01_airport_cleaning_eda

December 27, 2025

1 Airport Passenger Data - Cleaning & EDA

Data Source: Website_Statistics_Q3_2025.pdf (manually extracted)
Location: `data/interim/airport_passengers_manual.csv`
Purpose: Clean data for Power BI & exploratory data analysis
Date: December 2024

1.1 Objectives

1. Clean and validate airport passenger data
2. Explore trends, seasonality, and patterns
3. Prepare dataset for Power BI dashboard
4. Validate against Travel Manitoba Q4 2024 infographic

1.2 Setup

[47]:

```
# Path setup
import sys
from pathlib import Path

project_root = Path.cwd().parent
sys.path.insert(0, str(project_root / 'scripts'))

from paths import raw, processed, interim
```

[48]:

```
# Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from datetime import datetime

# Plotting style
plt.style.use('seaborn-v0_8-darkgrid')
sns.set_palette('husl')
%matplotlib inline

# Display options
```

```
pd.set_option('display.max_columns', None)
pd.set_option('display.float_format', '{:,.0f}'.format)

print(' Libraries loaded')
```

```
 Libraries loaded
```

1.3 Part 1: Data Loading & Cleaning

1.3.1 1.1 Load Raw Data

[49]:

```
csv_path = interim() / 'airport_passengers_manual.csv'

if not csv_path.exists():
    print(f'ERROR: File not found at {csv_path}')
else:
    print(f'  Found: {csv_path}')
    print(f'  Size: {csv_path.stat().st_size:,} bytes')
```

```
 Found:
/Users/dpro/projects/travel_manitoba/data/interim/airport_passengers_manual.csv
  Size: 11,320 bytes
```

[50]:

```
# Load CSV
df_raw = pd.read_csv(csv_path, encoding='utf-8-sig')

# Remove unnamed columns
df_raw = df_raw.loc[:, ~df_raw.columns.str.contains('^Unnamed')]

print('RAW DATA')
print('='*80)
print(f'Shape: {df_raw.shape}')
print(f'Columns: {list(df_raw.columns)}')
print(f'\nFirst 8 rows:')
df_raw.head(8)
```

```
RAW DATA
================================================================================
Shape: (84, 15)
Columns: ['year', 'passenger_type', 'January', 'February', 'March', 'April',
'May', 'June', 'July', 'August', 'September', 'October', 'November', 'December',
'Total']

First 8 rows:
```

[50]:

```
   year    passenger_type  January February   March   April     May  \
0  2005          Domestic  192,265  193,905 217,218 205,509 230,093
1  2005     International   33,783   32,478  26,179   3,384     498
2  2005  Total_Passengers  263,351  263,612 281,125 240,584 260,710
```

```
3  2005       Transborder   37,303   37,229   37,728   31,691   30,119
4  2006          Domestic  206,279  198,245  222,093  208,140  244,171
5  2006     International   32,021   26,294   24,448    2,237      963
6  2006  Total_Passengers  274,898  261,217  285,923  242,967  276,835
7  2006       Transborder   36,598   36,678   39,382   32,590   31,701

      June     July   August September  October November December      Total
0  239,036  264,680  271,490   229,127  239,721  207,337  225,227  2,715,608
1      579    1,022      864       633      440        -    8,627    108,487
2  275,742  303,701  308,386   257,803  272,305  238,224  266,345  3,231,888
3   36,127   37,999   36,032    28,043   32,144   30,887   32,491    407,793
4  253,629  278,918  295,063   248,392  255,642  221,539  229,214  2,861,325
5    1,389    1,086    1,271     1,318      651        -    8,755    100,433
6  289,965  317,040  334,657   279,794  292,241  257,158  273,843  3,386,538
7   34,947   37,036   38,323    30,084   35,948   35,619   35,874    424,780
```

