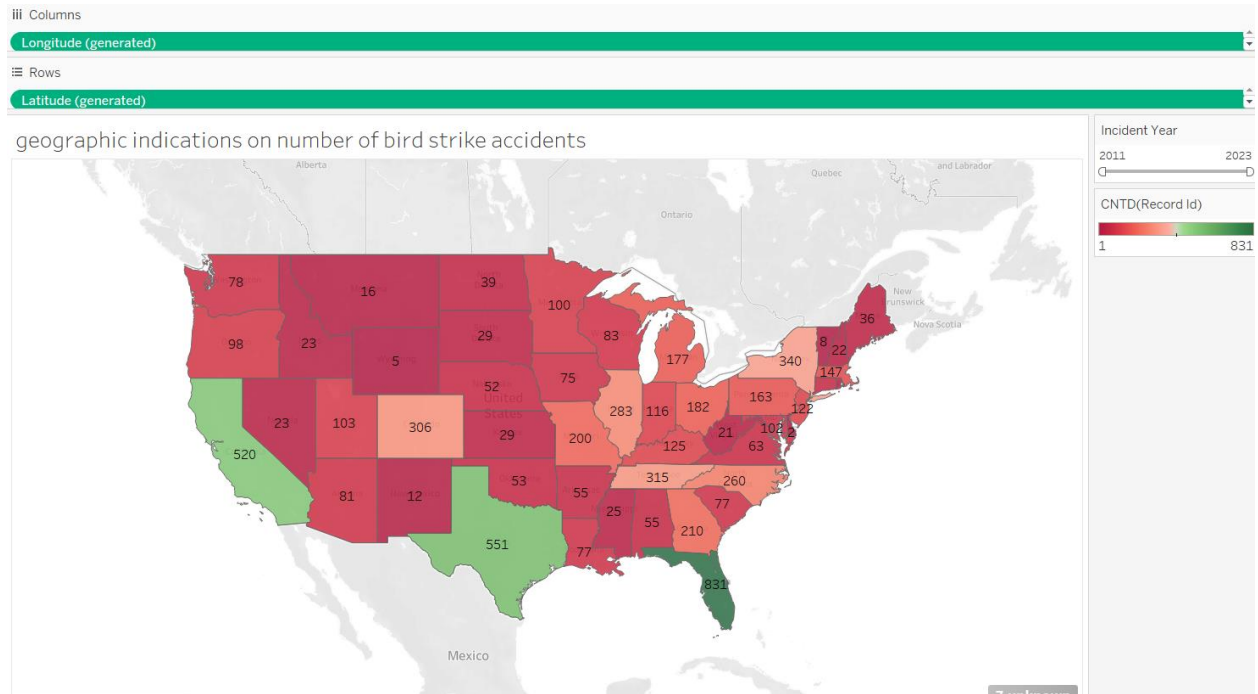
Map visualization is used to analyze the number of bird strikes occurred for particular state from 2011-2023 for all the years.

We have taken the states column in tableau to data pane and selected map visualization. Then distinct count of record Id was drawn on to the map then it shows the number of bird strikes state wise.

Analysis:

- We observed that more number of incidents are occurred in Texas state, followed by Florida and by California.
- Texas has 7417 number of strikes over 2011-2023, Florida has 6779 and California has 6403 number of bird strikes.
- By this we analyzed that bird strike frequency are more in the states which has more air traffic and with larger population.
- This visualization also suggest that certain migration patterns or environmental conditions may contribute to the frequency of incidents.

Now by adding filter parameter of incident years we can see the graph with number of records for each state for each year.



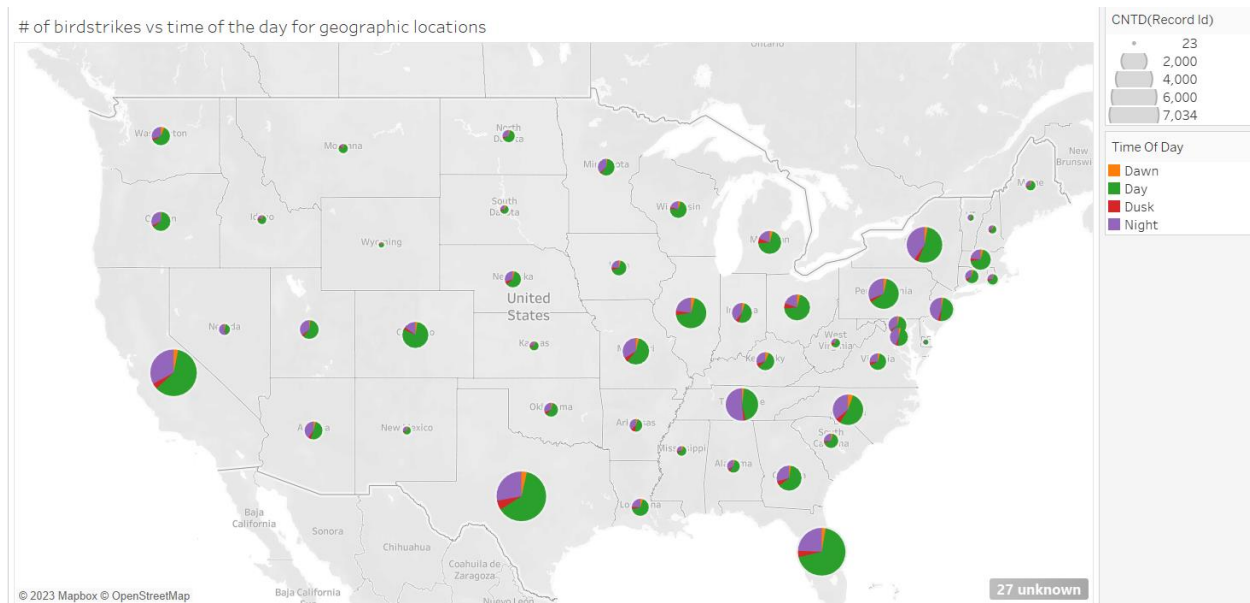
Analysis and Observations:

Here also similar to the over all visualization, Texas is the most impacted state for bird strikes with highest number of incidents happened with 551 for the year 2022. Then followed by Florida and then by California.

Recommendations:

- FAA should concentrate more on the highly impacted states and follow some potential habitat management or deterrence measures at the airport. Cutdown the trees and main empty grounds near to the airport. Maintaining radar signals and all might show the differences.
- Reporting the bird strike incidents mechanisms to collect more accurate data.
- Educational campaigns for the pilots and the people who working the airport area in high risk states to increase awareness and improve response strategies.

4. Number of birdstrikes in the geographic locations depends on the time of the day:



Type Of graph:

This is the map overlay with pie charts positioned on each state. Pie chart here represents the bird strikes in that particular state depends on the time of the day. Different times of the day are Dawn, Day, Dusk and Night.

