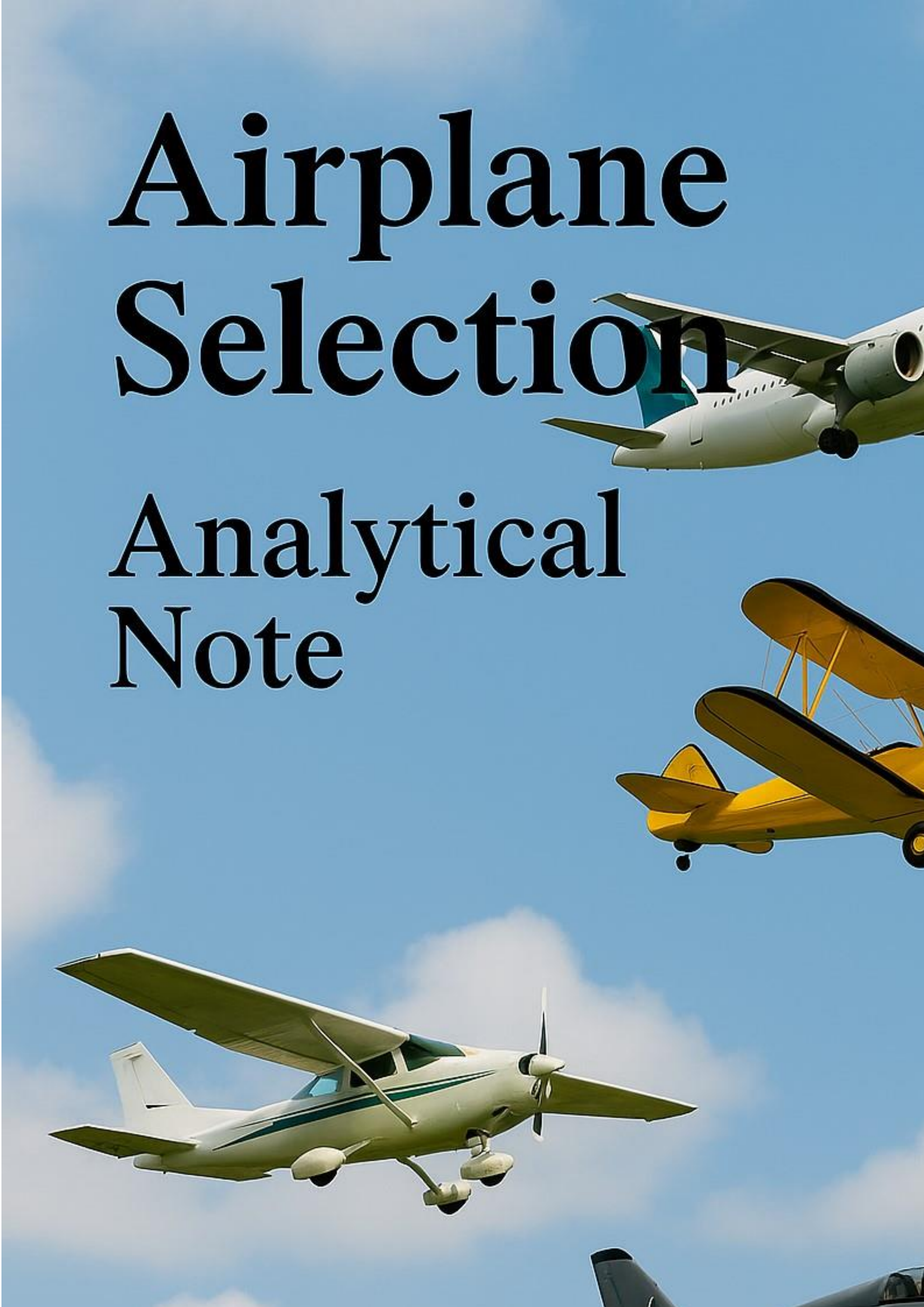
Airplane Selection

Analytical Note



Strategic Aircraft Risk Analysis for Investment Decision

Introduction

The aviation sector presents a unique intersection of opportunity and risk. As demand for private and business air travel surges, firms eyeing entry into aviation must prioritize safety in procurement decisions. The cost of a single aviation incident can be catastrophic—not only in human life but also in reputational damage, insurance premiums, and operational disruption. Therefore, informed aircraft selection based on empirical safety metrics becomes an essential strategy.