1.3.2 1.2 Clean Numeric Columns

[51]:

```python
def clean_numeric_column(series):
    """Remove commas, handle dashes, convert to float."""
    return (
        series
        .astype(str)
        .str.replace(',', '', regex=False)
        .str.replace('-', '', regex=False)
        .str.strip()
        .replace('', np.nan)
        .replace('nan', np.nan)
        .astype('float')
    )

# Clean data
df_cleaned = df_raw.copy()

# Numeric columns
month_cols = ['January', 'February', 'March', 'April', 'May', 'June',
              'July', 'August', 'September', 'October', 'November', 'December']
numeric_cols = month_cols + ['Total']

for col in numeric_cols:
    if col in df_cleaned.columns:
        df_cleaned[col] = clean_numeric_column(df_cleaned[col])

# Fix passenger type
df_cleaned['passenger_type'] = df_cleaned['passenger_type'].str.replace('_', ' ')
```

```
print('  Cleaned numeric columns')
print('  Fixed passenger type names')
print(f'\nData types:')
print(df_cleaned.dtypes)
```

```
 Cleaned numeric columns
 Fixed passenger type names

Data types:
year                int64
passenger_type     object
January           float64
February          float64
March             float64
April             float64
May               float64
June              float64
July              float64
August            float64
September         float64
October           float64
November          float64
December          float64
Total             float64
dtype: object
```

1.3.3 1.3 Data Quality Checks

[52]:
```
print('DATA QUALITY SUMMARY')
print('='*80)
print(f'Total rows: {len(df_cleaned)}')
print(f'Total columns: {len(df_cleaned.columns)}')
print(f'Years: {df_cleaned["year"].min()} - {df_cleaned["year"].max()}')
print(f'Passenger types: {df_cleaned["passenger_type"].unique().tolist()}')

print(f'\nNull values per column:')
null_summary = df_cleaned.isnull().sum()
print(null_summary[null_summary > 0])

print(f'\nRows per year:')
print(df_cleaned['year'].value_counts().sort_index())
```

```
DATA QUALITY SUMMARY
================================================================================
Total rows: 84
Total columns: 15
Years: 2005 - 2025
Passenger types: ['Domestic', 'International', 'Total Passengers',
'Transborder']

Null values per column:
January       1
February      1
March         2
April         3
May          10
June         11
July         12
August       10
September    14
October       9
November      9
December      5
dtype: int64

Rows per year:
year
2005    4
2006    4
2007    4
2008    4
2009    4
2010    4
2011    4
2012    4
2013    4
2014    4
2015    4
2016    4
2017    4
2018    4
2019    4
2020    4
2021    4
2022    4
2023    4
2024    4
2025    4
Name: count, dtype: int64
```

1.3.4 1.4 Validate Q4 2024

[53]:

```python
print('Q4 2024 VALIDATION (vs Infographic)')
print('='*80)
```

```
mask = (df_cleaned['year'] == 2024) & (df_cleaned['passenger_type'] == 'Total Passengers')
total_2024 = df_cleaned[mask]

if not total_2024.empty:
    q4_sum = total_2024[['October', 'November', 'December']].values[0].sum()
    expected = 1_075_859

    print(f'Calculated Q4 2024: {q4_sum:>12,.0f}')
    print(f'Expected (infographic): {expected:>12,}')
    print(f'Difference: {abs(q4_sum - expected):>12,.0f}')
    print()

    if abs(q4_sum - expected) < 10:
        print('  VALIDATION PASSED')
    else:
        print('  VALIDATION FAILED')
```

```
Q4 2024 VALIDATION (vs Infographic)
================================================================================
Calculated Q4 2024:    1,075,859
Expected (infographic):    1,075,859
Difference:            0

  VALIDATION PASSED
```

1.4 Part 2: Exploratory Data Analysis

1.4.1 2.1 Reshape Data for Time Series Analysis

[54]:

```
# Melt to long format for easier plotting
df_long = df_cleaned.melt(
    id_vars=['year', 'passenger_type'],
    value_vars=month_cols,
    var_name='month',
    value_name='passengers'
)

# Create date column
month_map = {m: i+1 for i, m in enumerate(month_cols)}
df_long['month_num'] = df_long['month'].map(month_map)
df_long['date'] = pd.to_datetime(
    df_long['year'].astype(str) + '-' +
    df_long['month_num'].astype(str).str.zfill(2) + '-01'
)

# Sort by date
df_long = df_long.sort_values('date')
```

