WILDLIFE STRIKE RISK ANALYSIS FOR AIRCRAFT DAMAGE PREVENTION

Sector - Aviation Manufacturing & Safety Engineering

G-14

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CONTEXT & PROBLEM STATEMENT

Sector Overview

Aircraft manufacturers must design planes that withstand wildlife strikes while meeting strict safety standards. Bird strikes can cause engine failure, structural damage, high maintenance costs, and safety risks.
Decision Maker: Aircraft Design & Safety Engineering Team

Business Problem

Not all wildlife strikes cause damage.
Which conditions (flight phase, species, engine ingestion, environment) significantly increase aircraft damage risk?

Objective

To identify high-risk factors that drive aircraft damage and support data-driven design improvements to enhance structural and engine safety.

DATA ENGINEERING

Source

- Raw_Dataset.csv
- Initial size:174,000 rows
- Final cleaned dataset: 9,999 rows

Major Cleaninig Actions

- Removed null and irrelevant coulmns
- Duplicate removal
- Handled missing values
- Formatted the data

Final Dataset Structure

- **Flight Info**: Year, Month, Flight Phase, Airport, State
- **Aircraft & Engine**: Aircraft Type, Engine, Engine Type, Engine Ingestion
- **Environment**: Visibility, Precipitation, Height Band, Speed Band
- **Wildlife**: Species, Quantity
- **Impact**: Aircraft Damage, Flight Impact

KPI & METRICS FRAMEWORK

Peak Migration Month

Metric: Highest monthly incident count
Wildlife strikes significantly increase during migration periods due to flock movement patterns.

Engine Ingestion Risk

Metric: % of strikes where engine ingestion occurred
Engine ingestion represents the most critical failure scenario, often leading to emergency inspections and potential engine replacement.

High-Risk Flight Phases

Metric: Maximum strike occurrence by flight phase
Most strikes occur at low altitude during takeoff and landing operations where aircraft intersect bird airspace.

Engine Type D Damage Exposure

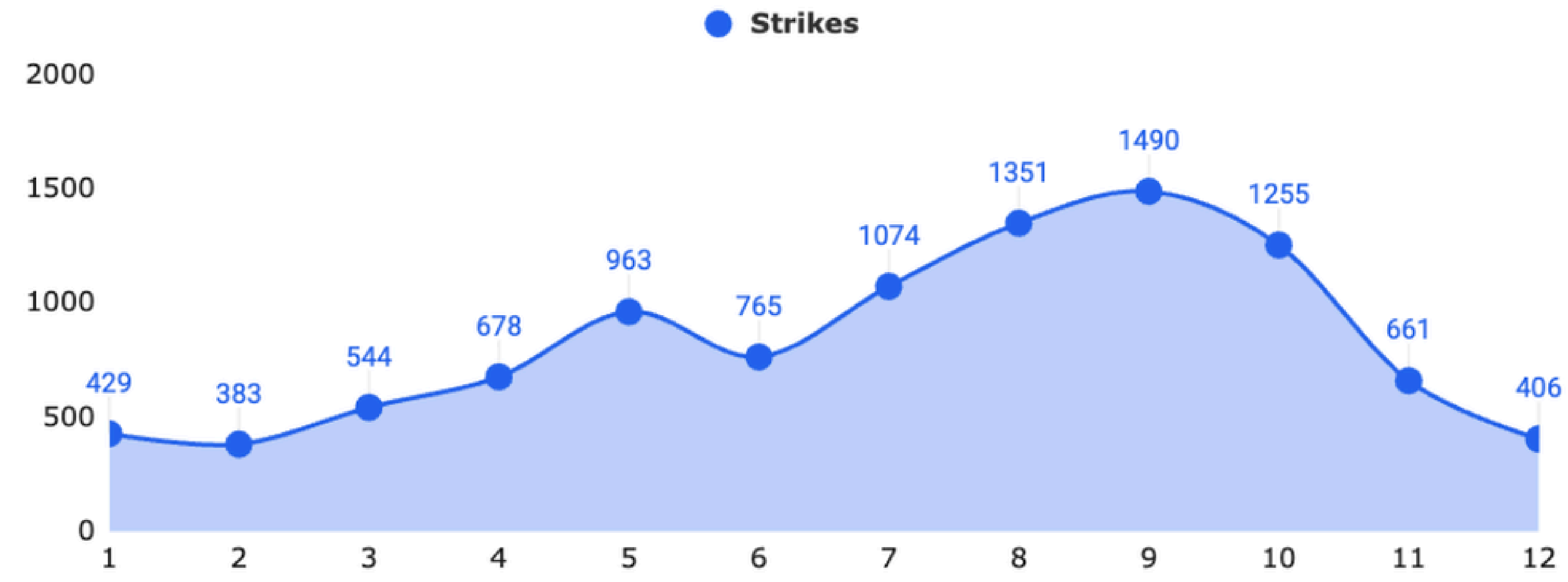
Metric: Highest number of damaging strikes recorded
Large turbofan engines have higher exposure due to larger intake diameter and commercial flight frequency.

