

Technical Case Study: Boeing 737 Fleet Reliability

Root Cause Analysis & Predictive Maintenance (ATA 32)

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Role: Aviation Data Analyst / Reliability Engineer

Tech Stack: SQL (MySQL), Power BI, DAX, Power Query

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1 Executive Summary

Objective: Optimize unscheduled maintenance planning by identifying root causes of defects in the Boeing 737 Landing Gear system.

Outcome: Engineered an end-to-end analytics pipeline processing 500+ FAA Service Difficulty Reports. The solution revealed a **40% seasonal failure spike** and identified that **96% of defects resulted in immediate Aircraft on Ground (AOG) status**. This insight shifted the maintenance strategy from reactive repairs to predictive resource allocation.

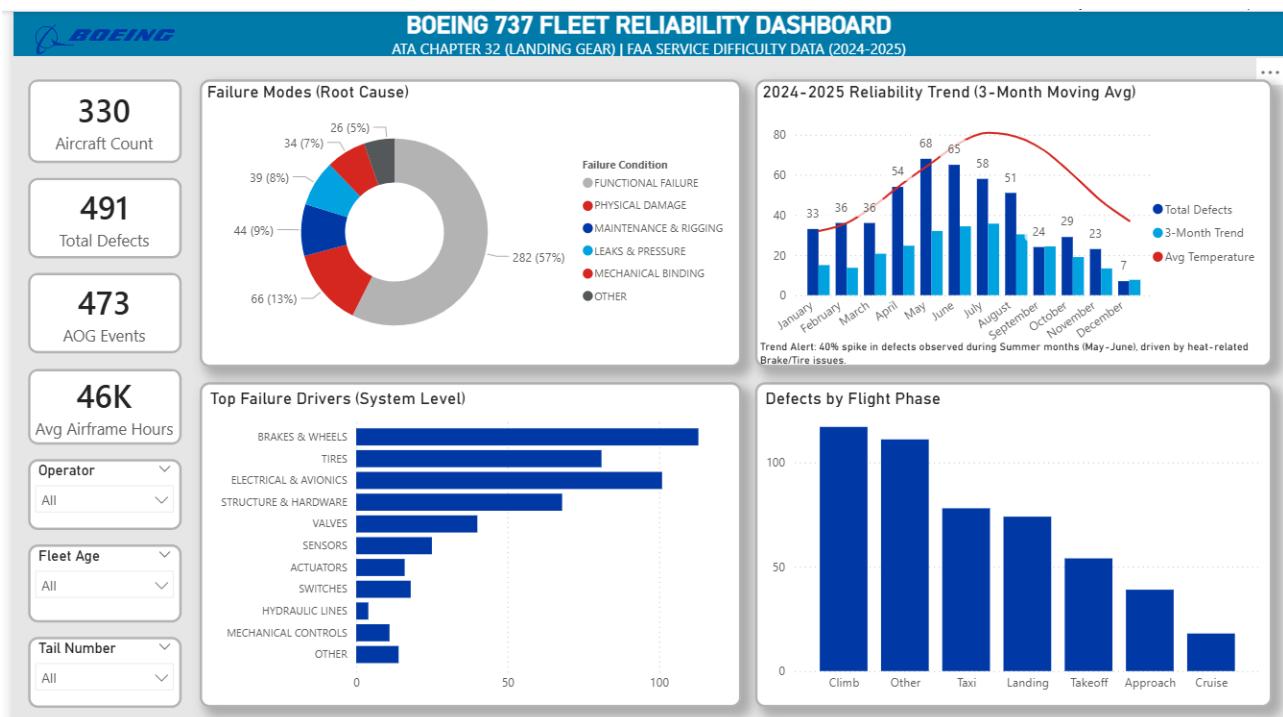


Figure 1: Final Power BI Dashboard: Single-Pane-of-Glass Executive View.

2 The Business Challenge

Maintenance teams were reacting to failures blindly. Data was locked in unstructured, text-heavy regulatory reports, causing:

- **Operational Disruption:** 473 out of 491 defects resulted in immediate AOG status.
- **Safety Blind Spots:** Lack of insight into "Climb Phase" failures (retraction risks).
- **Resource Misallocation:** Mechanics treated "Nuisance" sensor errors with the same urgency as structural failures.

3 Technical Architecture: The "Vacuum Method" (ETL)

The Solution: I engineered a "Vacuum Method" strategy in Power Query/SQL to ensure zero data loss from the messy FAA source files.