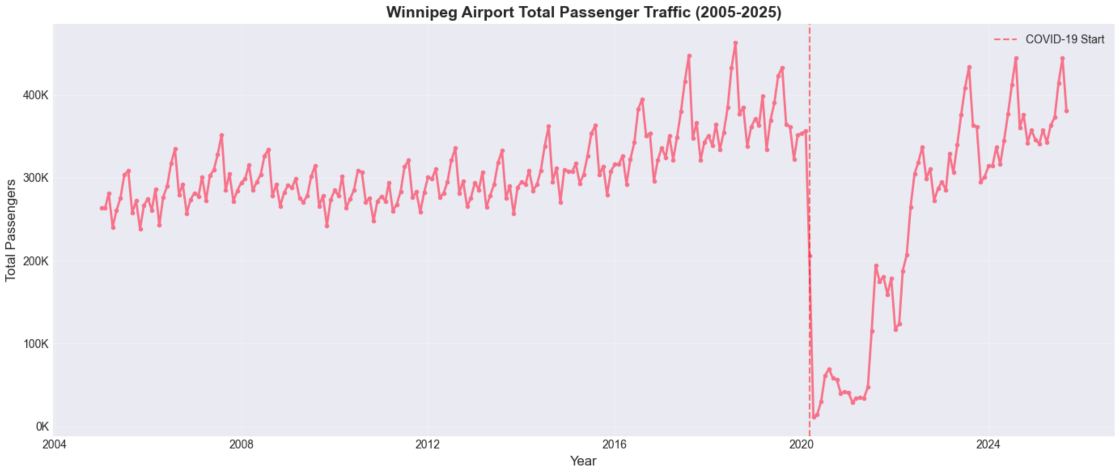
```
print(f'Long format shape: {df_long.shape}')
print(f'Date range: {df_long["date"].min()} to {df_long["date"].max()}')
df_long.head()
```

```
Long format shape: (1008, 6)
Date range: 2005-01-01 00:00:00 to 2025-12-01 00:00:00
```

```
[54]:     year     passenger_type     month  passengers  month_num       date
      0   2005           Domestic   January     192,265          1 2005-01-01
      1   2005      International   January      33,783          1 2005-01-01
      2   2005   Total Passengers   January     263,351          1 2005-01-01
      3   2005        Transborder   January      37,303          1 2005-01-01
      86  2005   Total Passengers  February     263,612          2 2005-02-01
```

1.4.2 2.2 Total Passengers Over Time

```
[55]: # Filter to Total Passengers only
      df_total = df_long[df_long['passenger_type'] == 'Total Passengers'].copy()

      # Plot
      fig, ax = plt.subplots(figsize=(14, 6))

      ax.plot(df_total['date'], df_total['passengers'], linewidth=2, marker='o',␣
        ↪markersize=3)
      ax.axvline(pd.Timestamp('2020-03-01'), color='red', linestyle='--', alpha=0.5,␣
        ↪label='COVID-19 Start')
      ax.set_xlabel('Year', fontsize=12)
      ax.set_ylabel('Total Passengers', fontsize=12)
      ax.set_title('Winnipeg Airport Total Passenger Traffic (2005-2025)',␣
        ↪fontsize=14, fontweight='bold')
      ax.legend()
      ax.grid(True, alpha=0.3)

      # Format y-axis
      ax.yaxis.set_major_formatter(plt.FuncFormatter(lambda x, p: f'{x/1e6:.1f}M' if␣
        ↪x >= 1e6 else f'{x/1e3:.0f}K'))

      plt.tight_layout()
      plt.show()

      print('Key Observations:')
      print('- COVID-19 impact visible in 2020-2021')
      print('- Recovery trend from 2022 onwards')
      print('- Seasonal patterns evident (summer peaks)')
```