KEY INSIGHTS (EDA)

- **High-Risk Phases:** Takeoff & Approach cause most damage → engine and nose vulnerability.
- **Engine Susceptibility:** Engine Type D shows highest damage cases.
- **Bird Strike Load:** Single strikes are frequent, but multi-bird strikes have higher damage rates.
- **Trend:** Damage peaked in 1991–1992.
- **Airport Hotspots:** Few airports account for most incidents → focus for design validation.
- **Engine Ingestion:** Strongly linked to damage → engines are primary failure points.

DASHBOARD

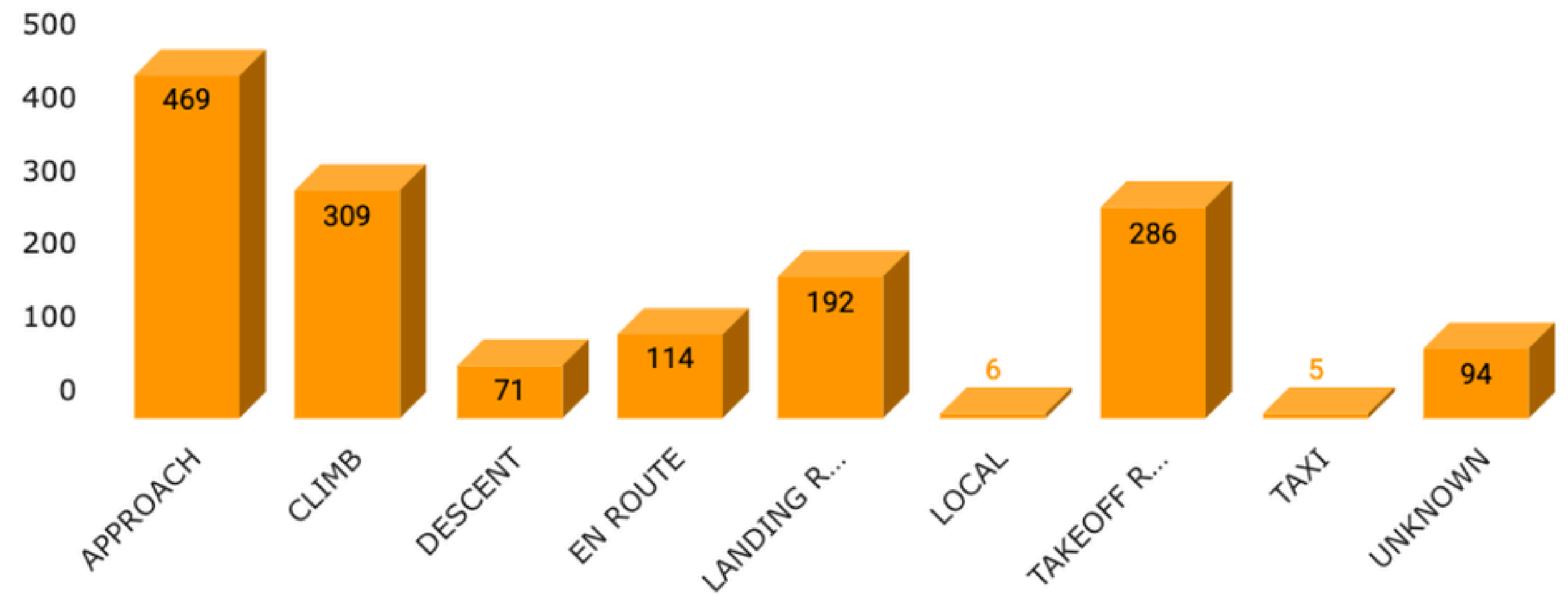
Monthly Strike Trend (Rolling 12 Months)