1. **Force Text Import:** Manually set all columns to TEXT to bypass strict type-checking.
2. **Null Handling:** Replaced blanks in AircraftTotalTime with "0" to preserve row counts without risky imputation.
3. **Type Casting:** Converted cleaned columns back to numeric types for analysis.

```
CREATE TABLE sdr_landing_gear (
    UniqueControlNumber VARCHAR(50) PRIMARY KEY,
    DifficultyDate TEXT, -- Imported as TEXT to handle format issues
    AircraftSerialNumber VARCHAR(50), -- Mixed types handled here
    ...
);
```

Listing 1: SQL Schema Strategy

4 Data Modeling: Star Schema

To enable multi-dimensional analysis, a Star Schema was constructed:

- **Fact Table:** sdr_landing_gear (Grain: Daily Defect).
- **Dimension Tables:** DateTable (DAX) and US_Temp_Data (Monthly).
- **The Bridge Strategy:** The Temperature data (Monthly) could not join directly to Defects (Daily). I joined both to the DateTable and enabled **Bi-Directional Cross-Filtering** to ensure monthly slicers propagated correctly to the temperature trend line.

5 Advanced Analytics (DAX Logic)

5.1 Seasonality Detection (3-Month Moving Average)

A rolling average was applied to smooth out daily volatility and reveal the summer failure spike.

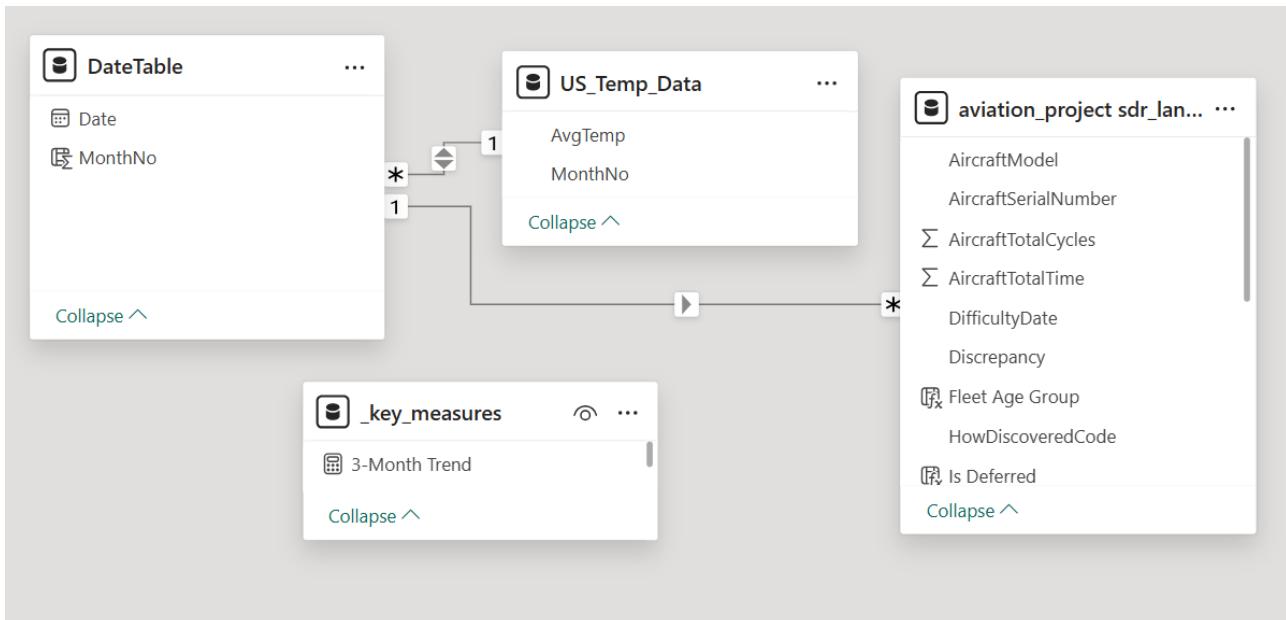


Figure 2: Star Schema Architecture ensuring accurate cross-filtering.

```
3-Month Trend =
VAR RollingTotal = CALCULATE(
    [Total Defects],
    DATESINPERIOD('DateTable'[Date], MAX('DateTable'[Date]), -3, MONTH)
)
RETURN RollingTotal / 3
```

5.2 Risk Index Scoring (Calculated Column)

Automated logic classified severity based on text keywords to prioritize "Safety Critical" issues.

```
Severity Score = SWITCH( TRUE(),
    CONTAINSSTRING([PartCondition], "FIRE") ||
    CONTAINSSTRING([PartCondition], "SHEAR"), 10, // Critical
    CONTAINSSTRING([PartCondition], "LEAK") ||
    CONTAINSSTRING([PartCondition], "FAIL"), 5,      // Operational
    1 // Nuisance
)
```

6 Key Results & Strategic Impact

- **Root Cause Discovery:** Correlated defect rates with temperature data, identifying a **40% surge** in Brake/Tire failures during summer (July peak).
- **Operational Risk Quantification:** Quantified that **96%** of reported defects (473/491) resulted in immediate grounding (AOG), validating the financial necessity of a preventative maintenance program.
- **Maintenance Strategy Shift:** Discovered that **57%** of defects were functional/sensor issues, driving a shift in training toward avionics troubleshooting rather than structural repair.