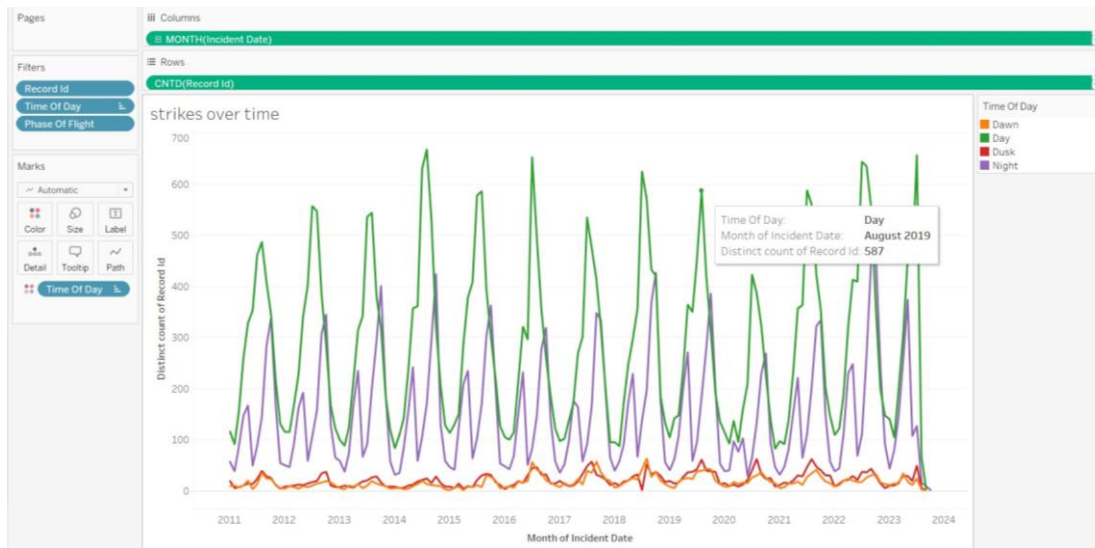
Observations and Analysis:

- The size of the pie chart indicates the highest number of bird strikes occurred in particular state. As you have seen from the earlier graph, Texas, Florida and California has the more number of bird strikes.
- Distribution in the pie chart indicates that the bird strikes occurred during the time of the day. Here you can see that green represents the bird strikes occurred in Day, Purple represents strikes occurred at night, orange represent strikes happened at Dawn and Red at Night.
- By observing we can see that green distribution is more for all the states or most of the states.
- With this visualization we can analyze that more number of incidents are happening during the time of day, followed by night times. Strikes during Dawn and dusk are less comparatively.

Recommendations:

- FAA should train pilots more and also for air traffic controllers to raise awareness of the increased bird strikes during Day and at Night. So that we can mitigate the risks.
- Also should conduct research into local bird activity patterns in high risk states to predict better and mitigate the number of strikes.

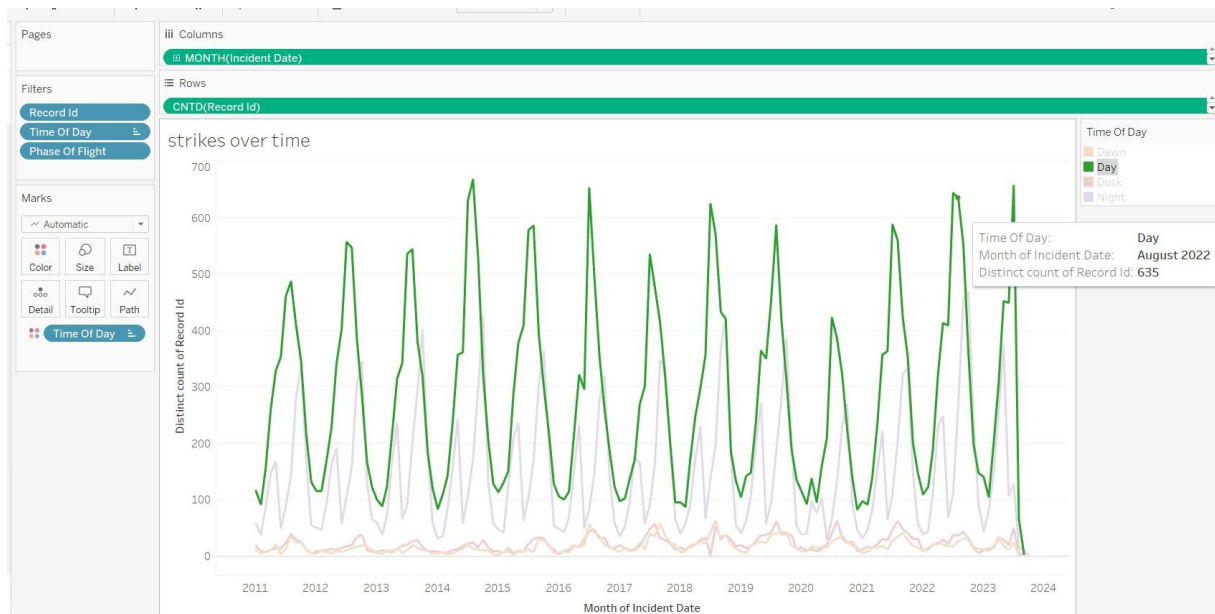
5. Number of strikes with seasons and Time of the day



Visualization 5a

Type of Graph:

This is a line graph which is used to display or analyze number of bird strike frequency changes with the seasons and with the time of the day – Dawn, Day, Dusk, and Night.



Visualization 5b

Observations and Analysis:

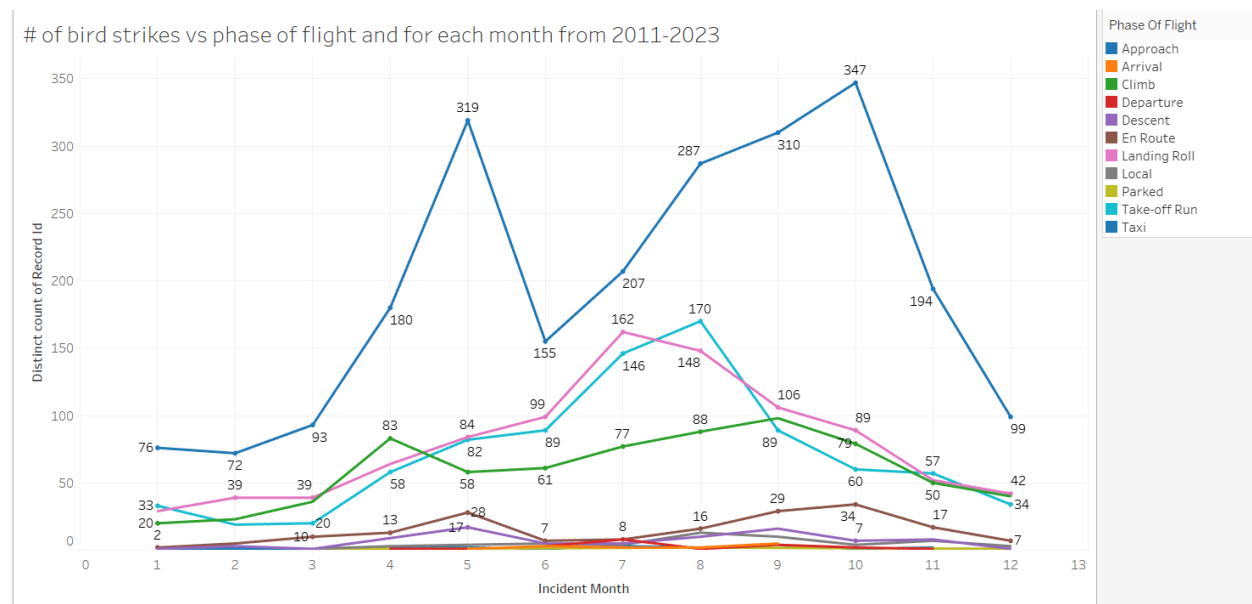
- There are some clear visuals and patterns according to seasons and time of the day. As we have already seen in the previous visualization that more number of strikes are occurring during day time and followed by night. Here also we can see that green color line graph is at the top.

- As we can hover over the graphs we can observe that there is peak for every year in line graph at the time of July, August and September.
- Night time strikes are low, because may be there is lower traffic at that time or may be lower visibility to record the strike.
- So we can analyze that more number of strikes are happening at the time of summer end and Fall season and at the day time.

Recommendations:

- Seasonal mitigation strategy that are adjusted for seasonals variations in bird activity to reduce the number of strikes.
- We can also mitigate that by scheduling flights more at the time of dawn and dusk.
- Pilots should be well trained who are flying at the fall season particularly during day time.