Incident Month All

Strike frequency rises steadily from early months and reaches its highest level in September (1,490 cases), highlighting significant seasonal exposure in Q3

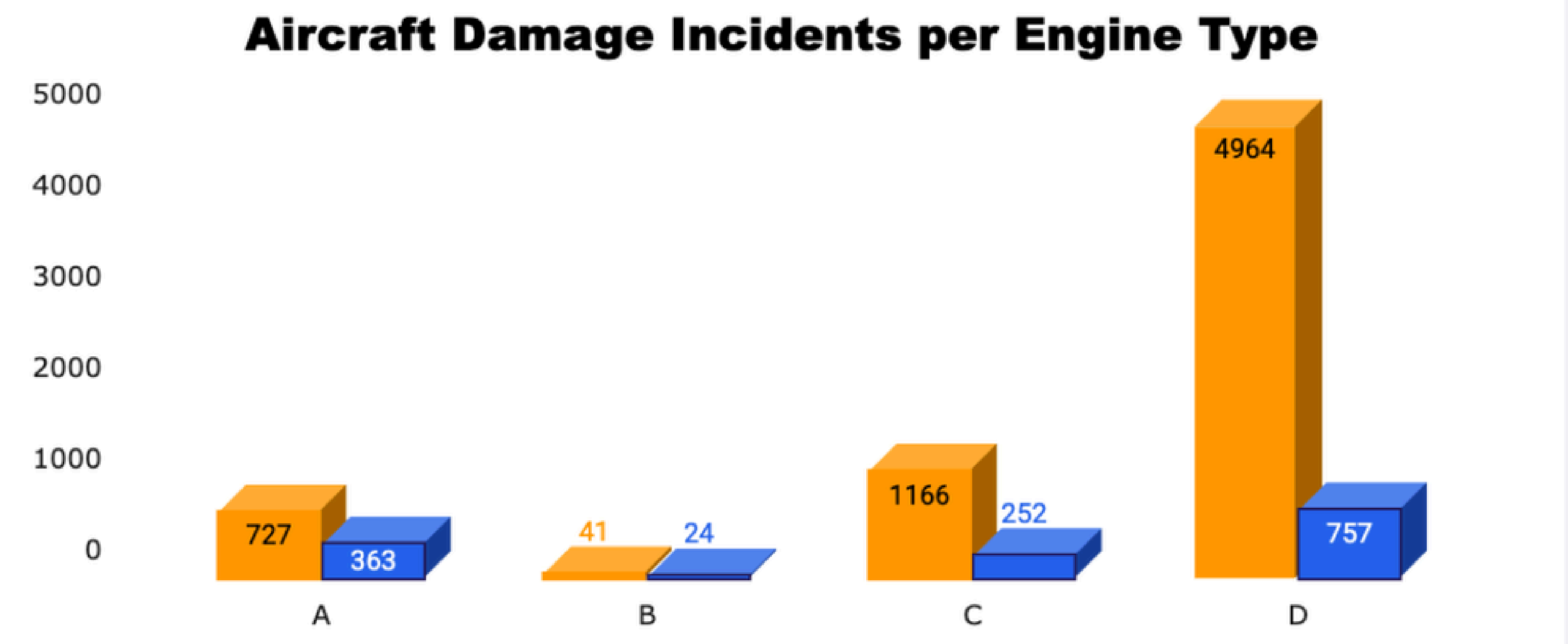
Aircraft Damage vs Flight Phase