However, the risks are not theoretical. According to the U.S. National Transportation Safety Board (NTSB), more than **1,200 general aviation accidents occur annually** in the United States alone. Over the last four decades, accident data has shown that **fatality rates for general aviation average 1.05 deaths per 100,000 flight hours**, significantly higher than commercial airline operations, which stand at fewer than 0.01 fatalities per 100,000 hours. The dataset used in this study, spanning 1982 to 2022, confirms this trend: private and instructional aviation dominate incident reports, accounting for over 80% of recorded cases. Aircraft damage—ranging from substantial to total destruction—appears in more than half of all incidents, reinforcing the importance of data-informed safety assessments.

This study aims to equip decision-makers with a data-driven framework to identify aircraft configurations with the most favorable safety performance. Through historical incident analysis and risk scoring, we isolate the safest aircraft models suited for private and business aviation contexts, forming the basis for investment, regulatory engagement, and operational planning.

Problem Statement

Investing in aircraft without safety intelligence exposes businesses to significant downside risks. Despite advances in aviation technology, accident frequency and survivability still vary widely across aircraft types and operational contexts. Business and private aviation, in particular, show divergent patterns of incident severity. The core challenge lies in translating raw aviation incident records into actionable safety insights that can guide procurement and investment. Without this transformation, organizations risk acquiring aircraft that, while technically sound, carry higher historical incident rates or fatality likelihoods. This analysis seeks to bridge that gap by building indices of severity and survival to rank aircraft safety objectively.

Data Overview and Preprocessing

The dataset used in this analysis comprises aviation incident records sourced from publicly available national aviation databases. It includes over 30,000 records spanning a variety of aircraft categories, flight purposes, engine configurations, and injury outcomes. Key variables include:

- Aircraft make and model
- Flight purpose (e.g., Personal, Business, Instructional)
- Injury severity levels (fatal, serious, minor, uninjured)
- Aircraft damage classification (minor, substantial, destroyed)
- Amateur-built status and number/type of engines

Initial inspection revealed heterogeneous text formats in aircraft names, frequent null entries (especially in damage fields), and categorical redundancy. Cleaning involved:

- Dropping records with missing damage scores or injury totals
- Harmonizing aircraft type labels
- Grouping flight purposes into business-relevant categories
- Isolating aircraft categories relevant to commercial/private investment (Airplane and Helicopter only)

This curated dataset enabled precise computation of safety indicators and focused the scope on investment-applicable aircraft.

Methodology

Step 1: Filtering Relevant Aircraft

We began by narrowing the dataset to include only **Airplanes** and **Helicopters**, the two aircraft types most prevalent in private and business aviation. This filter excluded experimental, lighter-than-air, and ultralight aircraft, which are less relevant to mainstream investment. By doing so, the analysis concentrated on configurations that are both commercially viable and widely used.

Step 2: Grouping Flight Purpose

Flight purpose is a critical determinant of aircraft exposure to risk. We grouped usage into two broad categories:

- **Business-Oriented Flights**: Includes flights logged as "Business," "Executive/Corporate," "Ferry," and "Positioning."
- **Private Enterprise**: Covers "Personal" and "Instructional" use.

This classification revealed how flight mission shapes incident severity and survivability, offering important contextual nuance for risk interpretation.

Step 3: Computing Safety Indices

To standardize safety performance across aircraft configurations, we developed two indices:

- **Survival Rate (%)**: This index captures the share of passengers who emerged uninjured from incidents involving a given aircraft configuration. It is calculated as:

  A higher survival rate indicates a configuration more likely to preserve life during incidents.