6. Bird strike frequency Vs Phase of Flights:



Type of Graph:

This is “Multi Line Graph”, which is used to analyze the bird strike frequency with the phase of the flight. Phase of the flight means the position of the flight at the time of bird hit. It may be during approaching, landing roll, taking-off, or at climb, or may be during parking also.

Observation and Analysis:

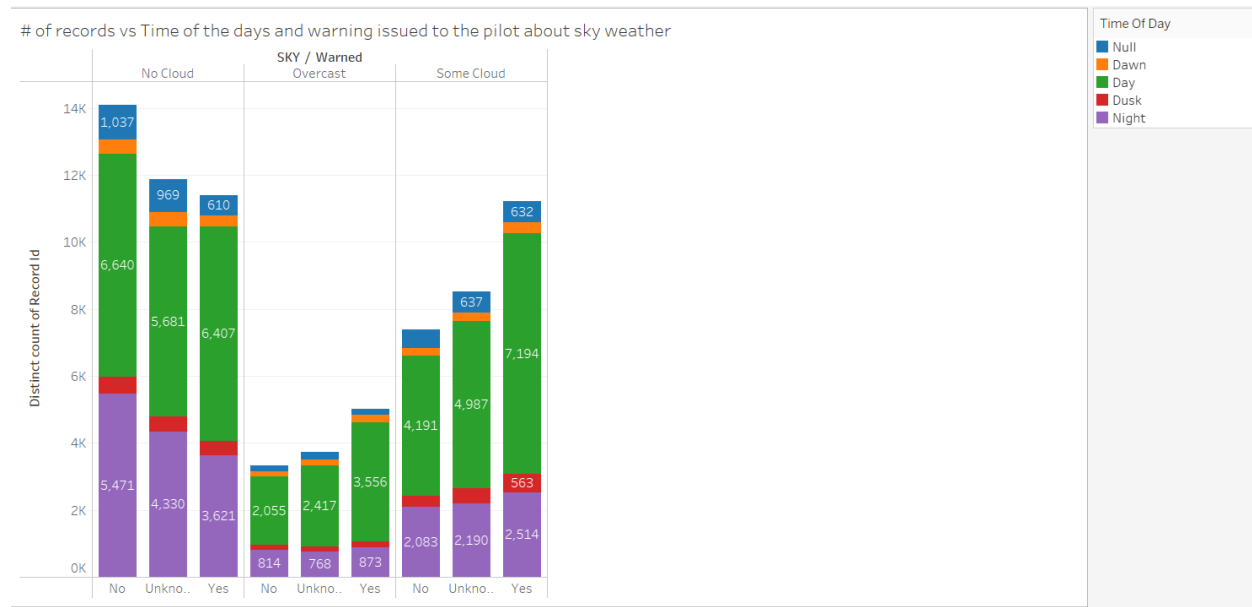
- The approach phase of flight has the highest number of birds trikes recorded across all the months. Then followed by Landing roll and take-off run.
- We can also see the number of birds strikes for each month. We can observe that mostly three is peak during august, September and October.
- Dark blue line indicates the incidents occurred during approach phase of flight.

- We can analyze by the above observations that the bird strikes frequency during certain phase of flight, particularly those are close to the ground and during ascent or decent.
- Birds usually fly at lower altitudes only, if the flights are at higher altitudes then the chances of bird strike incidents are very low.

Recommendations:

- By focusing more on the time of approach, landing and taking off and using more technologies we can mitigate the birdstrikes.
- By giving best pilot training and to the people who are working at the airports can minimize the bird strikes during these times.
- Pilots should be informed about the wildlife in their vicinity and should be made better equipped and trained to handle the wildlife.

7. Bird strike frequency Vs Time of the day and warning issued to the pilot about sky:



Type Of Graph:

We have used stacked bar chart showing the number of bird strikes with the time of the day and warning issued to the pilot.

Observations:

- Time of the is indicated by colours. The largest number of incidents occurred during day time.
- The category with the highest number of bird strikes where warnings issued is under some cloud, followed by now cloud and then by overcast conditions.
- During the no cloud, maximum incidents warings are not issued to the pilot, and for the overcast warnings issued to the pilots cases are more. During some cloud warnings are issued to the pilot in most of the cases.
- Bird strikes are more frequent during the day across all the weather conditions.

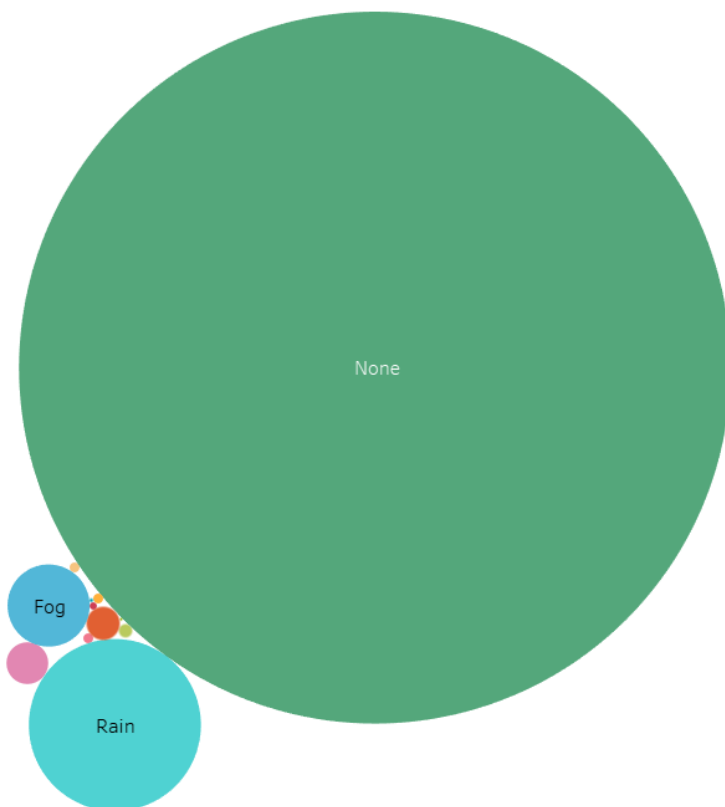
- Warnings issued to the pilots are correlated to the weather conditions. The number of unknown warnings suggest a potential area for improvement in the reporting and communication of bird strikes.

Recommendations:

- Data collection should be accurate.
- Improve technologies that which are giving the warnings.
- Pilot awareness is the most important.
- Depends on the patterns of the bird strikes we have to schedule the flight times.

8. Bird strikes frequency Vs precipitation:

precipitation



Type Of Graph:

Type of chart I have used to analyze the bird strikes with respect to precipitation is bubble chart. Precipitation type are none, fog, snow etc.

