Data-Driven Decision Support for Aircraft Procument

Student: Daniel Mwaka

Student Pace: DSF-FT12-Hybrid

Instructor: Samuel Karu

Overview

This project aims to support the company's data-driven decision to procure relatively low-risk airplane models to operate the fleet in the commercial and private enterprise sectors. It analyzes a dataset compiled by the National Transportation Safety board and retrieved from Kaggle.com. Presented recommendations are deduced from descriptive statistics results and backed-up by interactive visualizations modeled using Tableau Public.

Business Problem

Venturing into a new industry avails a company of potential growth opportunities. Diversifying a company's portfolio lowers reliance on a single revenue stream (asset diversification) and optimizes resilience against unfavorable business environments/ factors (Luo, 2022). However, venturing into a highly sensitive sector, such as operating airplanes for commercial and private enterprises, necessitates data-driven decisions, strategic implementation, and formative performance evaluation (Altundag & Wynn, 2024). Purchasing airplane models prone to crashing poses a substantial risk to human life, brand image, competitiveness, profitability, and the company's longevity once it ventures into the new industry.

Data Understanding

The NTSB aviation accident database contains information on crashes and contingency incidents within the U.S., its territories, and across international waters from 1962 to 2023. The dataset was retrieved from Kaggle.com (NTSB, 2023). The dataset is formatted as a .csv file with 31 columns and 88889 rows. The columns are meticulously organized to capture variables of interest in aircraft accidents and incidents. Extracting, analyzing, and visualizing relevant data from the dataset is vital to shedding insight into the safest, low-risk airplane models for a new entrant to the commercial aviation industry.

However, the dataset is enormous, contains some missing values duplicates, and needs to be customized to meet new entrants' needs aiming to purchase and operate airplanes for commercial and private enterprises. For instance, it contains data for airplane crashes across multiple scenarios (purpose of the flight), in which some cases exceed the target scope of the company. For this project, the target variables are categorized into Dimensions and Measures. The Dimension variables include: Event Date, Investigation Type, Aircraft Damage, Location, Make, Model, Weather Condition, and Purpose of Flight. The Measure variables include: The number of Engines, Total Fatal Injuries, Total Minor Injuries, and Total Uninjured passengers. The insights yielded from analyzing these variables and visualizing their respective relationships are deemed appropriate for deducing recommendations to support data-driven decisions by the company to procure a fleet that comprises safe, low-risk airplanes

In [50]:
```
# Import standard packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

In [51]:
```
# Load the dataset and creating the master dataframe
df_master = pd.read_csv("data/aviation-data.csv", encoding='latin1', low_me
df_master.head()
```

Out[51]:

	Event.Id	Investigation.Type	Accident.Number	Event.Date	Location	Country	Latituc
0	20001218X45444	Accident	SEA87LA080	1948-10-24	MOOSE CREEK, ID	United States	Na
1	20001218X45447	Accident	LAX94LA336	1962-07-19	BRIDGEPORT, CA	United States	Na
2	20061025X01555	Accident	NYC07LA005	1974-08-30	Saltville, VA	United States	36.92222
3	20001218X45448	Accident	LAX96LA321	1977-06-19	EUREKA, CA	United States	Na
4	20041105X01764	Accident	CHI79FA064	1979-08-02	Canton, OH	United States	Na

5 rows × 31 columns

Copying the initialy loaded DataFrame to perfom ETL processes without modifying df_master.

In [52]:
```
df=df_master.copy()
df.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 88889 rows
This data set consists of 31 columns
```

In [53]:
```
# Check columns names
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 88889 entries, 0 to 88888
Data columns (total 31 columns):
 #   Column                  Non-Null Count  Dtype  
---  ------                  --------------  -----  
 0   Event.Id                88889 non-null  object 
 1   Investigation.Type      88889 non-null  object 
 2   Accident.Number         88889 non-null  object 
 3   Event.Date              88889 non-null  object 
 4   Location                88837 non-null  object 
 5   Country                 88663 non-null  object 
 6   Latitude                34382 non-null  object 
 7   Longitude               34373 non-null  object 
 8   Airport.Code            50249 non-null  object 
 9   Airport.Name            52790 non-null  object 
 10  Injury.Severity         87889 non-null  object 
 11  Aircraft.damage         85695 non-null  object 
 12  Aircraft.Category       32287 non-null  object 
 13  Registration.Number     87572 non-null  object 
 14  Make                    88826 non-null  object 
 15  Model                   88797 non-null  object 
 16  Amateur.Built           88787 non-null  object 
 17  Number.of.Engines       82805 non-null  float64
 18  Engine.Type             81812 non-null  object 
 19  FAR.Description         32023 non-null  object 
 20  Schedule                12582 non-null  object 
 21  Purpose.of.flight       82697 non-null  object 
 22  Air.carrier             16648 non-null  object 
 23  Total.Fatal.Injuries    77488 non-null  float64
 24  Total.Serious.Injuries  76379 non-null  float64
 25  Total.Minor.Injuries    76956 non-null  float64
 26  Total.Uninjured         82977 non-null  float64
 27  Weather.Condition       84397 non-null  object 
 28  Broad.phase.of.flight   61724 non-null  object 
 29  Report.Status           82508 non-null  object 
 30  Publication.Date        75118 non-null  object 
dtypes: float64(5), object(26)
memory usage: 21.0+ MB
```

It is evident that the columns from 4th index to the 30th index are missing some data values.

In [54]:
```
# Check dataframe data types
df.dtypes
```

Out[54]:
```
Event.Id                   object
Investigation.Type         object
Accident.Number            object
Event.Date                 object
Location                   object
Country                    object
Latitude                   object
Longitude                  object
Airport.Code               object
Airport.Name               object
Injury.Severity            object
Aircraft.damage            object
Aircraft.Category          object
Registration.Number        object
Make                       object
Model                      object
Amateur.Built              object
Number.of.Engines         float64
Engine.Type                object
FAR.Description            object
Schedule                   object
Purpose.of.flight          object
Air.carrier                object
Total.Fatal.Injuries      float64
Total.Serious.Injuries    float64
Total.Minor.Injuries      float64
Total.Uninjured           float64
Weather.Condition          object
Broad.phase.of.flight      object
Report.Status              object
Publication.Date           object
dtype: object
```

The data type for all the variables is either an object or a float. This information reveals the need for data type transformations (to be perfomed later).

In [55]:
```
# Check the number of missing values for each column
df.isna().sum()
```

Out[55]:
```
Event.Id                      0
Investigation.Type            0
Accident.Number               0
Event.Date                    0
Location                     52
Country                     226
Latitude                  54507
Longitude                 54516
Airport.Code              38640
Airport.Name              36099
Injury.Severity            1000
Aircraft.damage            3194
Aircraft.Category         56602
Registration.Number        1317
Make                         63
Model                        92
Amateur.Built               102
Number.of.Engines          6084
Engine.Type                7077
FAR.Description           56866
Schedule                  76307
Purpose.of.flight          6192
Air.carrier               72241
Total.Fatal.Injuries      11401
Total.Serious.Injuries    12510
Total.Minor.Injuries      11933
Total.Uninjured            5912
Weather.Condition          4492
Broad.phase.of.flight     27165
Report.Status              6381
Publication.Date          13771
dtype: int64
```

Data Preparation

Digital maturity in leveraging novel data analytics is the key driver for aircraft safety. Manufacturers use these technologies to design safer aircraft (Boyd & Stolzer, 2016). On the other hand, companies operating in the airline sector base their strategic procurement plans on data-supported decisions (Altundag & Wynn, 2024). The progressive scope in which key stakeholders in the airline sector are embracing data analytics is reflected in the cumulative number of aircraft accidents and accidents recorded by the NTSB for each decade. Additionally, structural and material design advancements progressively increase aircraft safety.

The first step in cleaning the data is to check if the dataset contains duplicate entries.

In [56]:
```
# Check the number of duplicate entries in the DataFrame
df.duplicated().sum()
```

Out[56]:
```
0
```

In [57]:
```
# Drop duplicate entries
df.drop_duplicates(inplace=True)
```

In [58]:
```
# Confirm if duplicates are removed
df.duplicated().sum()
```

Out[58]: 0

The second step is to convert the `Event.Date` format from an object to the datetime format and slice the DataFrame to capture data for accidents and incidents from 2000 to 2023.

In [59]:
```
# Convert the 'Event.Date' column to a datetime dtype
df['Event.Date'] = pd.to_datetime(df['Event.Date'])
# Incoporate conditionals to select the period between 2000 and 2023
mask_2000_2023 = (df['Event.Date'].dt.year >= 2000) & (df['Event.Date'].dt.
# Apply the mask to impute the sliced df
df = df[mask_2000_2023]
```

In [60]:

```
# Set the 'Event.Date' as the index
df.set_index('Event.Date', inplace=True)

# Resample the data to count incidents per year (year-end)
yearly_counts = df.resample('Y').size()

# Create a time series line plot
plt.figure(figsize=(10, 6))
plt.plot(yearly_counts.index, yearly_counts.values, marker='o', linestyle='

# Customize plot title, axes, and display grid for easy visibility
plt.title('Aircraft Accidents/Incidents From 2000 to 2023')
plt.xlabel('Year')
plt.ylabel('Number of Accidents/Incidents')
plt.grid(True)

plt.tight_layout()

# Save the plot to the images folder
plt.savefig("./images/time-series-plot.png", dpi=300, facecolor='white')
plt.show()
```

As captured in the time-series plot, the number of aircraft accidents and incidents has been dropping. The selected period is deemed appropriate because analyzing data for aircraft accidents and incidents before 2000 would comprise the reliability of deduced recommendations for real-world application in the 2020s.The next step is to drop all the columns deemed inappropriate for this project

In [61]:
```
# Drop columns with data deemed inappropriate per the project's objectives
columns_to_drop = ['Event.Id', 'Latitude', 'Longitude', 'Airport.Code', 'Ai
df.drop(columns = columns_to_drop, inplace=True)
```

In [62]:
```
df.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 41214 rows
This data set consists of 14 columns
```

In [63]:
```
df.dtypes
```

Out[63]:
```
Investigation.Type          object
Location                    object
Country                     object
Aircraft.damage             object
Make                        object
Model                       object
Number.of.Engines          float64
Engine.Type                 object
Purpose.of.flight           object
Total.Fatal.Injuries       float64
Total.Serious.Injuries     float64
Total.Minor.Injuries       float64
Total.Uninjured            float64
Weather.Condition           object
dtype: object
```

Droping rows for entries with NaNs except for the float data type columns. The missing values for `Number.of.Engines` are also dropped because the number of engines in an aircraft despite being an interger represent an object and the variable is discrete.

In [64]:
```
df = df.dropna(subset=['Location'])
df = df.dropna(subset=['Aircraft.damage'])
df = df.dropna(subset=['Make'])
df = df.dropna(subset=['Model'])
df = df.dropna(subset=['Number.of.Engines'])
df = df.dropna(subset=['Engine.Type'])
df = df.dropna(subset=['Purpose.of.flight'])
df = df.dropna(subset=['Weather.Condition'])
```

In [65]:
```
df.isna().sum()
```

Out[65]:
```
Investigation.Type            0
Location                      0
Country                       8
Aircraft.damage               0
Make                          0
Model                         0
Number.of.Engines             0
Engine.Type                   0
Purpose.of.flight             0
Total.Fatal.Injuries       9213
Total.Serious.Injuries    10005
Total.Minor.Injuries       9283
Total.Uninjured            4517
Weather.Condition             0
dtype: int64
```

The descriptive statistics for the float data type columns (except Number.of.Engines) are computed to determine the best approach to impute missing values.

In [66]:
```
# Compute the descriptive statistics for float dtype columns
columns_to_check = ['Total.Fatal.Injuries', 'Total.Serious.Injuries', 'Tota

for col in columns_to_check:
    print(f"Descriptive Statistics for {col}:")
    print(df[col].describe())
```