- **Severity Index (%)**: This quantifies the average structural damage level sustained by an aircraft during incidents, standardized on a 100-point scale:

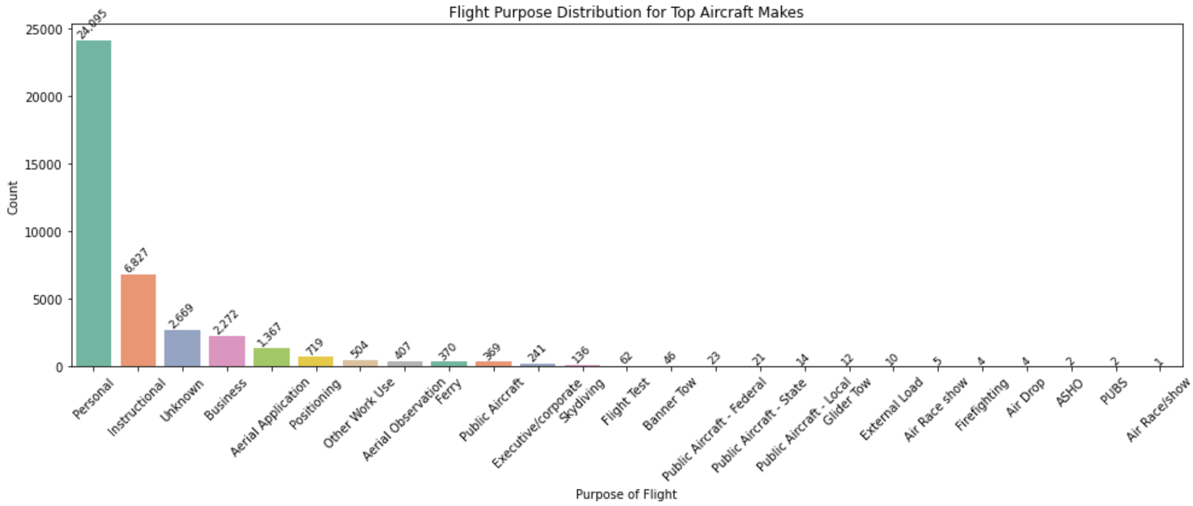
Where damage is scored as: Minor = 1, Substantial = 2, Destroyed = 3. A lower score implies reduced structural loss risk and lower replacement or repair costs.

Together, these indices define the **safety quadrant space**, enabling us to locate aircraft in zones like "Safest," "Danger Zone," or "Low Survival."

Findings and Visual Insights

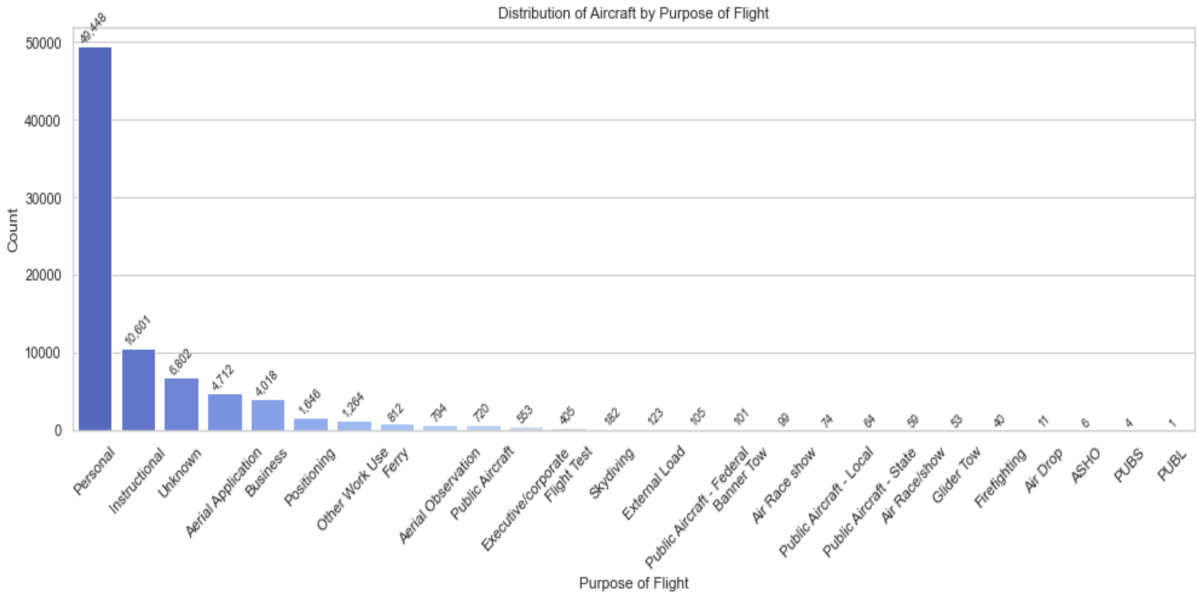
1. Aircraft Purpose Distribution (Figure: Flight Purpose Distribution)