Observations and Analysis:

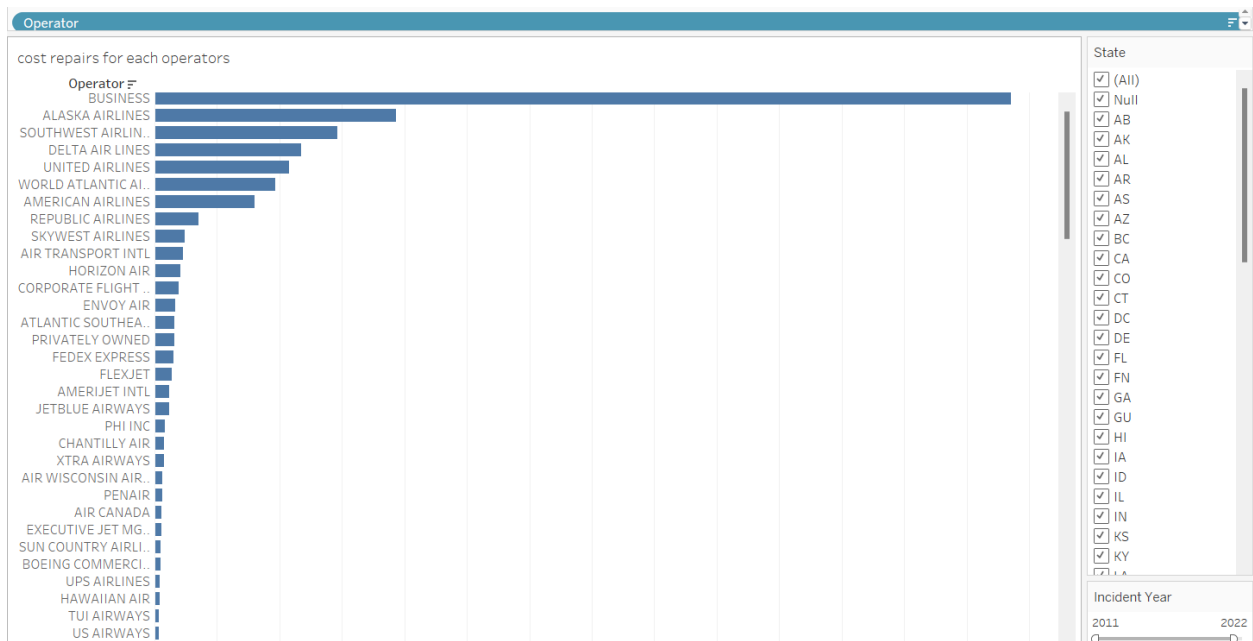
- In the above chart none has the largest bubble, gives that bird strikes occur most at no precipitation.

- We have observed that number of bird strikes are more for the day time as we seen earlier.
- During any time of day more number of birds got struck and more bird strikes occurred to the engine d type.
- Blue indicates when 1 bird got stuck and orange indicates 2-10 birds got stuck and green indicates 11-100 and red more than 100 birds got stuck.
- But most of the cases are with 1 bird got stuck with the engines of the plane.
- Type d engine has more number of strikes during anytime of the day and got more number of birds stuck.

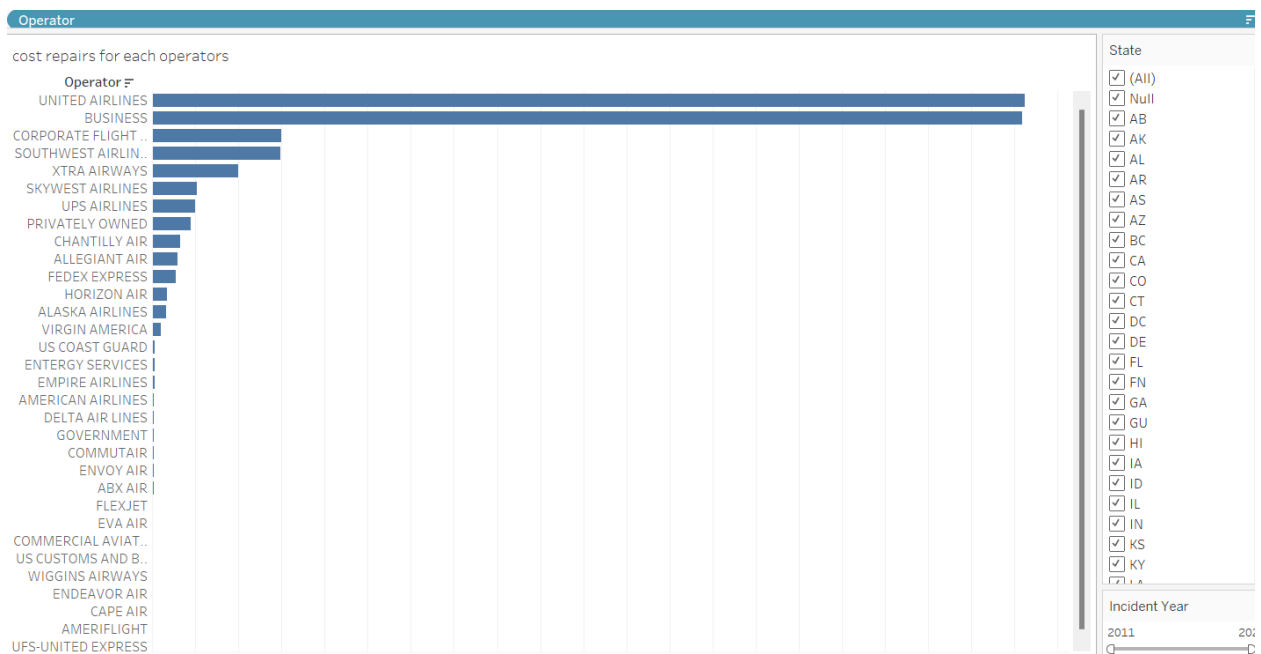
Recommendations:

- Enhance bird strike mitigation for the engines and turbofans are by focusing mitigation efforts on those engines could be beneficial.
- Training and awareness to the pilots and the people who are working in the airports could be the best way to make a smaller number of strikes over the time.

10. Operator vs Cost Repairs:



Viz-10.a



Viz-10. b

Type Of Graph:

The visualization I have picked to show the or analyze the operator vs cost repairs is bar graph. I have taken operators in the row pane and repair costs sum for the operators on the column pane. So that we can see the relation graph between them. We have added incident year as a parameter to this chart. So that we can see year wise records.

10.a graph is for all the years from 2011 to 2023. 10.b visualization is for particular year, here we selected for 2021.

Observations and Analysis:

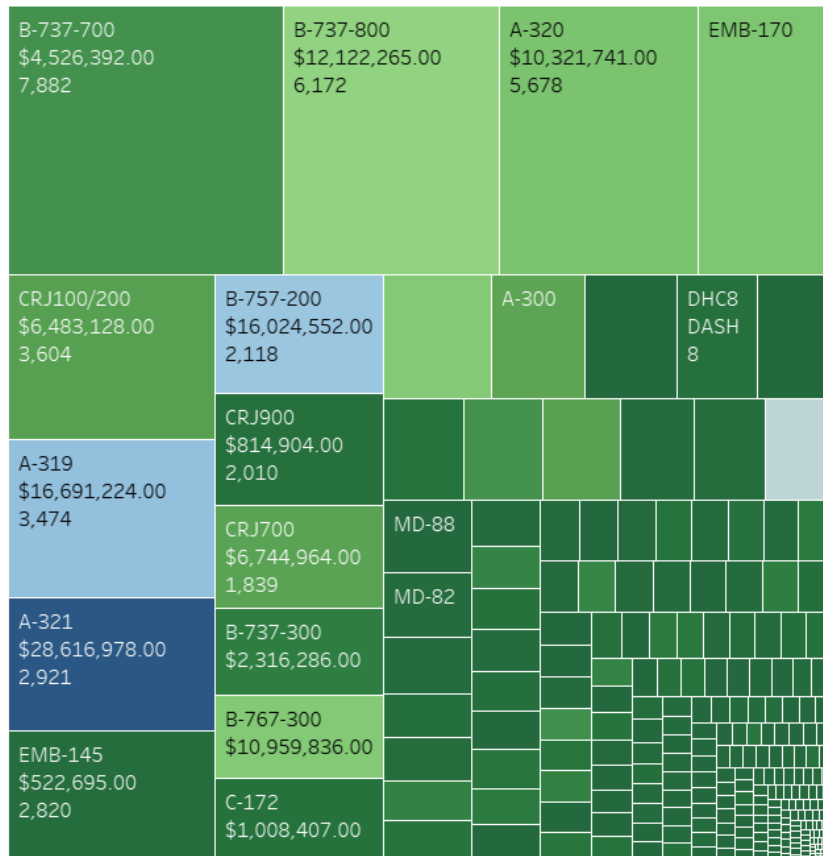
- From the above chart we can see that Business airlines is listed at the top. This shows that it has invested highest repair costs due to bird strikes.
- Followed by next is Alaskan Airlines, has invested most for repairing the damages.
- US airways is the operator which has invested low for cost repairs.
- For the particular year 2021 in Viz 10.b we can see that United Airlines listed on top and then followed by Business and corporate flight airlines.
- For the year 2021 UFS-United express operator is the one which invested very low amount for cost repairs.
- Here we can say that Alaskan, united, Business airways are the most operating airways in USA. So, we can see major bird strikes with these operators. So, they must invest more amount for repairing damages.