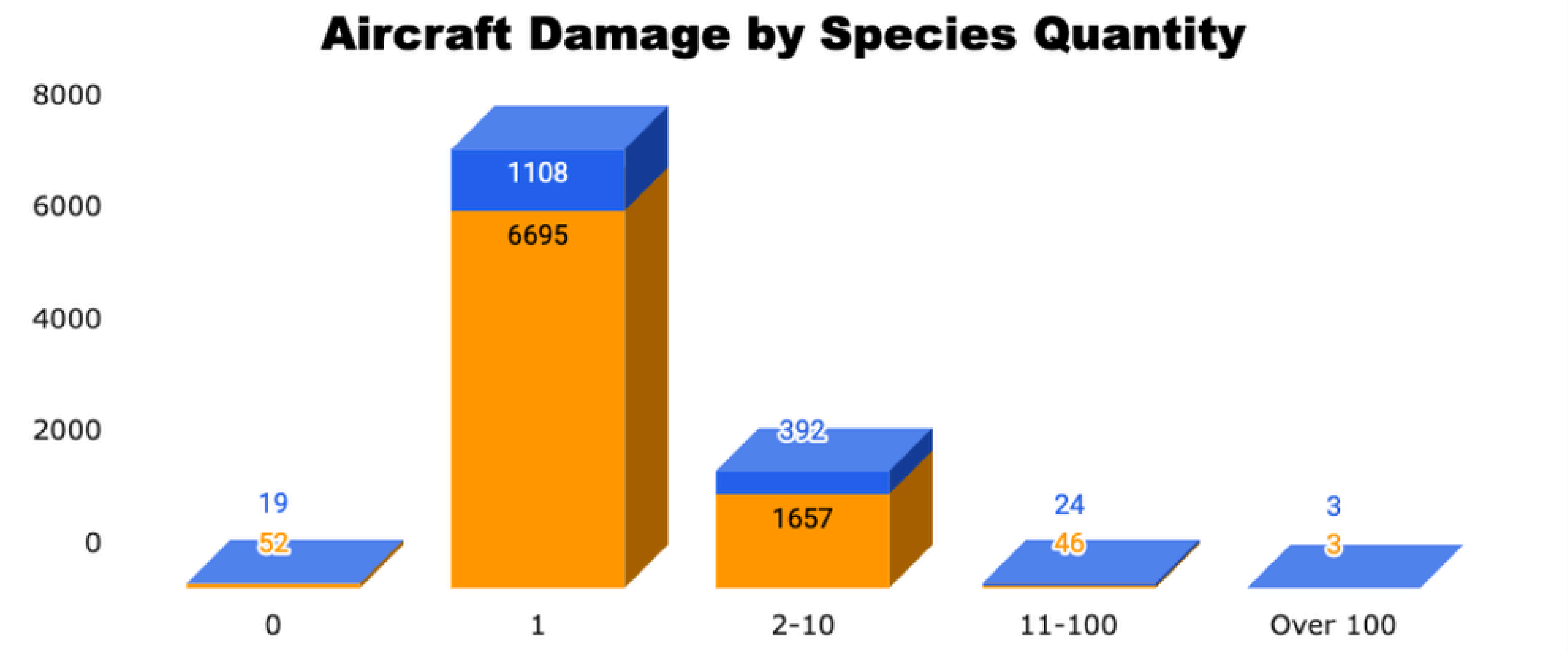
Aircraft Damage Incidents by Flight Phase All

Aircraft damage incidents are most frequent during the Approach (469 cases) and Climb (309 cases) phases, indicating critical risk exposure during transitional flight stages.