The majority of incidents involved personal use, followed by instructional and business flights. Personal and instructional flights accounted for over 80% of total records, but business-related flights still offered a meaningful base for safety profiling. This highlights the necessity of separating flight purpose in safety analysis, as exposure and mission-criticality vary significantly.



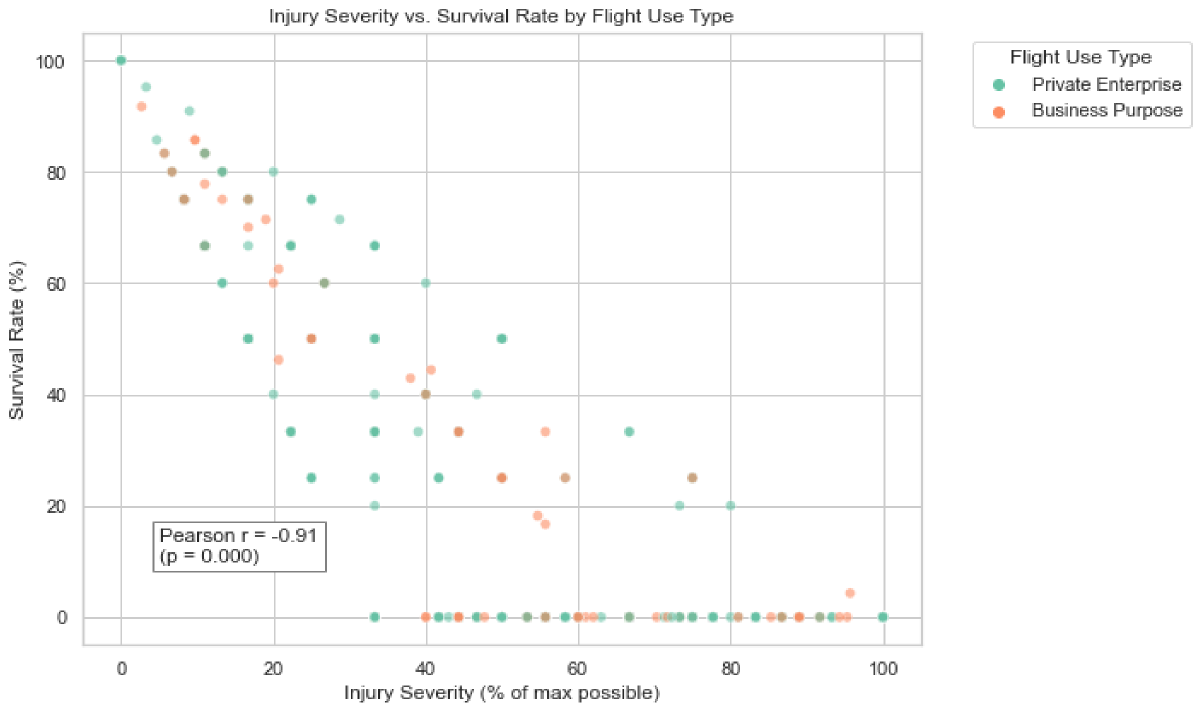
2. Aircraft Category Distribution (Figure: Aircraft Category Distribution)

Airplanes dominated the dataset (~28,000 incidents), followed by helicopters. Their prevalence confirms the appropriateness of limiting our study to these two types. This insight also confirms that our investment context aligns well with data availability.