Recommendations:

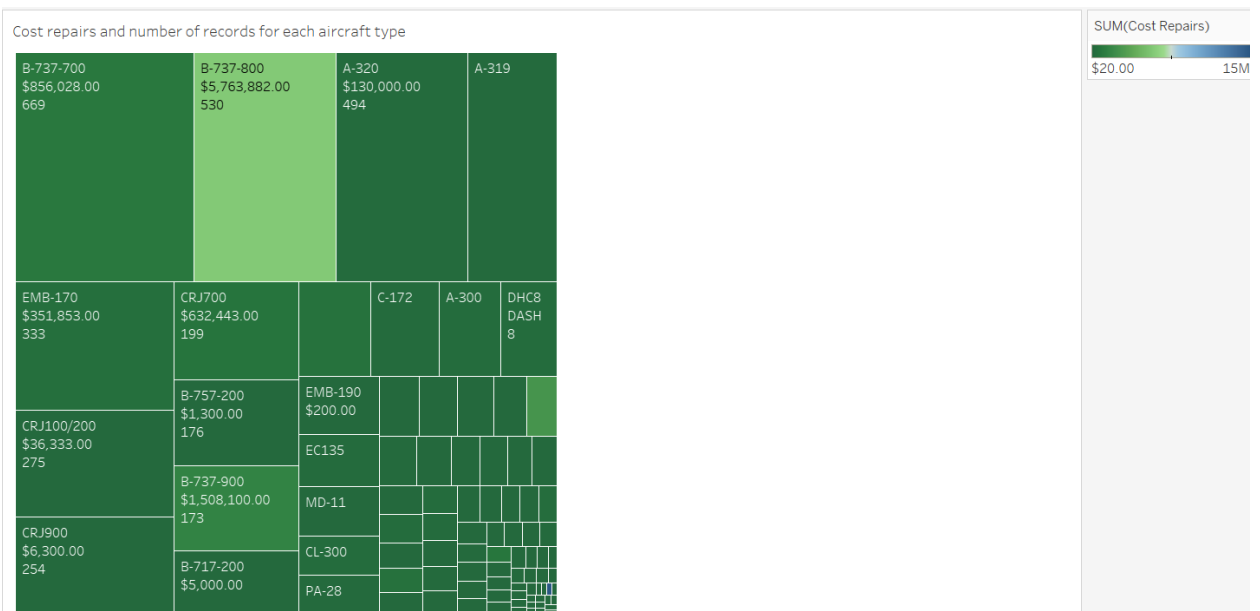
- Major airlines like Alaskan airlines, business airlines and united airlines may benefit from a deeper cost-benefit analysis to determine if investing. Cost analysis for major carriers is important.
- For airlines with high repair costs, investing in bird strikes mitigation technology, such as bird detection systems, could reduce the frequency and severity of these incidents.
- Collaborative efforts with all the other airports to improve habitat management around airfields, making the environment less attractive to wildlife, especially birds.
- Pilot training is important obviously along with all the other recommendations.

11. Aircraft vs bird strike frequency Vs cost repairs:

Cost repairs and number of records for each aircraft type



Viz 11.a. For all years from 2011- 2023



Viz – 11.b . For particular year(Given 2022)

Type of Graph:

For the above visualization I have selected a tree map to show for which aircraft a greater number of incidents occurring and which aircraft investing more for cost repairs. For this I have taken all the required columns and dragged count of records to size in the marks pane in tableau. Dragged and dropped a sum of cost repairs column on top of color pane. So, you can see that the largest box in the tree map gives the aircraft which has more number of incidents of bird strikes happened. The box which has brighter blue color investing more amount on repairing damages.

Observations and Analysis:

- From the above tree map visualization 11.a we can see that B-737-700 incurred the highest bird strike incidents with around 7700 strikes and A-321 has incurred the highest repair costs with \$28,676,978.00. This is for all the years we have taken that is from 2011- 2023.
- From visualization 11.b we can see that more number of accidents occurred for b-737-800 has incurred the highest repair costs and highest bird strike incidents also.
- We can analyze that mostly A class aircrafts are investing more amount for repairing damages and Boing aircrafts are the ones which are having major number of bird strikes.
- Boing is the one which is using more by USA aviation, so major strikes will happen to that.

Recommendations:

- Cost analysis performance for the aircraft with numerous incidents but low-cost repairs costs to understand if these costs are accurate or if there are unaccounted long-term damages.
- Pilot training programs focus on averting these bird strikes, most important for the aircraft types which are most commonly affected.
- Considering operational changes, such as altering flights during the busy period and seasons to mitigate the risk for most affected aircraft.

12. Level of Damage when bird stuck:

Level of damage when birds stuck					
Num Struck	Damage Level				
	D	M	M?	N	S
1	6	1,481	2,520	55,404	642
2-10	3	230	564	7,316	217
11-100		20	38	362	15
More than 100		1	2	12	1

Type of Graph:

We have taken a summarizing table to show the number of birds stuck into turbofan engines and damage level it has caused to the flight. In the above D represents most destroyed and S means more sustainable to the bird strikes.

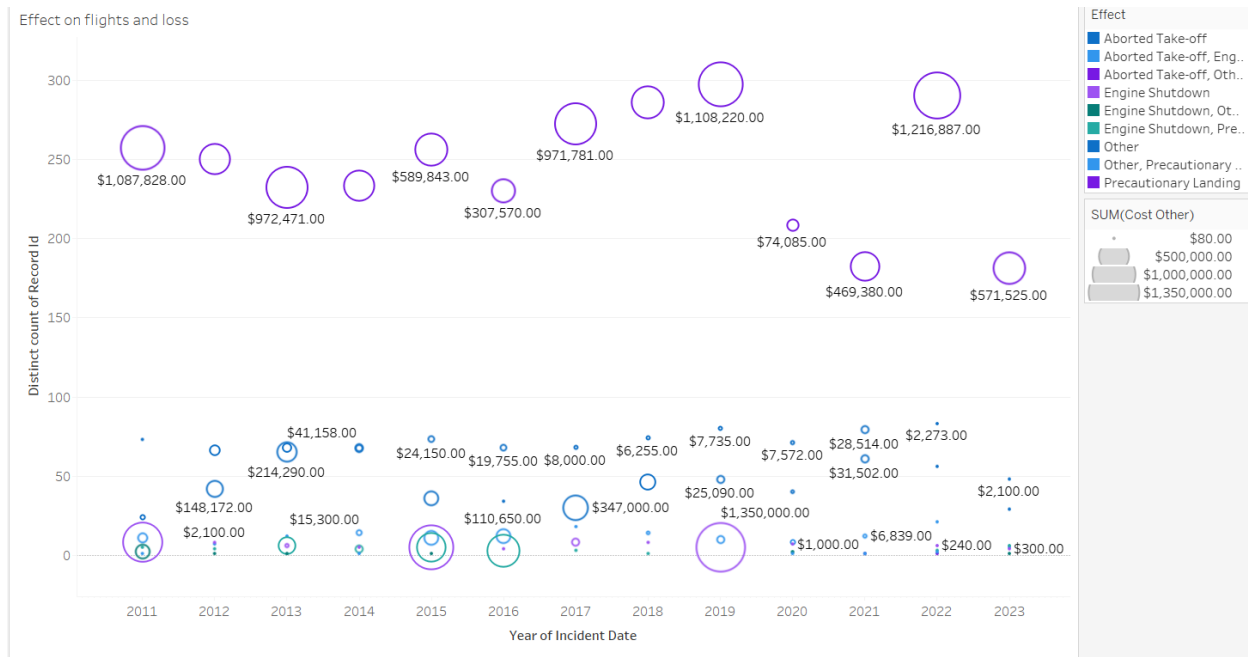
Observation and Analysis:

- The majority of single bird strikes (Num Struck = 1) have a damage rating of N (None), meaning that most of them do not cause any harm. M (Medium) and M? (Medium, Uncertain) come next. In a tiny percentage of cases, the aircraft was destroyed (D) or just suffered minor damage (S).
- The proportion of incidences resulting in medium damage (M and M?), however, noticeably increases as the number of birds. The majority of single bird strikes (Num Struck = 1) have a damage rating of N (None), meaning that most of them do not cause any harm. M (Medium) and M? (Medium, Uncertain) come next. In a tiny percentage of cases, the aircraft was destroyed (D) or just suffered minor damage (S).
- The proportion of incidences resulting in medium damage (M and M?), however, noticeably increases as the number of birds in these kinds of incidents.
- According to the research, bird hits typically cause no damage, especially when there is only one bird involved.
- Regardless of the quantity of birds involved, the great majority of bird strikes, however, do no damage or only questionable damage. This may demonstrate the strength of the aircraft design and the efficacy of the present bird strike mitigation techniques.

Recommendations:

- Aircraft design review is the most recommended thing.
- Wildlife management at the airports
- Pilot training on best practices to avert the bird strikes.

13. Effects on flight and Losses incurred:



Type of Graph:

This is a bubble chart visualization. We have taken a number of records on the rows and years are on columns. The position of the bubble indicates in which year it happened and the size indicates the cost that incurred due to bird strikes and the color indicates the effect on the flight due to bird strikes. The effects are like precautionary landing, engine shutdown, aborted take-off, and others.

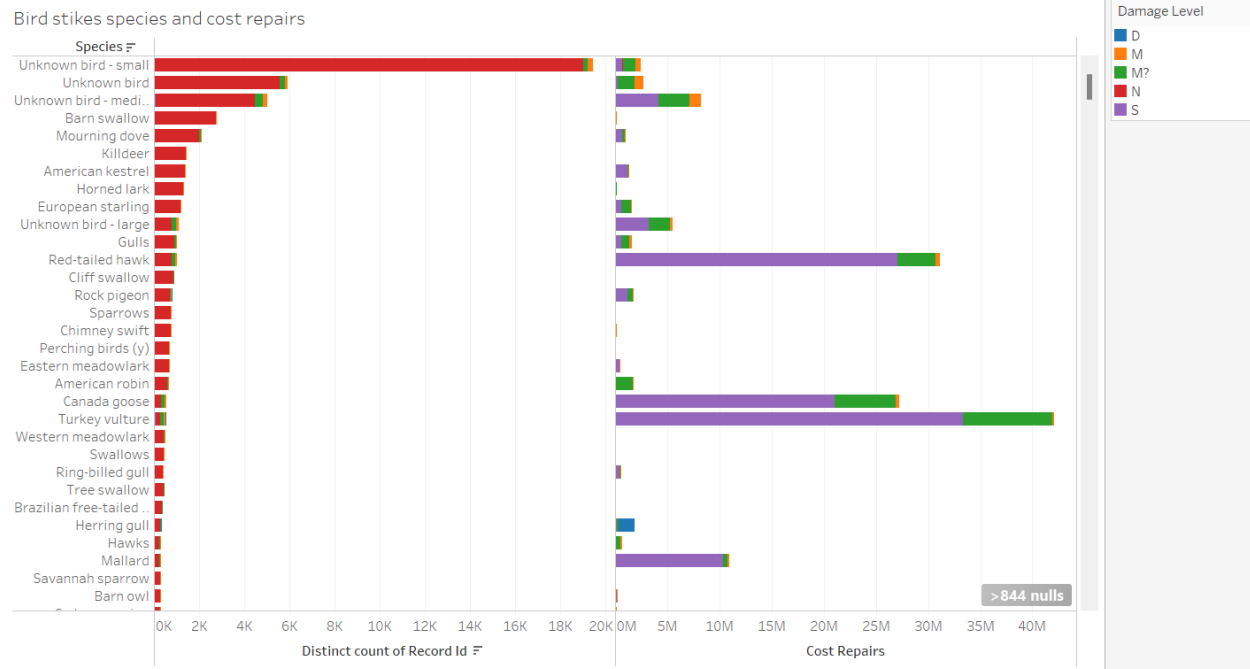
Observations:

- The highest bubble is in 2020, indicates that highest cost due to bird strikes occurred in that year.
- The largest bubble also in 2020. This indicates that most loss due to effect of precautionary landing which is in purple color gives us that due the effect of precautionary landing loss is more.

Recommendations:

- Bird strike mitigation technology should improve.
- Enhanced pilot training.
- Cost management strategies are important.

14. Bird strikes spices and cost repairs:



Type of Graph:

This is a stacked bar chart (horizontal) Bird strikes species on the rows and cost repairs and number of birds strikes on the columns.

Colors indicate damage level that it caused. D means destroyed, M means medium, m? means uncertain, N means None and s means sustainable.

Observations:

- The species "Unknown bird-small," "Unknown bird," and "Unknown bird-medium" are the ones that cause the most strikes and the most repair expenses.
- In comparison to the "Unknown bird" categories, the bars for recognized species, including "Canada goose" and "gulls," show fewer incidents but higher repair costs.
- Bird strikes involving smaller birds are common but may not always be recorded or identified, and the high costs linked with unknown bird species indicate that identifying the species involved in bird strikes is difficult.
- The greater repair costs for species such as the "Canada goose," which is recognized for its big size and flocking propensity, suggest that larger birds or flocks tend to inflict more serious damage.

Recommendations:

- Focus wildlife management and habitat alteration efforts at airports to deter large bird species, as they are linked to higher costs in repairs.
- This issue requires improvements in pilot training and simulation, especially for the pilots flying.

15. Damage level Vs cost repairs:



Type of Chart:

The type of visualization chart is pie chart. We have analyzed the level of damage when bird strikes to the aircraft and how much investing for that level of damage. D means destroyed(blue), M means medium(orange), M? means medium uncertain(green), N means none(red) , S means sustainable to the damage(purple).

Observations:

- We can see here even it is sustainable to the damage though it may have some dents or something on the aircrafts which is costing more than the destroyed costs for aviation authority.
- This is because a greater number of smaller incidents are huge than having serious incidents.
- So, we can analyze that even if the damage is small since it is in huge number cost repairs are more.