DASHBOARD

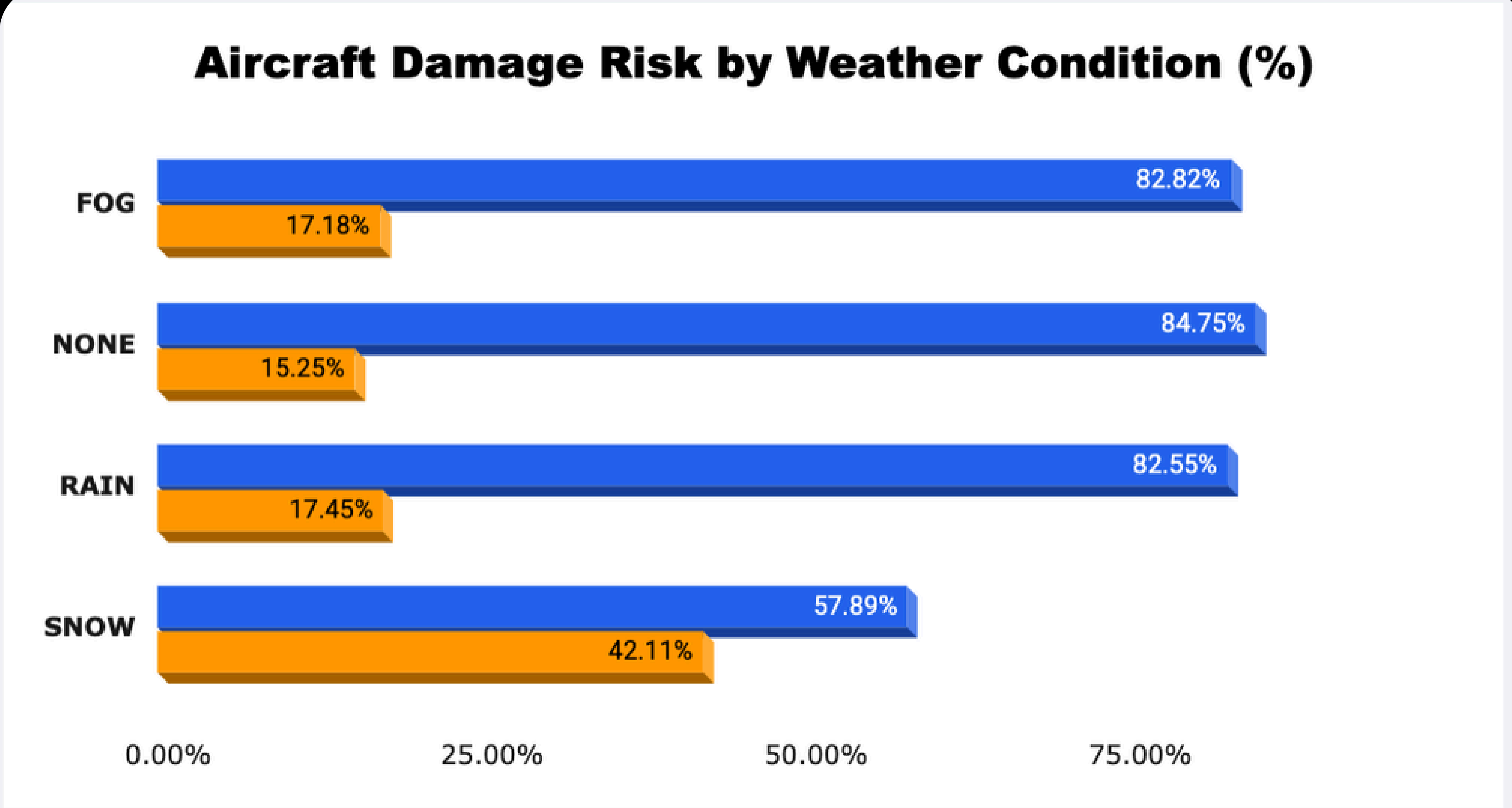


The sharp concentration of damage incidents in Engine Type D suggests potential structural or operational factors influencing higher strike susceptibility.