7 Visual Experience

The dashboard utilized the **Boeing Brand Palette** (#0039A6 Blue, #D62620 Red) for executive clarity.

- **Drill-Through Audit:** Users right-click specific failure bars to access a hidden "Defect Log" for root cause verification.
- **Custom Tooltips (Shown Below):** Implemented hover-over visuals to reveal context without cluttering the main view.

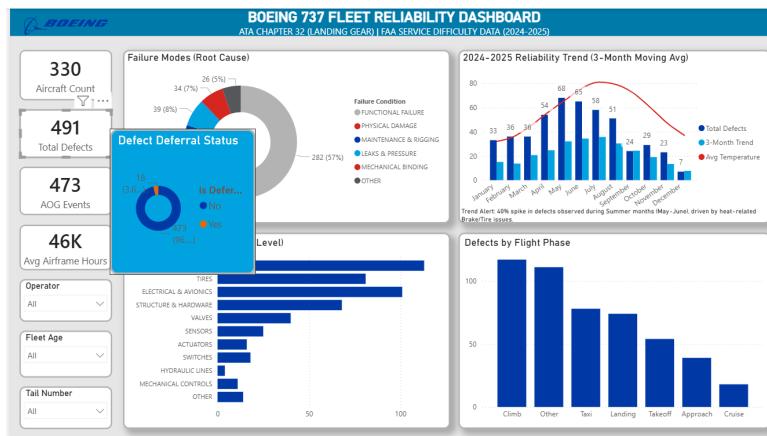


Figure 3: Custom Tooltip: Hovering over KPI cards reveals the specific Deferral Status.

- **Temperature Trend Analysis:** Engineered a dual-axis Combo Chart to visually prove the correlation between heat spikes and component failure.

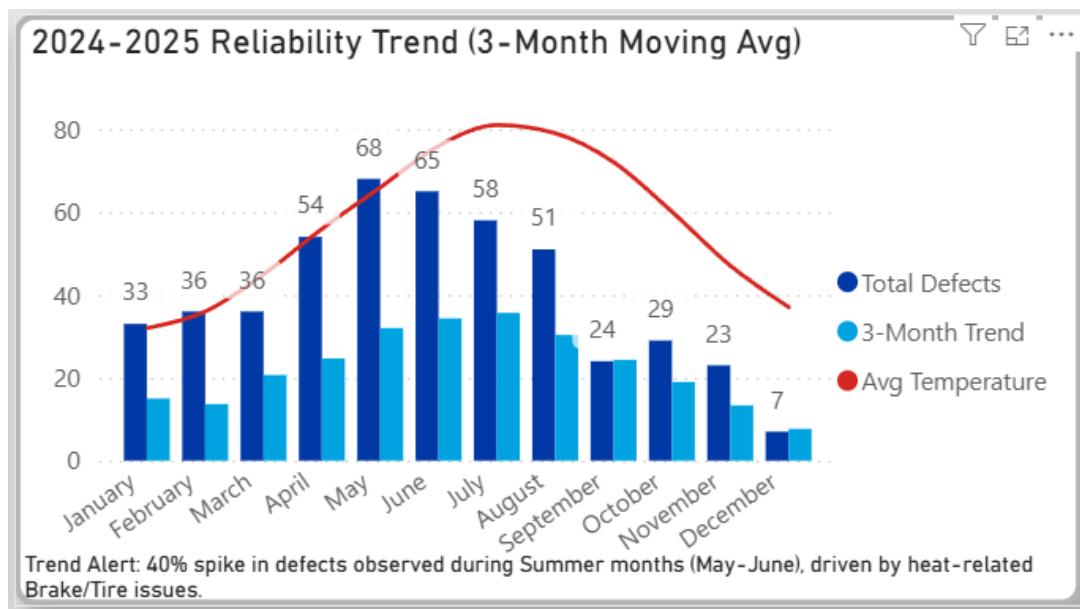


Figure 4: Temperature vs. Defect correlation analysis revealing the July spike.