Recommendations:

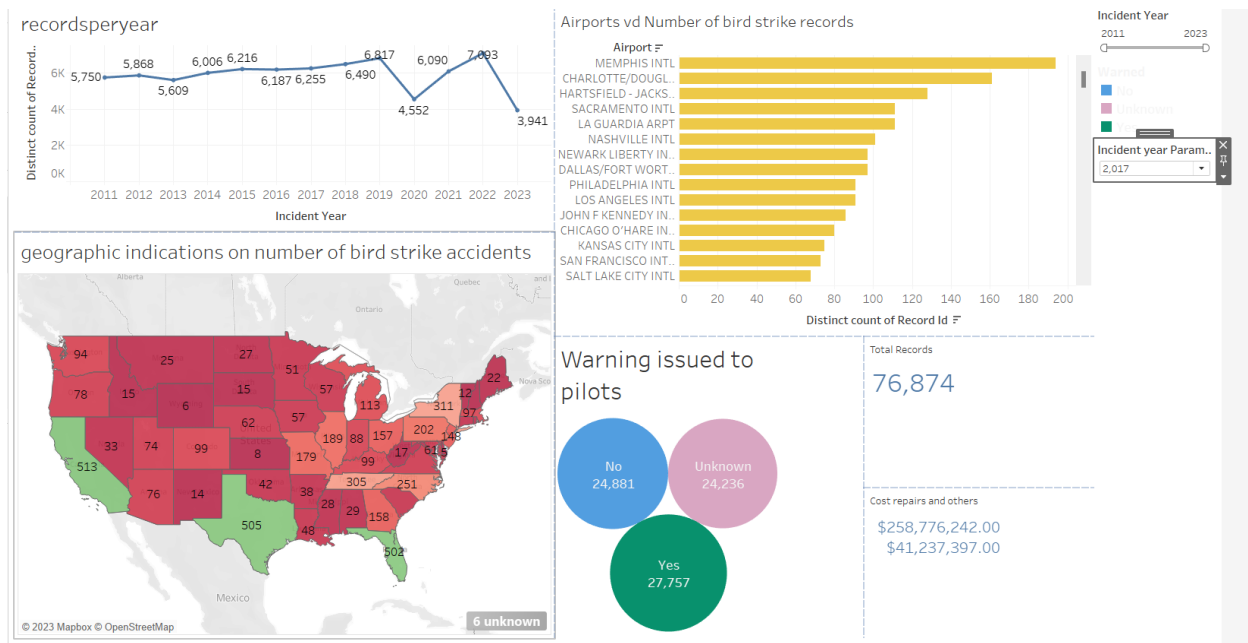
- Cost allocation review might mitigate the bird strikes.
- Enhancing the damage assessment improves the accuracy and then it might decrease the cost of repairs for the damages.
- Pilots and airfield workers should focus more on preventing this bird hits.

Dashboards:

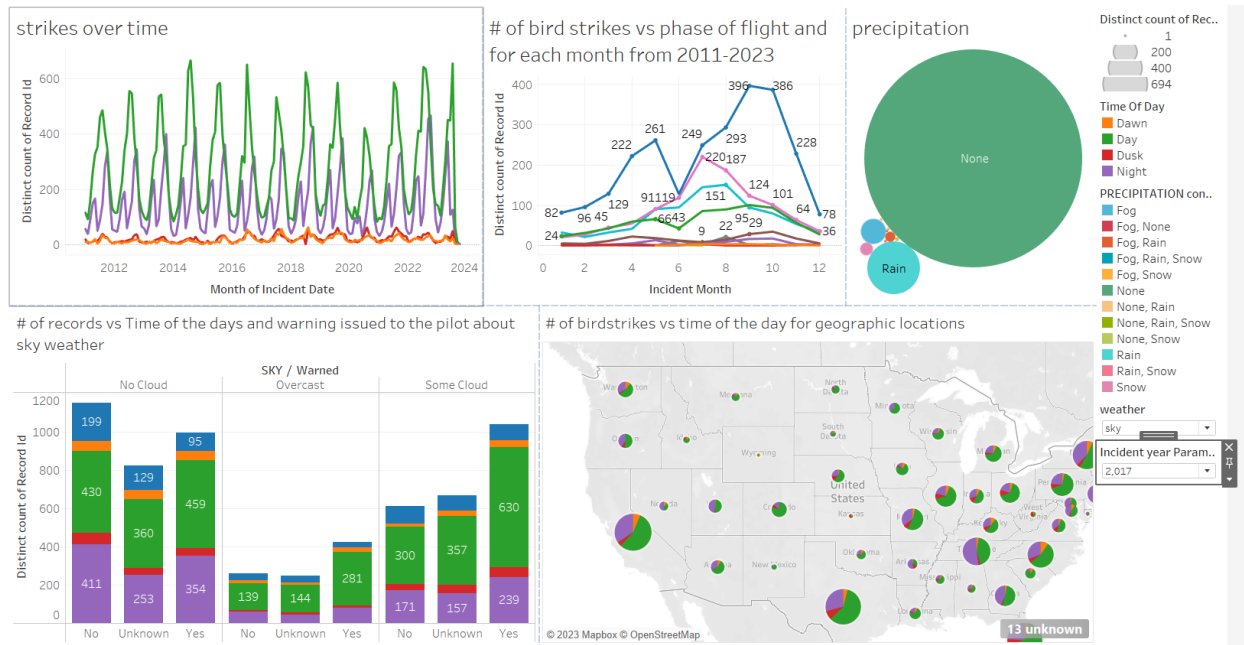
Dashboards are important because they transform data into visuals like charts graphs and maps. This makes the most complex information or data into easy analysis. We can observe many insights also from this. This is the time saving method.

I have created 4 dash boards here for the above analyzations. We can see all the interaction dashboards down here.

1. For number of records on different factors:



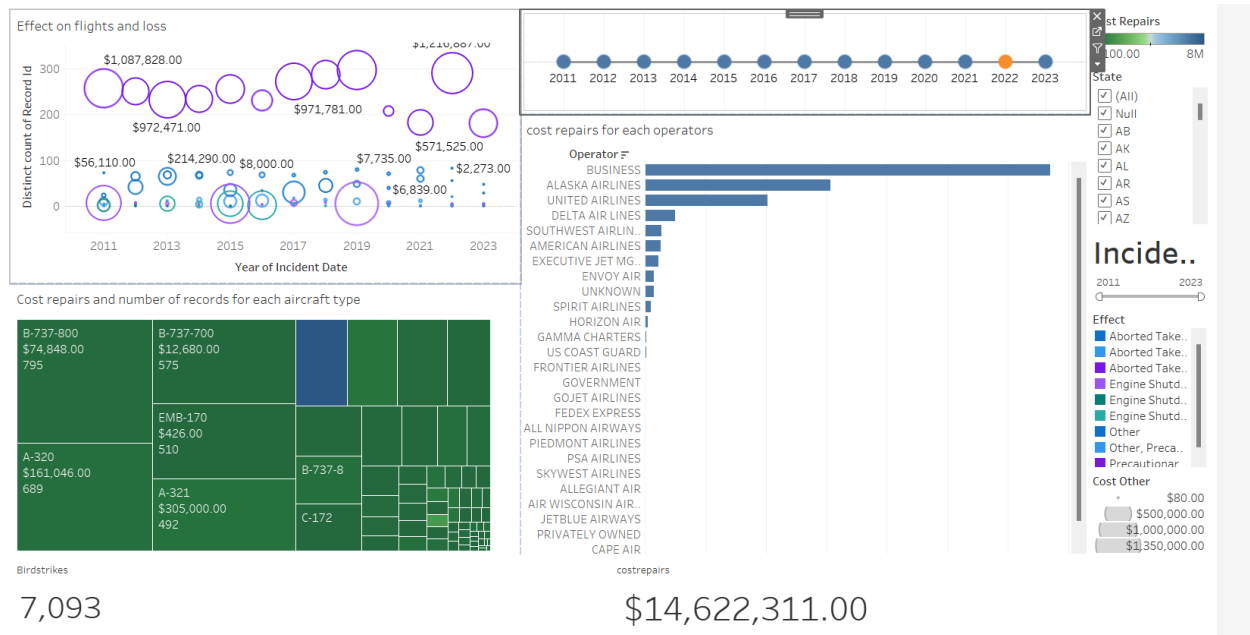
- Here there are 4 visualizations for different factors all the things analyzing number of incidents happened.
 - Line chart is giving number of bird strike incidents happened for each year count is analyzing.
 - For the bar chart it is analyzing which airport has the greatest number of bird strike incidents occurred.
 - Map chart is for geographic indications, and it changes according to respective year. This is analyzing which state in USA has a greater number of bird strike incidents happened.
 - Bubble chart is analyzing how many cases of bird strikes happened if the warning issued to the pilot or not.
 - Total records is the text which tells that total number of bird strikes happened for all the years from 2011-2023.
 - Cost repairs and other costs which incurred for the bird strike damages from 2011-2023.
2. Second dashboard is for to analyze the bird strike incidents with respect to seasons, time of the day, phase of flight:



In this dashboard there are 5 visualizations where bird strikes in aviation impacts with different features like time of the day, phase of flight, seasons, precipitation, warning issued to the pilots about the sky condition and its geographical indications.