3. Correlation between Severity and Survival (Figure: Severity vs Survival Scatter)

We observed a strong negative correlation of **r = -0.91** between the Severity Index and Survival Rate, indicating that aircraft suffering more damage tend to result in lower passenger survivability. Interestingly, flights categorized under "Private Enterprise" consistently outperformed others, clustering in the high-survival, low-severity quadrant. This suggests that private aviation—possibly due to more cautious flight profiles or better maintenance discipline—may be inherently safer.



4. Quadrant Safety Analysis by Aircraft Attributes (Figure: Quadrant Plots)

Plotting aircraft across the four risk quadrants revealed that non-amateur builds with reciprocating engines tended to dominate the **Safest Zone** (high survival, low severity). In contrast, turbine-powered helicopters and amateur-built kits frequently appeared in the Danger Zone. This quadrant analysis enabled us to isolate safety not just by aircraft name, but also by structural and mechanical characteristics, aiding in informed procurement.

Table 1: Safest Aircraft Configurations (100% Survival, 0% Severity)

This table summarizes the aircraft configurations that achieved perfect scores in both survival and damage avoidance:

MAKE	MODEL	AMATEUR BUILT	NO. OF ENGINES	ENGINE TYPE	COUNT	AVG SEVERITY	SAFETY SCORE
SAVAGE AIR LLC	EPIC LT	YES	1	TURBO PROP	1	0.0%	100.0%
MURPHY AIRCRAFT	MURPHY REBEL	YES	1	RECIPROCATING	1	0.0%	100.0%
NORD (SNCAN)	STAMPE SV4C	NO	1	RECIPROCATING	1	0.0%	100.0%
NORMAN	QUAD CITY CHALLENGER	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	0-47B	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT 6D	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT 6F	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT-6	NO	2	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT-6C	NO	1	RECIPROCATING	6	0.0%	100.0%
NORTH AMERICAN	AT-6D	NO	1	N/A	2	0.0%	100.0%
NORTH AMERICAN	AT-6D	NO	1	RECIPROCATING	2	0.0%	100.0%
NORTH AMERICAN	AT-6F	NO	1	N/A	1	0.0%	100.0%
NORTH AMERICAN	AT-6F	NO	1	RECIPROCATING	1	0.0%	100.0%
NORTH AMERICAN	AT-6G	NO	2	RECIPROCATING	1	0.0%	100.0%

Conclusion: Addressing the Analysis Objectives

The standout performer, **NORTH AMERICAN AT-6**, is a non-amateur build with multiple reciprocating engines. Its high observation count adds robustness to its safety profile. The **MURPHY REBEL** and **STAMPE SV4C** are lighter, amateur-built aircraft, but still recorded flawless safety histories in the dataset. These models serve as benchmarks for procurement consideration.

Conclusion

This analysis has produced a robust, evidence-based roadmap for selecting safe aircraft for private and business aviation investment.

- **Objective 1: Aircraft Identification**
    - We narrowed 30,000+ incident records to aircraft in active private and business use, focusing on airplanes and helicopters with commercial viability.
- **Objective 2: Risk Index Computation**
    - We developed and applied two critical indices: Severity and Survival. The strong inverse relationship (r = -0.91) validated their interpretability and predictive power.
- **Objective 3: Recommendation**
    - We identified a subset of aircraft that scored **100% in survivability and 0% in structural damage**. These configurations, particularly the **NORTH AMERICAN AT-6**, emerged as top recommendations.

Policy Implication: Decision-makers are now equipped with a repeatable, transparent process to select low-risk aircraft based on historical evidence. This approach strengthens due diligence for capital expenditure, insurance negotiations, and operational strategy in aviation investments.

Future studies can extend this model by incorporating weather, pilot age, and maintenance data to deepen causal understanding.