```
Descriptive Statistics for Total.Fatal.Injuries:
count    20912.000000
mean         0.447972
std          1.111269
min          0.000000
25%          0.000000
50%          0.000000
75%          1.000000
max         88.000000
Name: Total.Fatal.Injuries, dtype: float64
Descriptive Statistics for Total.Serious.Injuries:
count    20120.000000
mean         0.320974
std          0.668653
min          0.000000
25%          0.000000
50%          0.000000
75%          0.000000
max          9.000000
Name: Total.Serious.Injuries, dtype: float64
Descriptive Statistics for Total.Minor.Injuries:
count    20842.000000
mean         0.305057
std          0.744264
min          0.000000
25%          0.000000
50%          0.000000
75%          0.000000
max         42.000000
Name: Total.Minor.Injuries, dtype: float64
Descriptive Statistics for Total.Uninjured:
count    25608.000000
mean         1.398899
std          5.919773
min          0.000000
25%          0.000000
50%          1.000000
75%          2.000000
max        386.000000
Name: Total.Uninjured, dtype: float64
```

All four variables exhibit right skewness, meaning most incidents have low injury counts. Since a few incidents have substantially higher counts, the median is more robust to outliers and better represents the typical value in skewed distributions. Thus, imputing missing values with the median for each column is more logical.

In [67]:
```
# Impute missing values with medians
df.loc[:, 'Total.Fatal.Injuries'] = df['Total.Fatal.Injuries'].fillna(df['T
df.loc[:, 'Total.Serious.Injuries'] = df['Total.Serious.Injuries'].fillna(d
df.loc[:, 'Total.Minor.Injuries'] = df['Total.Minor.Injuries'].fillna(df['T
df.loc[:, 'Total.Uninjured'] = df['Total.Uninjured'].fillna(df['Total.Uninj
```

In [68]:
```
df.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 30125 rows
This data set consists of 14 columns
```

In [71]:
```
# Confirm no NaNs in sliced DataFrame
df.isna().sum()
```

Out[71]:
```
Investigation.Type        0
Location                  0
Country                   8
Aircraft.damage           0
Make                      0
Model                     0
Number.of.Engines         0
Engine.Type               0
Purpose.of.flight         0
Total.Fatal.Injuries      0
Total.Serious.Injuries    0
Total.Minor.Injuries      0
Total.Uninjured           0
Weather.Condition         0
dtype: int64
```

Although the dataset doesnt have NANs, their could be entries assigned to an unknown variable

Using Lambda functions to drop unknown values for categorical columns

In [72]:
```
df['Aircraft.damage'].value_counts()
```

Out[72]:
```
Substantial    26006
Destroyed       3733
Minor            380
Unknown            6
Name: Aircraft.damage, dtype: int64
```

In [73]:
```
#Apply a lambda function to drop entries with unknown
df = df[df['Aircraft.damage'].apply(lambda which_damage: which_damage != 'U
```

In [74]:
```
df['Engine.Type'].value_counts()
```

Out[74]:
```
Reciprocating    26916
Turbo Prop        1367
Turbo Shaft       1338
Turbo Fan          294
Turbo Jet          145
Unknown             35
None                13
Electric             7
NONE                 2
LR                   1
UNK                  1
Name: Engine.Type, dtype: int64
```

In [75]:
```
#Apply a lambda function to drop entries with unknown
df = df[df['Engine.Type'].apply(lambda drop_unknown: (drop_unknown != 'Unkn
```

In [76]:
```
df['Purpose.of.flight'].value_counts()
```

Out[76]:
```
Personal                       19838
Instructional                   4332
Aerial Application              1544
Business                         879
Positioning                      773
Other Work Use                   487
Flight Test                      344
Aerial Observation               326
Unknown                          314
Public Aircraft                  220
Ferry                            169
Executive/corporate              148
Skydiving                        132
Banner Tow                        94
External Load                     92
Public Aircraft - Federal         86
Public Aircraft - Local           67
Public Aircraft - State           60
Air Race show                     57
Air Race/show                     48
Glider Tow                        35
Firefighting                      22
Air Drop                           8
ASHO                               2
PUBS                               2
PUBL                               1
Name: Purpose.of.flight, dtype: int64
```

In [77]:
```
# Apply a Lambda function to select only entries whose purpose of flight ar
df = df[df['Purpose.of.flight'].apply(lambda niche: niche in ['Aerial Appli
```

In [78]:
```
df.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 2571 rows
This data set consists of 14 columns
```

In [79]:
```
df['Weather.Condition'].value_counts()
```

Out[79]:
```
VMC    2376
IMC     191
UNK       2
Unk       2
Name: Weather.Condition, dtype: int64
```

In [80]:
```
#Apply a lambda function to drop entries with unknown
df = df[df['Weather.Condition'].apply(lambda drop_unknown: (drop_unknown !=
```

In [81]:
```
df['Make'].value_counts()
```

Out[81]:
```
Cessna                            265
Air Tractor                       220
AIR TRACTOR INC                   154
CESSNA                            153
Piper                             142
                                 ...
RAYTHEON COMPANY                    1
Hawker Siddely                      1
HAWKER                              1
RICHARDS HEAVYLIFT HELO INC         1
Piaggio Aero Industries S.p.a.      1
Name: Make, Length: 297, dtype: int64
```

Converting all the values in the `Make` column to uppercase

In [82]:
```
df['Make'] = df['Make'].str.upper().str.strip()
```

In [83]:
```
df['Make'].value_counts()
```

Out[83]:
```
CESSNA                     418
AIR TRACTOR                265
PIPER                      231
BELL                       224
AIR TRACTOR INC            156
                          ...
BELL HELICOPTER              1
SAN JOAQUIN HELICOPTERS      1
BELL-TELLIJOHN               1
CASA                         1
FOUND ACFT CANADA INC        1
Name: Make, Length: 233, dtype: int64
```

Since their is another USState.csv file in the downloaded Zipped data from Kaggle (Presumed to be utilized in ploting a regional map in Tableau), the `Country` column is sliced to only feature rows

In [85]:
```
#Apply a lambda function to select entries for accidents and incidents that
df = df[df['Country'].apply(lambda which_country: which_country == 'United 
```

Spliting the state abbreviation section from the location's values and creating a new column `Abbreviation` to hold them. The created new column will facilitate the establishment of a relationship with the USState.csv dataset when plotting visualizations in Tableau Desktop.

In [86]:
```
# Create a new column 'Abbreviation' and extracting the Abbreviations for t
df['Abbreviation'] = df['Location'].apply(lambda x: x.split(', ')[-1] if is

# Overwrite the 'Location' column with values that dont feature the Abbrevi
df['Location'] = df['Location'].apply(lambda x: x.split(', ')[0] if isinsta