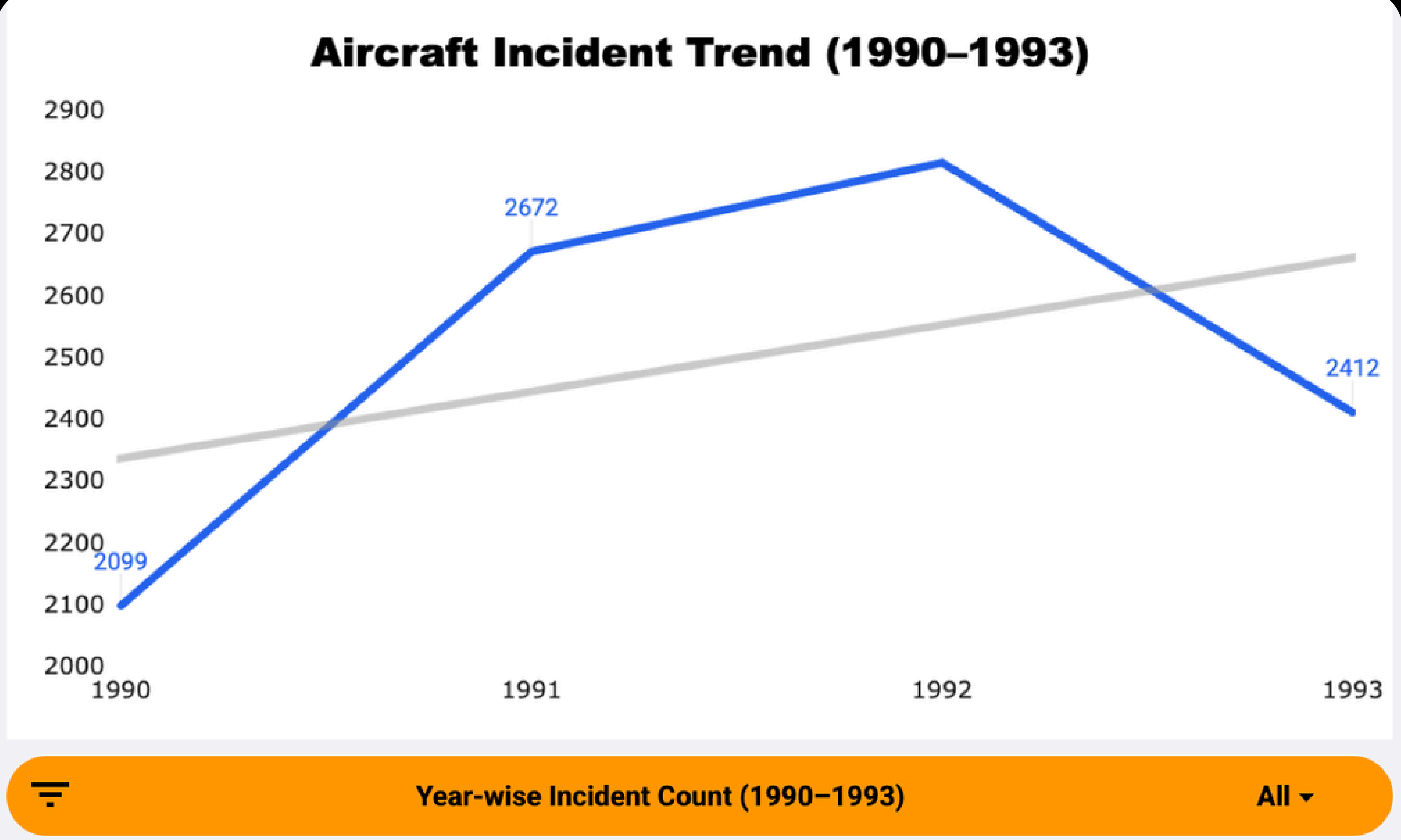


Single-bird strikes dominate overall damage exposure (1,108 cases), while multi-bird strikes in the 2-10 range also contribute substantially (392 cases), highlighting cumulative risk impact.