- Strikes over time analyzes the bird strikes patterns with respect to time of the day. Day time is the one where a greater number of strikes are happened.
- Number of bird strikes occurring and their pattern during which months are more and at which phase of flight is more. We analyzed that it happened most at approaching phase and during fall season like august, September and October are more.
- With no precipitation, a greater number of bird strikes are happening. This is because during clear weather more air traffic is there, so the chances of bird strikes are more than rainy or snowy days.
- With the warning issued, we observed that even when the warning is issued to the pilots sometimes, they are unable to avert the situation. So, there are a greater number of bird strikes happened when the pilots issued warning also.
- Finally, we have shown all these factors for different geographical locations.

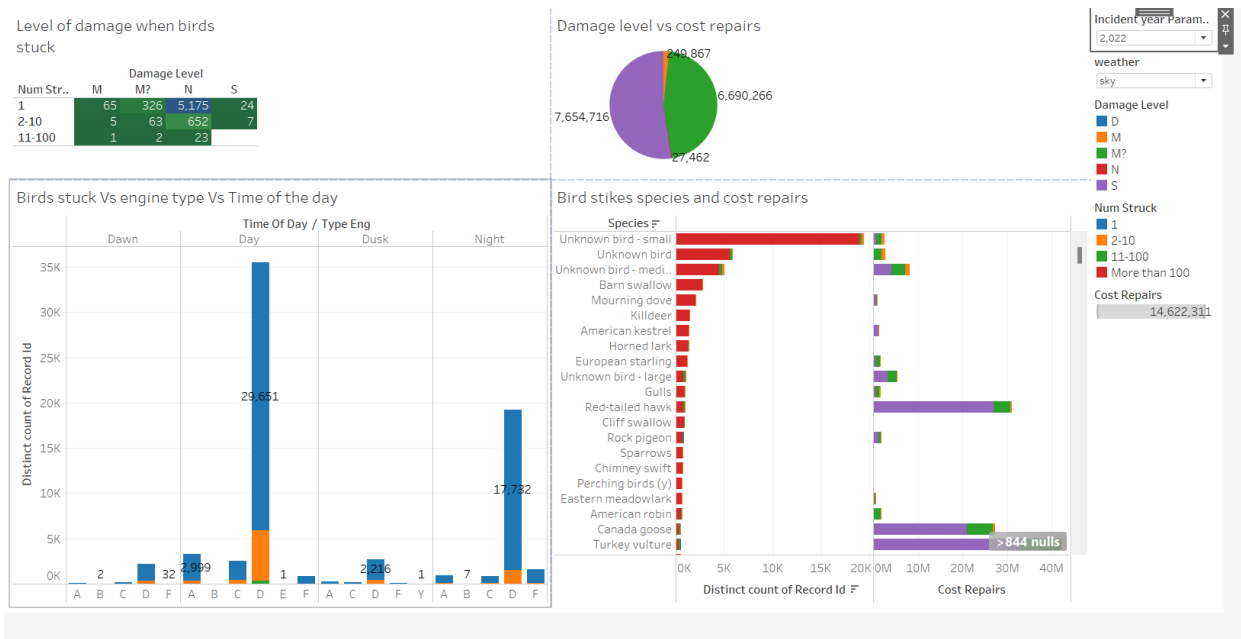
3. Third dashboard deals with cost repairs and other costs incurred due to damages caused by bird strike incidents:



This dashboard has 4 graphical visualizations and 2 text charts. Here we have concentrated more on the cost of repairs and other costs spend by different operators, aircrafts for different effects caused by the damages. Different effects are like precautionary landing, engine shutdown, aborted flight take-off, and others.

- Bubble chart analyzes for which year, and for which type of effect caused by bird strikes has more number and invests more amount to compensate damages.
- Next is the time series line chart just for the interactive element. If you click on any year the other graphs change accordingly.
- The tree map is the one which visualizes which aircraft has incurred more to cost repairs and which aircraft has the greatest number of bird strike incidents. Box indicates the number of incidents occurred and color indicates the amount that aircraft invested.
- Last is the bar graph which shows which operator invested more amount for cost repairs.
- The text chart is for number of incidents happened and the total cost spent for the damages for the particular year than selects from the time series chart.

4. Fourth dashboard has visualizations showing that damage level caused due to bird strikes and species of the birds that are responsible for and how much investing for the damage:



This dashboard consists of 4 visualizations which explain species and size of birds can easily get stuck into the turbo engines and how much damage it is creating. For that level of m=damage how much we are investing to repair it and Which engine is most vulnerable to birds strikes.

- In the last visualization we can analyze which size of birds are more frequently striking the aircraft and how much damage costs they are creating depends on the level of damage those birds caused.
- The blue bar graph analyzes which type of engines are most vulnerable to bird strikes. We can see that D type engine has the greatest number of birds strikes incidents happened.
- The pie chart shows which level of damage making aviation authority must invest more amount for cost repairs.
- The table chart shows how many numbers of birds got stuck into the turbo fans and the level of damage they are creating.

These are the different dashboards that I have created to analyze different factors or features involved in bird strikes in aviation. These visualizations help us to find some recommendations and implement better solutions to mitigate the number of bird strikes happening every year. Though this is unavoidable because we cannot always control nature, but at least we can try to mitigate the number.

Conclusion:

By creating visualizations and consolidated visualizations in dashboards pertaining to bird strikes in aviation, giving a multi picture of hazards and impacts involved with that events. The analysis reveals several key points.

1. Related to bird strike patterns:
 - a. Patterns of the birds: We can analyze that bird strikes are predominantly happening during daytime, aligning with increased flight activity and bird movement.
 - b. Seasonal fluctuations also suggest a correlated pattern with the bird strikes. We analyzed that a greater number of bird strikes happening during fall time.
2. Related to Damage and cost implications:
 - a. Most bird strikes do not have any impact on the aircraft and cause huge damage to the aircraft. Though it may cause some dents and little effect to the aircraft which also needs to get repaired.
 - b. But we can see that the greatest number of damages are caused during the approaching time. So, more focus on the approaching phase we can mitigate the damages and cost repairs.
3. Depends on weather conditions:
 - a. Clear weather conditions have the highest number of bird strikes indicating that there is more air traffic at the time of clear conditions, and we need to use advanced radar technologies to reduce the damage during these weather conditions.
 - b. Technologies should also enhance which are used for identifying the cloudy conditions and warnings should be issued to the pilot in prior so there are more chances to prevent the bird strikes from happening.
4. Engine types:
 - a. Some engine types are more vulnerable to bird strikes, suggesting that specific models or operations might benefit from targeted risk reduction.
5. Bird species and sizes:
 - a. Data collection should be accurate about the bird species which are causing more damage to the aircraft.
 - b. So that we can make our engines and aircraft sustainable to the damage caused by those species.

There should be a fool-proof set of guidelines generated to deal with a bird strike warning. ATC, ground staff and the pilot in-charge should work hand in hand to avert a possible bird strike.

Every pilot should be aware of the wildlife in and around the area from which the flight will take off and well-planned and tactical simulations about how to tackle the wildlife should be incorporated into their training.

Considering the repair costs being posed, it is recommended to avoid using class-A and class-B aircraft, since the aircraft, on being involved in a bird strike incur a high repair cost.