# Remove the 'Abbreviation' column from the dataframe
abbreviation_col = df.pop('Abbreviation')

# Insert the 'Abbreviation' column next to the 'Location' column
df.insert(df.columns.get_loc('Location') + 1, 'Abbreviation', abbreviation_
```

In [87]:
```
# Examine whether the new column was successfully created and positioned ad
df.head()
```

Out[87]:

	Investigation.Type	Location	Abbreviation	Country	Aircraft.damage	Make	Model
Event.Date							
2000-01-13	Accident	FILLMORE	UT	United States	Substantial	BEECH	K35
2000-01-18	Accident	BRAWLEY	CA	United States	Substantial	BELL	OH-58C
2000-01-18	Accident	SOMERSET	KY	United States	Destroyed	BEECH	C-90
2000-01-20	Accident	PLAINVILLE	CT	United States	Substantial	CESSNA	T310R
2000-01-25	Accident	RAYVILLE	LA	United States	Substantial	AIR TRACTOR	AT-401

Checking if there are missing values in the newly created `Abbreviations` column.

In [88]:
```
# Check the number of null values in the newly created Abbreviations column
df['Abbreviation'].isna().sum()
```

Out[88]: 4

In [89]:
```
# Drop entries that are missing values in the Abbreviation column
df = df.dropna(subset=['Abbreviation'])
```

In [90]:
```
df.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 2534 rows
This data set consists of 15 columns
```

Checking for duplicate rows

In [91]:
```
# Check the data types for selected columns of interest for this project
df.dtypes
```

Out[91]:
```
Investigation.Type         object
Location                   object
Abbreviation               object
Country                    object
Aircraft.damage            object
Make                       object
Model                      object
Number.of.Engines         float64
Engine.Type                object
Purpose.of.flight          object
Total.Fatal.Injuries      float64
Total.Serious.Injuries    float64
Total.Minor.Injuries      float64
Total.Uninjured           float64
Weather.Condition          object
dtype: object
```

Making necessary transformations for the data type of the variables to their respective appropriate d-types

In [92]:
```
df['Investigation.Type'] = df['Investigation.Type'].astype('category')
df['Aircraft.damage'] = df['Aircraft.damage'].astype('category')
df['Number.of.Engines'] = df['Number.of.Engines'].astype(str)
df['Engine.Type'] = df['Engine.Type'].astype('category')
df['Purpose.of.flight'] = df['Purpose.of.flight'].astype('category')
df['Weather.Condition'] = df['Weather.Condition'].astype('category')
```

In [95]:
```
# Confirm if data type transformations are successful
df.dtypes
```

Out[95]:
```
Investigation.Type        category
Location                    object
Abbreviation                object
Country                     object
Aircraft.damage           category
Make                        object
Model                       object
Number.of.Engines           object
Engine.Type               category
Purpose.of.flight         category
Total.Fatal.Injuries       float64
Total.Serious.Injuries     float64
Total.Minor.Injuries       float64
Total.Uninjured            float64
Weather.Condition         category
dtype: object
```

Exporting the cleaned dataset to a new .csv file

In [96]:
```
# Set index = False to prevent pandas from creating a redundant index colum
df.to_csv("data/cleaned-aviation-data.csv", index=False, encoding='latin1')
```

Data Modeling

Loading the .csv file of the cleaned data

In [97]:
```
# Load the cleaned .csv file and creating a new dataframe
df_clean = pd.read_csv("data/cleaned-aviation-data.csv",encoding='latin1', 
df_clean.head()
```

Out[97]:

	Investigation.Type	Location	Abbreviation	Country	Aircraft.damage	Make	Model	Number.
0	Accident	FILLMORE	UT	United States	Substantial	BEECH	K35	
1	Accident	BRAWLEY	CA	United States	Substantial	BELL	OH-58C	
2	Accident	SOMERSET	KY	United States	Destroyed	BEECH	C-90	
3	Accident	PLAINVILLE	CT	United States	Substantial	CESSNA	T310R	
4	Accident	RAYVILLE	LA	United States	Substantial	AIR TRACTOR	AT-401	

In [98]:
```
# Examine the columns of the df_clean DataFrame
df_clean.columns
```

Out[98]:
```
Index(['Investigation.Type', 'Location', 'Abbreviation', 'Country',
       'Aircraft.damage', 'Make', 'Model', 'Number.of.Engines', 'Engine.Ty
pe',
       'Purpose.of.flight', 'Total.Fatal.Injuries', 'Total.Serious.Injurie
s',
       'Total.Minor.Injuries', 'Total.Uninjured', 'Weather.Condition'],
      dtype='object')
```

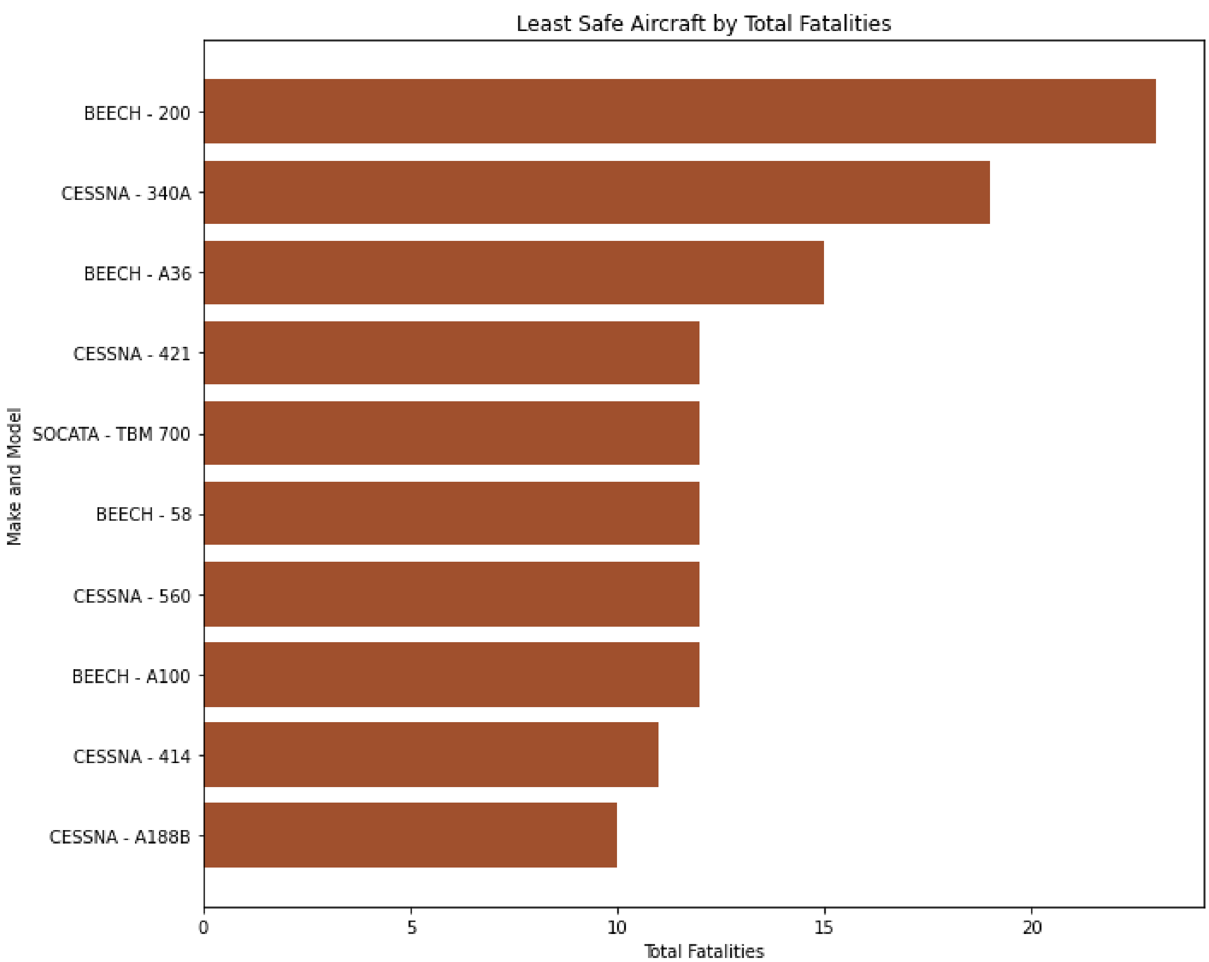
In [99]:
```
# Check the shape of df_clean
df_clean.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 2534 rows
This data set consists of 15 columns
```

The Least Safe Aircraft

To gain insight on the least safe aircrafts, I group the `Model` and the `Make` variable and plot a barplot against `Total.Fatal.Injuries`

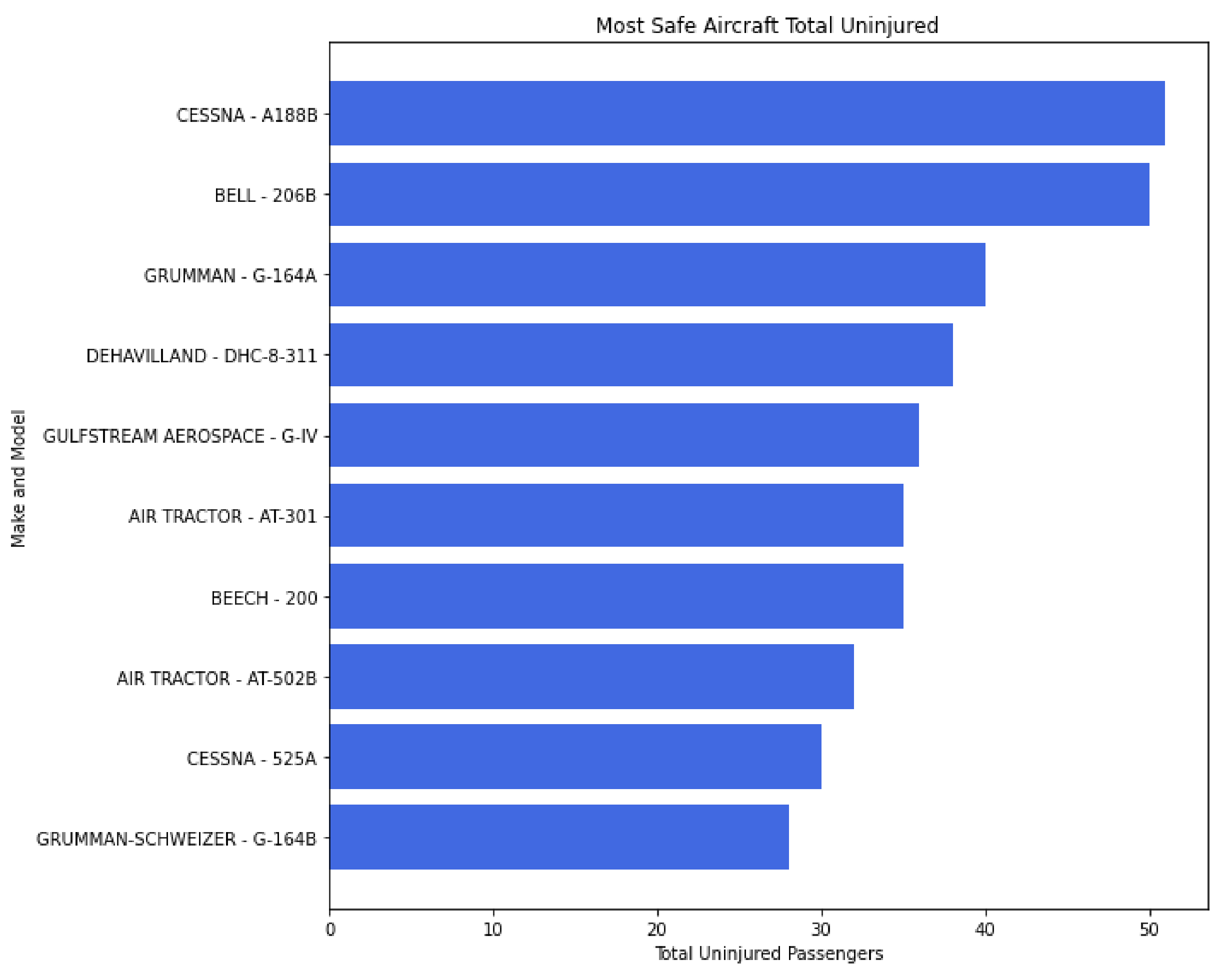
In [100]:
```
# Group by 'Make' and 'Model', and sum 'Total.Fatal.Injuries'
Fatality_by_make_model = df_clean.groupby(['Make', 'Model'])['Total.Fatal.I