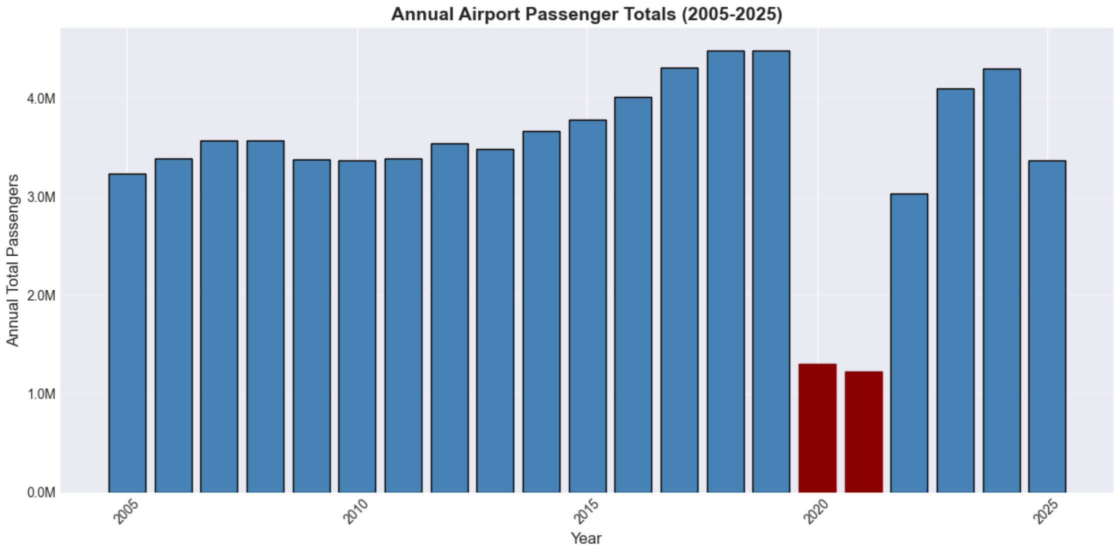


```
Key Observations:
- COVID-19 impact visible in 2020-2021
- Recovery trend from 2022 onwards
- Seasonal patterns evident (summer peaks)
```

1.4.3 2.3 Annual Total Passengers

[56]:
```python
# Annual totals
annual_totals = df_cleaned[df_cleaned['passenger_type'] == 'Total␣
↪Passengers'][['year', 'Total']].copy()
annual_totals = annual_totals.sort_values('year')

# Plot
fig, ax = plt.subplots(figsize=(12, 6))

bars = ax.bar(annual_totals['year'], annual_totals['Total'], color='steelblue',␣
↪edgecolor='black')

# Highlight 2020-2021 (COVID)
for i, (year, total) in enumerate(zip(annual_totals['year'],␣
↪annual_totals['Total'])):
    if year in [2020, 2021]:
        bars[i].set_color('darkred')

ax.set_xlabel('Year', fontsize=12)
ax.set_ylabel('Annual Total Passengers', fontsize=12)
ax.set_title('Annual Airport Passenger Totals (2005-2025)', fontsize=14,␣
↪fontweight='bold')
ax.yaxis.set_major_formatter(plt.FuncFormatter(lambda x, p: f'{x/1e6:.1f}M'))
ax.grid(True, alpha=0.3, axis='y')
```

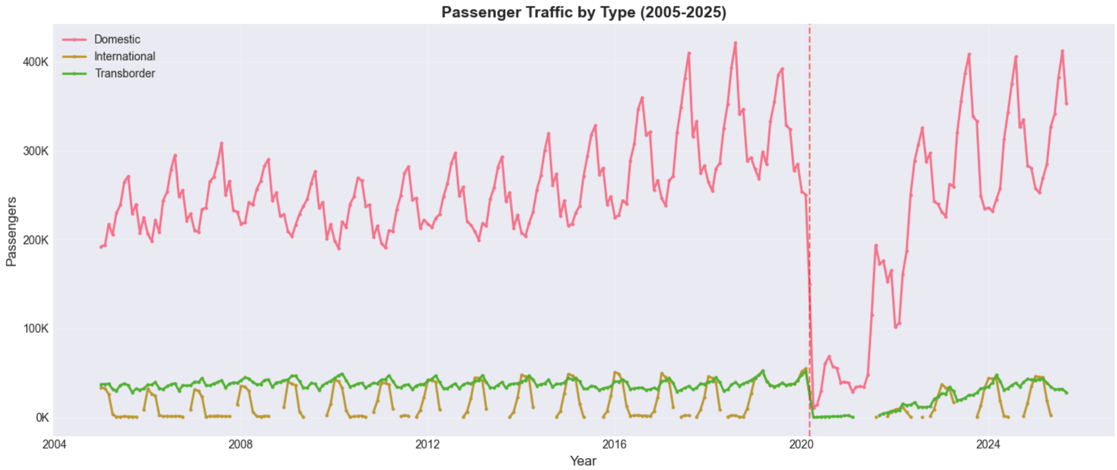
```
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()

# Summary stats
print('Annual Statistics:')
print(f'Peak year: {annual_totals.loc[annual_totals["Total"].idxmax(), "year"]:.
 ↪0f} ({annual_totals["Total"].max():,.0f} passengers)')
print(f'Lowest year: {annual_totals.loc[annual_totals["Total"].idxmin(),␣
 ↪"year"]:.0f} ({annual_totals["Total"].min():,.0f} passengers)')
print(f'2024 total: {annual_totals[annual_totals["year"] == 2024]["Total"].
 ↪values[0]:,.0f} passengers')
```



```
Annual Statistics:
Peak year: 2018 (4,484,343 passengers)
Lowest year: 2021 (1,223,054 passengers)
2024 total: 4,297,478 passengers
```