DASHBOARD



Aircraft damage risk is significantly higher during snow conditions (42.11%) compared to fog (17.18%), rain (17.45%), and clear conditions (15.25%), indicating that snow substantially amplifies strike severity.



Wildlife strike incidents increased significantly from 2,099 in 1990 to a peak of 2,816 in 1992 before declining in 1993. The trend indicates a short-term rise in wildlife interaction risk followed by stabilization.

RECOMMENDATIONS

- Increase wildlife patrols during September migration weeks due to seasonal strike spikes.
- Implement bird-control zones along approach and initial climb (0–1500 ft) corridors.
- Advise pilots to delay rotation or reduce thrust when flocks are detected to limit engine ingestion.
- Adjust runway allocation and departure timing for Type-D turbofan aircraft in high-risk conditions.
- Mandate engine inspection after strikes occurring in approach or climb phases.

BUSINESS IMPACT

Cost Impact

- Reduction in structural and engine repair costs
- Lower aircraft downtime and maintenance frequency
- Fewer unscheduled inspections

Safety & Reliability

- Improved engine ingestion resistance
- Reduced in-flight failure risk
- Stronger compliance with aviation safety standards

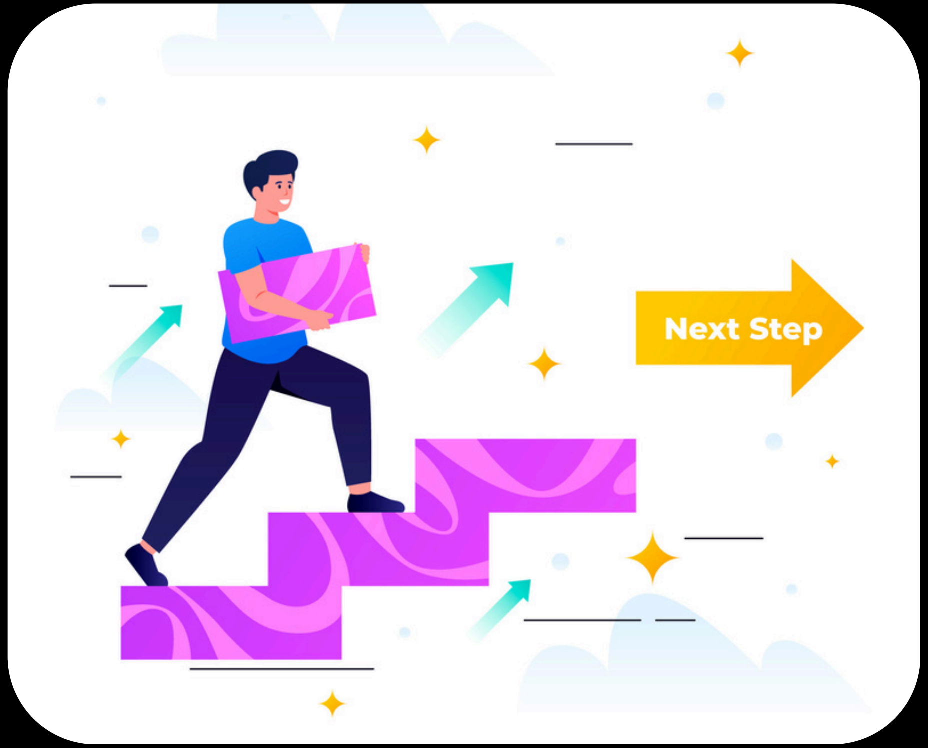
Business Value

- Improved engine ingestion resistance
- Reduced in-flight failure risk
- Stronger compliance with aviation safety standards

LIMITATIONS

- Missing/“Unknown” values in visibility and warning fields
- No direct repair cost or financial impact data
- Species mass/size not explicitly available
- No flight volume data to normalize strike risk per aircraft movement

NEXT STEPS



- Improve missing/unknown data quality
- Apply predictive modeling to estimate damage probability
- Perform engine-type comparative analysis to identify high-risk designs
- Integrate repair cost and maintenance data for financial impact analysis