# Create a list of the Make and Model labels for the y-axis
make_model_labels = [f"{make} - {model}" for make, model in Fatality_by_mak

# Create a horizontal bar plot using Matplotlib
fig, ax = plt.subplots(figsize=(10, 8))

# Reverse the order in which bars are plotted to descending
ax.barh(make_model_labels [::-1], Fatality_by_make_model.values [::-1], col

# Set and customize the plot's Title, X and Y labels
ax.set_title('Least Safe Aircraft by Total Fatalities')
ax.set_xlabel('Total Fatalities')
ax.set_ylabel('Make and Model')

fig.tight_layout()
# Save the plot to the image folder
plt.savefig("./images/least-safe-aircraft.png", dpi=300, facecolor='white')
plt.show()
```



The Most Safe Aircraft

To gain insight on the safest aircraft model and make, I group the `Model` and the `Make` variable and plot a barplot against `Total.Uninjured`

In [101]:
```
# Group by 'Make' and 'Model', and sum 'Total.Uninjured'
uninjured_by_make_model = df_clean.groupby(['Make', 'Model'])['Total.Uninju

# Create a list of the Make and Model labels for the y-axis
make_model_labels = [f"{make} - {model}" for make, model in uninjured_by_ma

# Plot a horizontal bar plot using Matplotlib
fig, ax = plt.subplots(figsize=(10, 8))

# Reverse the order in which bars are plotted to descending
ax.barh(make_model_labels[::-1], uninjured_by_make_model.values[::-1], colo

# Set and customize the plot's Title, X and Y labels
ax.set_title('Most Safe Aircraft Total Uninjured')
ax.set_xlabel('Total Uninjured Passengers')
ax.set_ylabel('Make and Model')
fig.tight_layout()

# Save the plot to the image folder
plt.savefig("./images/most-safe-aircraft.png", dpi=300, facecolor='white')
plt.show()
```

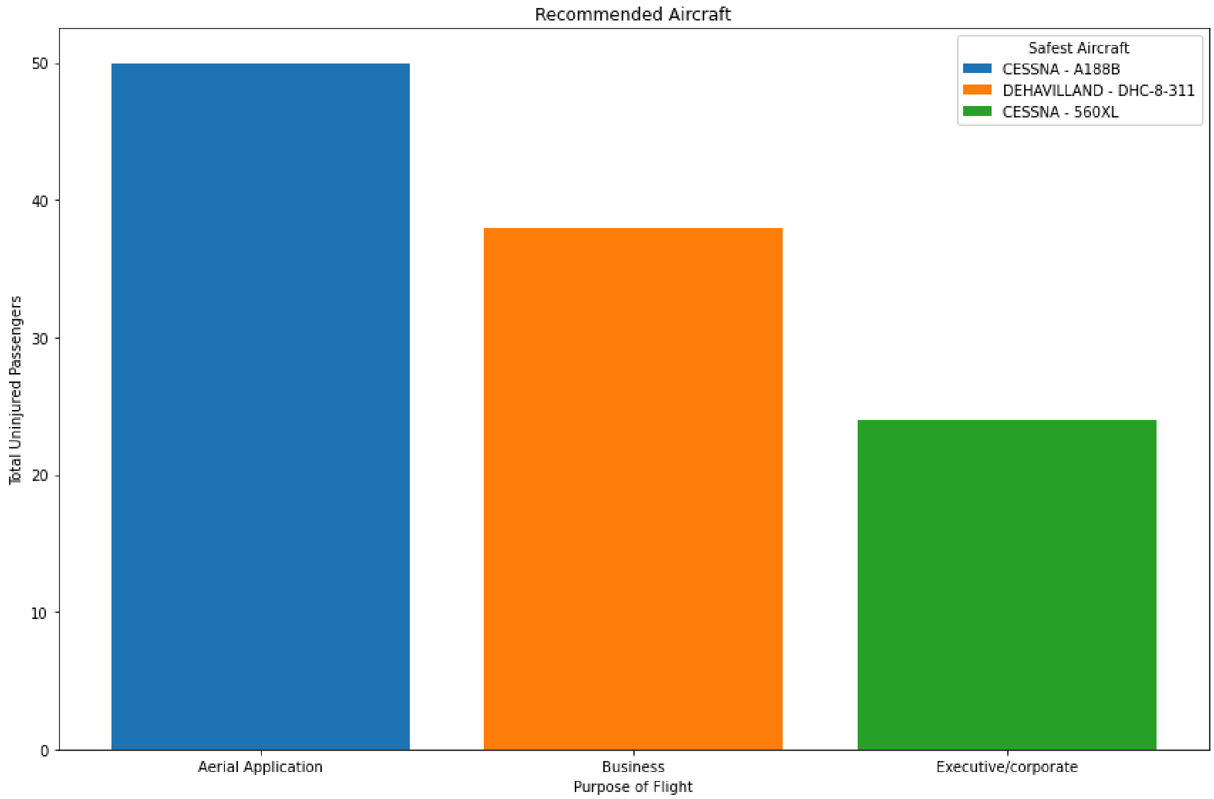


To determine the safest aircraft models for each of the three civil aviation services the company can venture into; the three categorical values for the `Purpose.of.Flight` columns are plotted in a barplot against uninjured passengers `Total.Uninjured` .

Recommended Aircraft for Targeted Aviation Services

In [103]:

```
# Filter for the relevant Purpose.of.flight values
df_filtered = df_clean[df_clean['Purpose.of.flight'].isin(['Aerial Applicat

# Group by 'Purpose.of.flight', 'Make', and 'Model', and sum 'Total.Uninjur
uninjured_by_purpose_make_model = df_filtered.groupby(['Purpose.of.flight',

# Find the safest aircraft (highest 'Total.Uninjured') for each purpose
safest_aircraft = uninjured_by_purpose_make_model.loc[uninjured_by_purpose_

# Create the "Make - Model" column
safest_aircraft['Make - Model'] = safest_aircraft['Make'] + ' - ' + safest_

# Create a bar plot using Matplotlib with subplots
fig, ax = plt.subplots(figsize=(12, 8))

# Define colors assigned to bars
colors = ['tab:blue', 'tab:orange', 'tab:green']

# Plot the horizontal barplot with individual labels for each bar
bars = ax.bar(safest_aircraft['Purpose.of.flight'], safest_aircraft['Total.

# Add a legend
legend_labels = safest_aircraft['Make - Model'].tolist()
ax.legend(bars, legend_labels, title="Safest Aircraft")

# Set and customize the plot's Title, X and Y labels
ax.set_title('Recommended Aircraft')
ax.set_xlabel('Purpose of Flight')
ax.set_ylabel('Total Uninjured Passengers')

fig.tight_layout()

# Save the plot to the image folder
plt.savefig("./images/recommended-aircraft.png", dpi=300, facecolor='white'

# Show plot
plt.show()
```



Evaluation

The baseline model shed the following insights:

- The BEECH-200 (8-seater), the CESSNA-340A (6-seater), and the BEECH-A36 (6-seater), are the top-three most risky aircraft overall.
- The CESSNA-A188B (1-seater), the BELL-206B (5-seater), and the GRUMMAN-G-164A (1-seater) are the top-three safest aircraft models overall.

Recommendations:

- The CESSNA-560XL (10-seater) is the safest aircraft for Executive/corporate flights.
- The DEHAVILLAND-DHC-8-311 (50-seater) is the safest airplane for business flights.
- The CESSNA-A188B (1-seater) is the safest aircraft for Aerial Applications.

The number of engines for these aircraft models.

- BEECH-200: 2 engines
- CESSNA-340A:2 engines
- BEECH-A36:1 engine
- BELL-206B: 1 engine
- GRUMMAN-G-164A: 1 engine
- CESSNA-560XL: 2 engines
- CESSNA-A188B: 1 engine
- DEHAVILLAND-DHC-8-311: 2 engines

Multi-engine aircraft are typically safer in comparison to single-engine airplanes (Pilot Institute, 2023). More than one engine avails redundancy to propulsion units. Pilots can recalibrate controls and continue flying if one engine stalls or malfunctions. In contrast, such an incident in a single-engine aircraft poses a substantial risk of crashing if the gliding distance falls short of a runway or a relatively flat surface for an emergency landing. Thus, I modified the baseline model to drop row entries whose `Number.of.Engines` is less than 2.

In [105]:
```
df_modified = df_clean.copy()
df_modified.shape
print(f"This data set consists of {df.shape[0]} rows")
print(f"This data set consists of {df.shape[1]} columns")
```