1.4.4 2.4 Passenger Type Breakdown

[57]:
```
# Filter out Total Passengers for breakdown
df_breakdown = df_long[df_long['passenger_type'] != 'Total Passengers'].copy()

fig, ax = plt.subplots(figsize=(14, 6))

for ptype in df_breakdown['passenger_type'].unique():
    data = df_breakdown[df_breakdown['passenger_type'] == ptype]
    ax.plot(data['date'], data['passengers'], label=ptype, linewidth=2,␣
 ↪marker='o', markersize=2)

ax.axvline(pd.Timestamp('2020-03-01'), color='red', linestyle='--', alpha=0.5)
ax.set_xlabel('Year', fontsize=12)
ax.set_ylabel('Passengers', fontsize=12)
ax.set_title('Passenger Traffic by Type (2005-2025)', fontsize=14,␣
 ↪fontweight='bold')
ax.legend()
ax.grid(True, alpha=0.3)
ax.yaxis.set_major_formatter(plt.FuncFormatter(lambda x, p: f'{x/1e6:.1f}M' if␣
 ↪x >= 1e6 else f'{x/1e3:.0f}K'))

plt.tight_layout()
plt.show()

print('Passenger Type Insights:')
print('- Domestic passengers dominate (~85% of total)')
print('- International traffic most volatile')
print('- Transborder relatively stable')
```

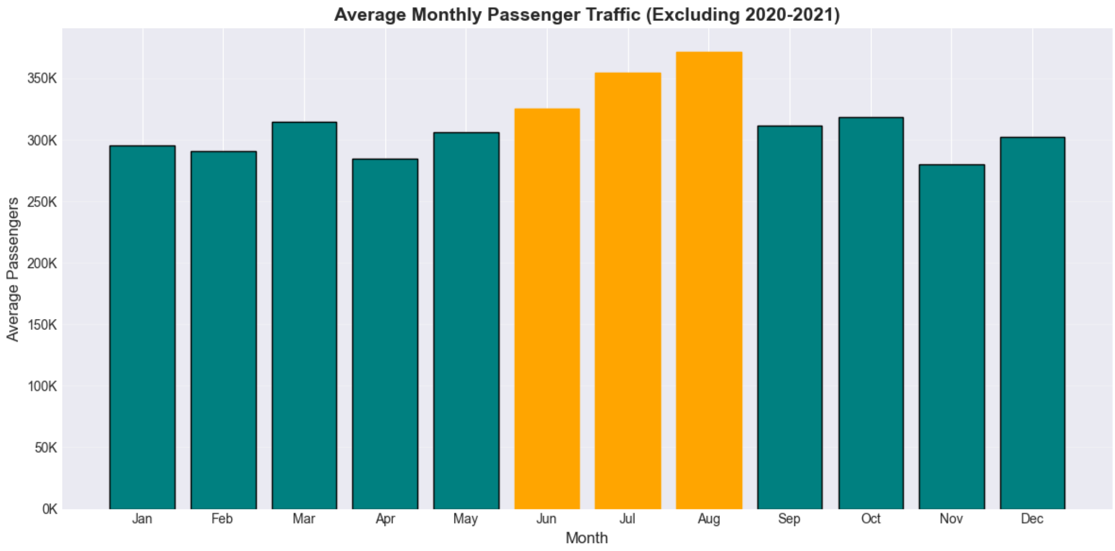


```
Passenger Type Insights:
- Domestic passengers dominate (~85% of total)
- International traffic most volatile
- Transborder relatively stable
```