```
This data set consists of 2534 rows
This data set consists of 15 columns
```

In [106]:
```
# Apply a lambda function to drop entries for single-engine aircraft
df_modified = df_modified[df_modified['Number.of.Engines'].apply(lambda x: 
```

In [107]:
```
# Confirm if single-engine entries dropped
df_modified['Number.of.Engines'].value_counts()
```

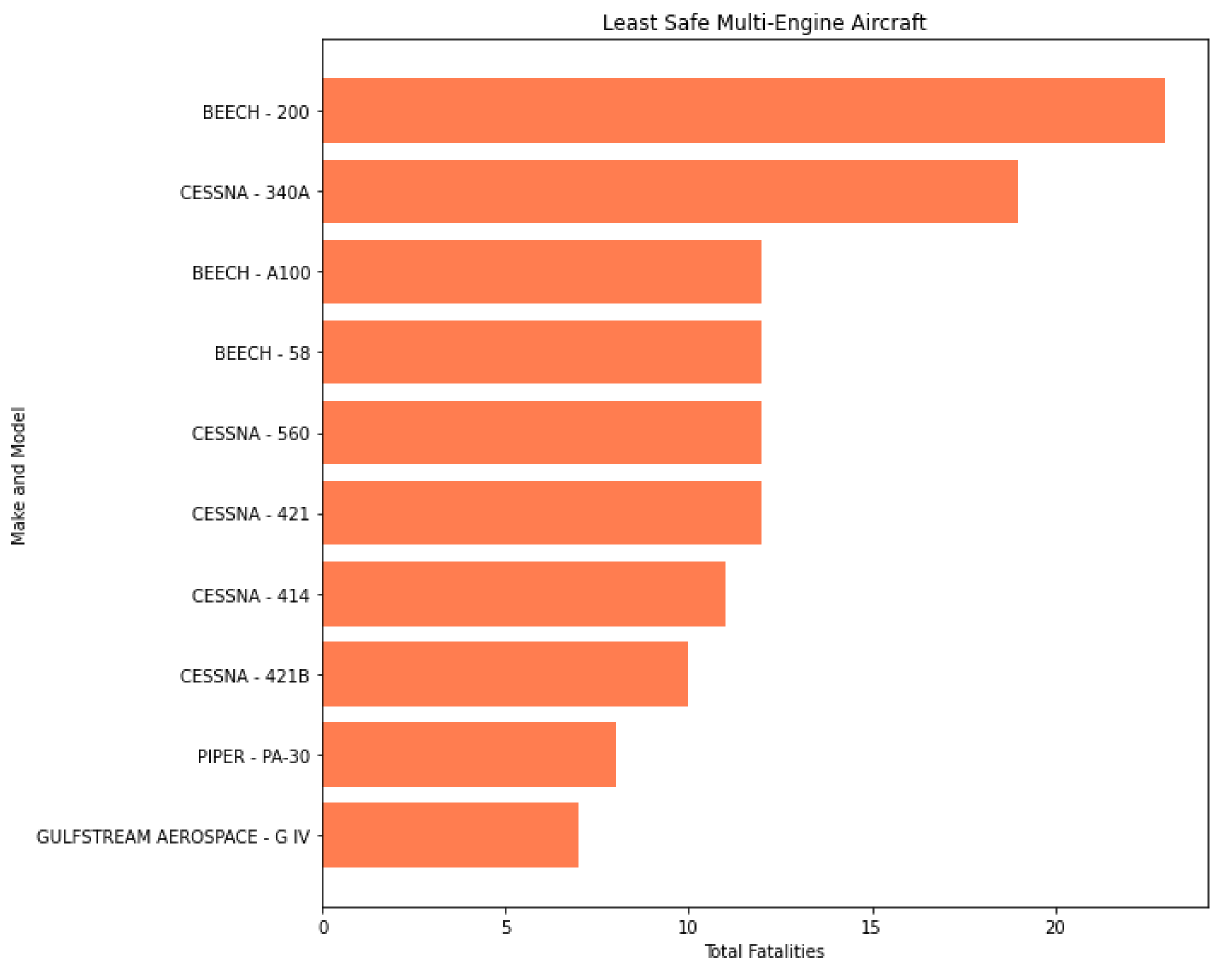
Out[107]:
```
2.0    369
3.0      7
4.0      3
Name: Number.of.Engines, dtype: int64
```

Replotting bar plots to determine the most risky, the safest, and the appropriate airplanes (that have more than one engine) for the company's operations

The Least Safe Multi-Engine Aircraft

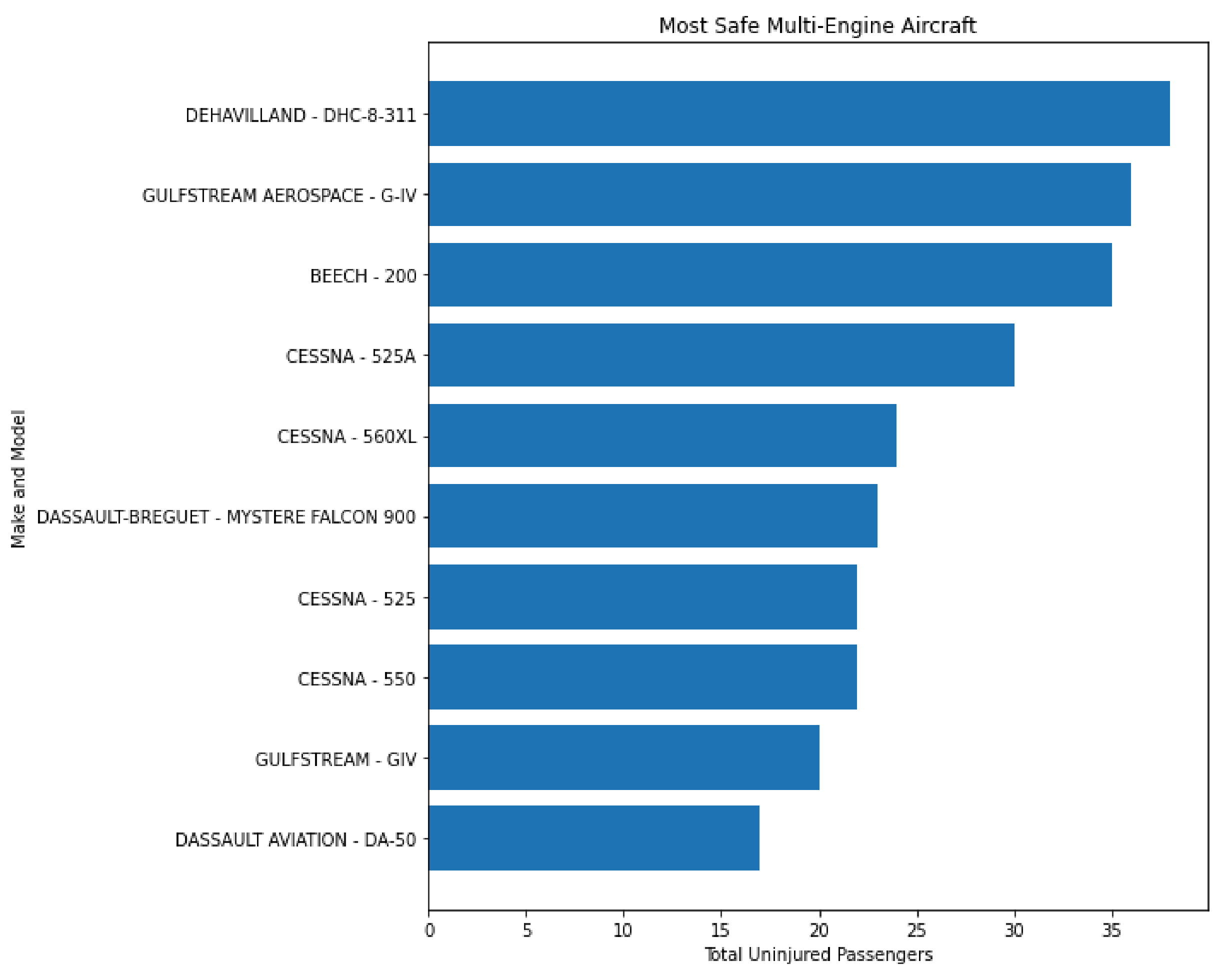
In [109]:

```
# Group by 'Make' and 'Model', and sum 'Total.Fatal.Injuries'
Fatality_by_make_model = df_modified.groupby(['Make', 'Model'])['Total.Fata

# Create a list of the Make and Model labels for the y-axis
make_model_labels = [f"{make} - {model}" for make, model in Fatality_by_mak

# Create a horizontal bar plot using Matplotlib
fig, ax = plt.subplots(figsize=(10, 8))

# Reverse the order in which bars are plotted to descending
ax.barh(make_model_labels [::-1], Fatality_by_make_model.values [::-1], col

# Set and customize the plot's Title, X and Y labels
ax.set_title('Least Safe Multi-Engine Aircraft')
ax.set_xlabel('Total Fatalities')
ax.set_ylabel('Make and Model')

fig.tight_layout()

# Save the plot to the image folder
plt.savefig("./images/least-safe-multi-engine-aircraft.png", dpi=300, facec
plt.show()
```



The Most Safe Multi-Engine Aircraft

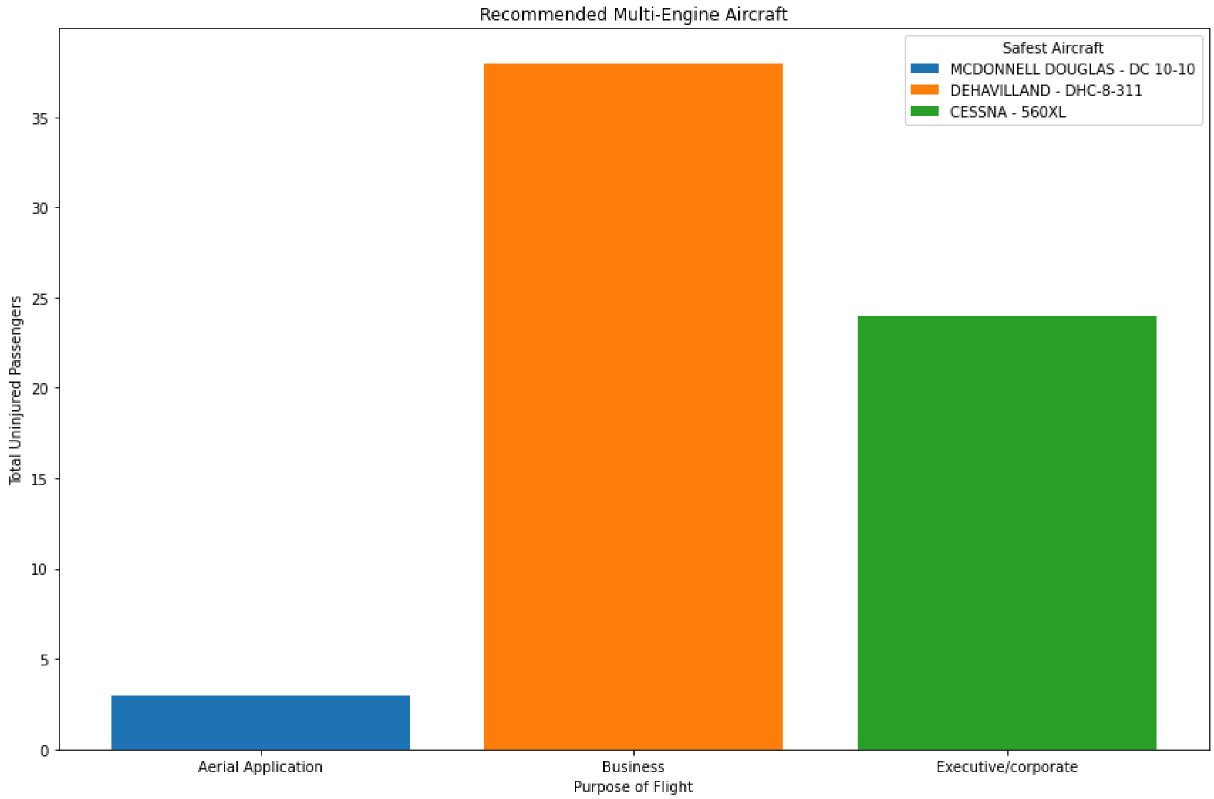
In [110]:
```
# Group by 'Make' and 'Model', and sum 'Total.Uninjured'
uninjured_by_make_model = df_modified.groupby(['Make', 'Model'])['Total.Uni

# Create a list of the Make and Model labels for the y-axis
make_model_labels = [f"{make} - {model}" for make, model in uninjured_by_ma

# Create a horizontal bar plot using Matplotlib
fig, ax = plt.subplots(figsize=(10, 8))

# Reverse the order in which bars are plotted to descending
ax.barh(make_model_labels[::-1], uninjured_by_make_model.values[::-1])

# Set and customize the plot's Title, X and Y labels
ax.set_title('Most Safe Multi-Engine Aircraft')
ax.set_xlabel('Total Uninjured Passengers')
ax.set_ylabel('Make and Model')

fig.tight_layout()
# Save to the image folder

plt.savefig("./images/most-safe-multi-engine-aircraft.png", dpi=300, faceco
plt.show()
```



Recommended Multi-Engine Aircraft

In [111]:

```
# Filter for the relevant Purpose.of.flight values
df_filtered = df_modified[df_modified ['Purpose.of.flight'].isin(['Aerial A

# Group by 'Purpose.of.flight', 'Make', and 'Model', and sum 'Total.Uninjur
uninjured_by_purpose_make_model = df_filtered.groupby(['Purpose.of.flight',

# Find the safest aircraft (highest 'Total.Uninjured') for each purpose
safest_aircraft = uninjured_by_purpose_make_model.loc[uninjured_by_purpose_

# Create the "Make - Model" column
safest_aircraft['Make - Model'] = safest_aircraft['Make'] + ' - ' + safest_

# Plot a bar plot using Matplotlib with subplots
fig, ax = plt.subplots(figsize=(12, 8))

# Define colors assigned to bars
colors = ['tab:blue', 'tab:orange', 'tab:green']
# Plot the horizontal barplot with individual labels for each bar
bars = ax.bar(safest_aircraft['Purpose.of.flight'], safest_aircraft['Total.

# Add a legend
legend_labels = safest_aircraft['Make - Model'].tolist()
ax.legend(bars, legend_labels, title="Safest Aircraft")

# Set and customize the plot's Title, X and Y labels
ax.set_title('Recommended Multi-Engine Aircraft')
ax.set_xlabel('Purpose of Flight')
ax.set_ylabel('Total Uninjured Passengers')

fig.tight_layout()

# Save the plot to the image folder
plt.savefig("./images/recommended-multi-engine-aircraft.png", dpi=300, face
plt.show()
```



The modified model sheds the following insight:

- The BEECH-200 (13-seater), the CESSNA-340A (6-seater), and the BEECH-A400 (8-seater) are the top-three most risky multi-engine aircraft to operate.
- The DEHAVILLAND DHC-8-311 (50-seater), the GULFSTREAM AEROSPACE-G-IV (10-seater), and the BEECH-200 (13-seater) are the top-three safest multi-engine aircraft to operate.

Recommendations:

- The CESSNA 560XL(10-seater) is the safest multi-engine aircraft for Executive/corporate flights.
- The DEHAVILLAND -DHC-8-311(50-seater) is the safest multi-engine aircraft for business flights.
- The MCDONNELL DOUGLAS-DC 10-10(250-seater) is the safest multi-engine aircraft for Aerial Applications.

The number of engines for these aircraft models.

- BEECH-200: 2 engines
- CESSNA-340A: 2 engines
- BEECH-A400: 2 engines
- GULFSTREAM AEROSPACE-G-IV: 2 engines
- CESSNA 560XL: 2 engines
- DEHAVILLAND DHC-8-311: 2 engines
- MCDONNELL DOUGLAS -DC 10-10: 3 engines

The findings from the results yielded by the baseline model are compared to those yielded by the modified model. After entering the industry, the recommended safest aircraft model for the aviation services the company will offer is based on respective applicability and operational logistics.

Conclusions

The analysis yields three recommendations on the aircraft models the company should procure and operate after entering the commercial aviation industry.

- **The CESSNA-560XL aircraft is recommended for Executive/ Corporate flights:** The baseline and modified model conform the aircraft is safest for executive and corporate flights.
- **The DEHAVILLAND DHC-8-311 aircraft is recommended for Business Flights:** The baseline and modified model conform the aircraft is safest for business flights.
- **The CESSNA-A188B aircraft is recommended for Aerial Applications:** The modified model proposes the MCDONNELL DOUGLAS-DC 10-10 (a three-engine, 250-seater) aircraft for aerial applications. The proposed alternative by the modified model is rejected because aerial applications typically include agricultural activities such as spraying crop fields. Hence, the single-engine CESSNA-A188B is recommended for aerial applications.

References

Altundag, A., & Wynn, M. (2024). Advanced Analytics and Data Management in the Procurement Function: An Aviation Industry Case Study. Electronics, 13(8), 1554. https://doi.org/10.3390/electronics13081554 (https://doi.org/10.3390/electronics13081554)

Boyd, D. D., & Stolzer, A. (2016). Accident-precipitating factors for crashes in turbine-powered general aviation aircraft. Accident Analysis & Prevention, 86, 209-216. https://doi.org/10.1016/j.aap.2015.10.024 (https://doi.org/10.1016/j.aap.2015.10.024)

NTSB. (2023). Aviation Accident Database & Synopses, up to 2023. https://doi.org/10.34740/KAGGLE/DSV/4875576 (https://doi.org/10.34740/KAGGLE/DSV/4875576)

Luo, J. (2022). Data-driven innovation: What is it?. IEEE Transactions on Engineering Management, 70(2), 784-790. https://doi.org/10.1109/TEM.2022.3145231 (https://doi.org/10.1109/TEM.2022.3145231)

Pilot Institute. (2023). Single Engine Vs. Multi Engine: Which is Better? https://pilotinstitute.com/single-vs-multi-engine/ (https://pilotinstitute.com/single-vs-multi-engine/)