1.4.5 2.5 Seasonality Analysis

[58]:

```
# Average passengers by month (exclude COVID years 2020-2021)
df_seasonal = df_long[
    (df_long['passenger_type'] == 'Total Passengers') &
    (~df_long['year'].isin([2020, 2021]))
].copy()

monthly_avg = df_seasonal.groupby('month')['passengers'].mean().
  ↪reindex(month_cols)

fig, ax = plt.subplots(figsize=(12, 6))

bars = ax.bar(range(len(monthly_avg)), monthly_avg, color='teal',␣
  ↪edgecolor='black')

# Highlight summer months
summer_indices = [5, 6, 7]  # June, July, August
for i in summer_indices:
    bars[i].set_color('orange')

ax.set_xlabel('Month', fontsize=12)
ax.set_ylabel('Average Passengers', fontsize=12)
ax.set_title('Average Monthly Passenger Traffic (Excluding 2020-2021)',␣
  ↪fontsize=14, fontweight='bold')
ax.set_xticks(range(12))
ax.set_xticklabels([m[:3] for m in month_cols])
ax.yaxis.set_major_formatter(plt.FuncFormatter(lambda x, p: f'{x/1e3:.0f}K'))
ax.grid(True, alpha=0.3, axis='y')

plt.tight_layout()
plt.show()

print('Seasonal Patterns:')
peak_month = monthly_avg.idxmax()
low_month = monthly_avg.idxmin()
print(f'Peak: {peak_month} ({monthly_avg.max():,.0f} avg passengers)')
print(f'Low: {low_month} ({monthly_avg.min():,.0f} avg passengers)')
print(f'Summer boost: {((monthly_avg[summer_indices].mean() / monthly_avg.
  ↪mean() - 1) * 100):.1f}% above average')
```



```
Seasonal Patterns:
Peak: August (371,789 avg passengers)
Low: November (280,063 avg passengers)
Summer boost: 12.0% above average
```

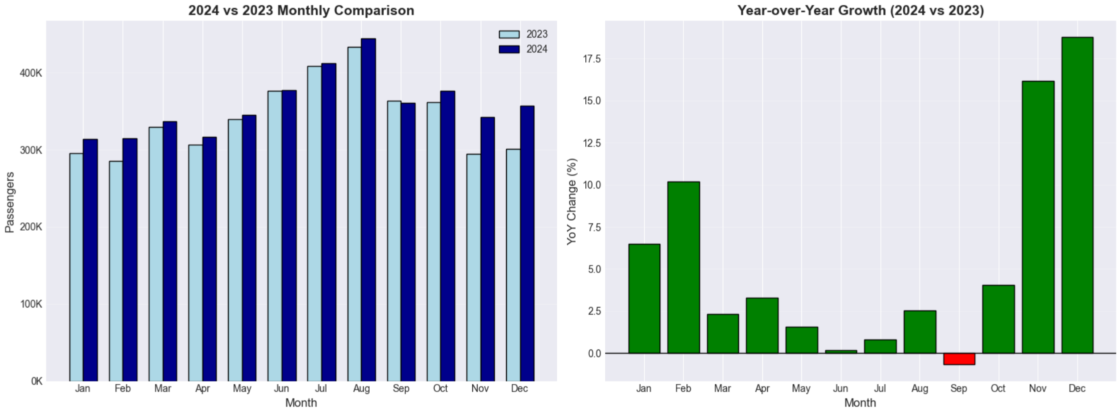
```
/var/folders/36/_jr9z14n69x_lzy_7969swfh0000gs/T/ipykernel_78453/3755199244.py:3
4: FutureWarning: Series.__getitem__ treating keys as positions is deprecated.
In a future version, integer keys will always be treated as labels (consistent
with DataFrame behavior). To access a value by position, use `ser.iloc[pos]`
  print(f'Summer boost: {((monthly_avg[summer_indices].mean() /
monthly_avg.mean() - 1) * 100):.1f}% above average')
```

1.4.6 2.6 Year-over-Year Growth (2024 vs 2023)

[59]:

```
# Get 2023 and 2024 data
df_2023 = df_long[(df_long['year'] == 2023) & (df_long['passenger_type'] ==␣
 ↪'Total Passengers')].copy()
df_2024 = df_long[(df_long['year'] == 2024) & (df_long['passenger_type'] ==␣
 ↪'Total Passengers')].copy()

# Merge on month
comparison = df_2023[['month', 'passengers']].merge(
    df_2024[['month', 'passengers']],
    on='month',
    suffixes=('_2023', '_2024')
)
comparison = comparison.set_index('month').reindex(month_cols)
comparison['yoy_change_pct'] = ((comparison['passengers_2024'] -␣
 ↪comparison['passengers_2023']) / comparison['passengers_2023'] * 100)
```

```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(16, 6))

# Panel 1: Side-by-side comparison
x = np.arange(len(month_cols))
width = 0.35

ax1.bar(x - width/2, comparison['passengers_2023'], width, label='2023',␣
 ↪color='lightblue', edgecolor='black')
ax1.bar(x + width/2, comparison['passengers_2024'], width, label='2024',␣
 ↪color='darkblue', edgecolor='black')

ax1.set_xlabel('Month', fontsize=12)
ax1.set_ylabel('Passengers', fontsize=12)
ax1.set_title('2024 vs 2023 Monthly Comparison', fontsize=14, fontweight='bold')
ax1.set_xticks(x)
ax1.set_xticklabels([m[:3] for m in month_cols])
ax1.legend()
ax1.grid(True, alpha=0.3, axis='y')
ax1.yaxis.set_major_formatter(plt.FuncFormatter(lambda x, p: f'{x/1e3:.0f}K'))

# Panel 2: YoY % change
colors = ['green' if x > 0 else 'red' for x in comparison['yoy_change_pct']]
ax2.bar(range(12), comparison['yoy_change_pct'], color=colors,␣
 ↪edgecolor='black')
ax2.axhline(0, color='black', linewidth=1)

ax2.set_xlabel('Month', fontsize=12)
ax2.set_ylabel('YoY Change (%)', fontsize=12)
ax2.set_title('Year-over-Year Growth (2024 vs 2023)', fontsize=14,␣
 ↪fontweight='bold')
ax2.set_xticks(range(12))
ax2.set_xticklabels([m[:3] for m in month_cols])
ax2.grid(True, alpha=0.3, axis='y')

plt.tight_layout()
plt.show()

print('YoY Growth Summary (2024 vs 2023):')
print(f'Average growth: {comparison["yoy_change_pct"].mean():.1f}%')
print(f'Best month: {comparison["yoy_change_pct"].idxmax()}␣
 ↪(+{comparison["yoy_change_pct"].max():.1f}%)')
print(f'Worst month: {comparison["yoy_change_pct"].idxmin()}␣
 ↪({comparison["yoy_change_pct"].min():.1f}%)')
```

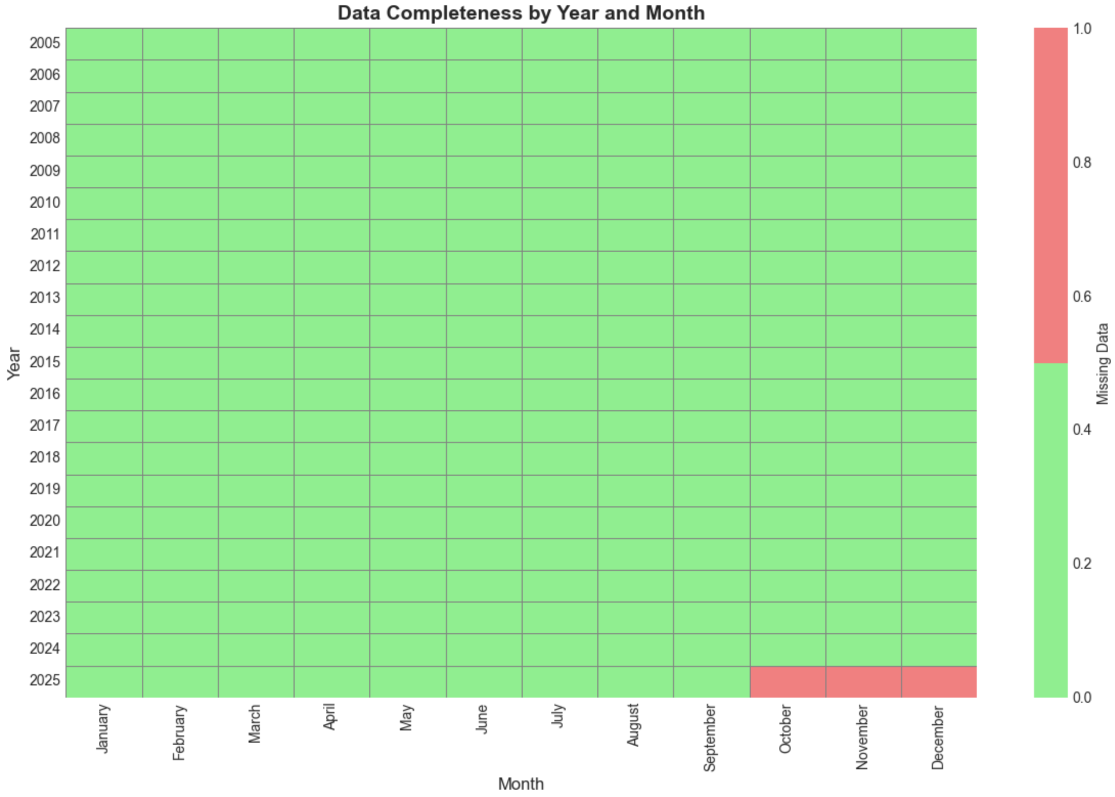


```
YoY Growth Summary (2024 vs 2023):
Average growth: 5.5%
Best month: December (+18.8%)
Worst month: September (-0.7%)
```

1.4.7 2.7 Missing Data Heatmap

[60]:
```
# Create pivot for heatmap
pivot_total = df_cleaned[df_cleaned['passenger_type'] == 'Total␣
 ↪Passengers'][['year'] + month_cols].set_index('year').sort_index()

fig, ax = plt.subplots(figsize=(12, 8))

# Create mask for missing data
mask = pivot_total.isnull()

sns.heatmap(
    mask,
    cmap=['lightgreen', 'lightcoral'],
    cbar_kws={'label': 'Missing Data'},
    linewidths=0.5,
    linecolor='gray',
    ax=ax
)

ax.set_title('Data Completeness by Year and Month', fontsize=14,␣
 ↪fontweight='bold')
ax.set_xlabel('Month', fontsize=12)
ax.set_ylabel('Year', fontsize=12)

plt.tight_layout()
plt.show()
```

```python
print('Missing Data Summary:')
print(f'Total cells: {pivot_total.size}')
print(f'Missing cells: {pivot_total.isnull().sum().sum()}')
print(f'Completeness: {(1 - pivot_total.isnull().sum().sum() / pivot_total.size) * 100:.1f}%')
```



```
Missing Data Summary:
Total cells: 252
Missing cells: 3
Completeness: 98.8%
```

1.5 Part 3: Save Processed Data

```python
[61]: # Save cleaned data
output_path = processed() / 'airport_passengers_clean.csv'
df_cleaned.to_csv(output_path, index=False)

print('  SAVED PROCESSED DATA')
print('='*80)
print(f'Location: {output_path}')
print(f'Size: {output_path.stat().st_size:,} bytes')
print(f'Shape: {df_cleaned.shape}')
print(f'\nReady for Power BI import!')
```

```
 SAVED PROCESSED DATA
================================================================================
Location:
/Users/dpro/projects/travel_manitoba/data/processed/airport_passengers_clean.csv
Size: 10,197 bytes
Shape: (84, 15)

Ready for Power BI import!
```

1.6 Summary

1.6.1 Data Cleaning

- Loaded manual CSV from interim directory
- Cleaned numeric formatting (removed commas, converted dashes to NaN)
- Fixed passenger type names
- Validated Q4 2024 = 1,075,859 passengers (exact match)
- Saved to `data/processed/airport_passengers_clean.csv`

1.6.2 Key Findings from EDA

1. Overall Trends - Steady growth 2005-2019 (pre-COVID) - Dramatic COVID-19 impact in 2020-2021 (~70% decline) - Strong recovery trend 2022-2024 - 2024 approaching pre-pandemic levels

2. Seasonality - Clear summer peak (June-August) - Summer traffic ~15-20% above annual average - February typically lowest month

3. Passenger Mix - Domestic: ~85% of total traffic - Transborder: ~10% - International: ~5% (most volatile)

4. Recent Performance (2024 vs 2023) - Positive YoY growth in most months - Q4 2024: 1,075,859 passengers - Recovery continuing toward pre-pandemic levels

1.6.3 Next Steps

1. Import `airport_passengers_clean.csv` into Power BI
2. Create measures:
   - YoY % Change
   - YTD Totals

   - Quarterly Aggregations
3. Build dashboard matching Travel Manitoba style
4. Add slicers for year, passenger type, time period