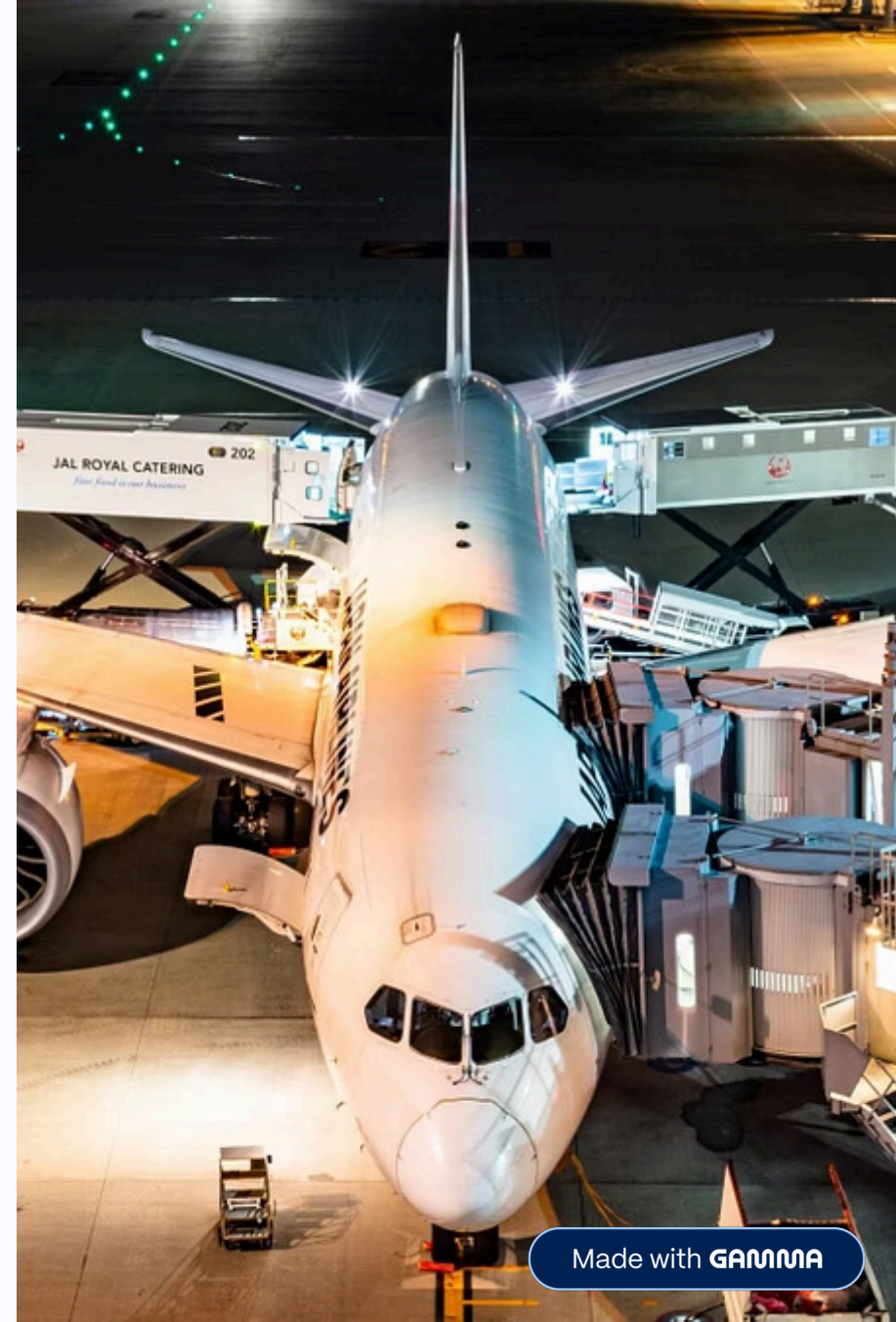




SkyHack 3.0 2025 Submission

Team: *The Airbenders*

Members: *Akshit Sahu (2K22/EC/027) & Atharva Jakhetiya (2K22/EC/063)*



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PROBLEM STATEMENT

Frontline teams at United Airlines are responsible for ensuring every flight departs on time and is operationally ready. However, not all flights are equally easy to manage. Certain flights pose **greater complexity** due to factors such as:

- Limited ground time
- Higher volumes of checked or carry-on baggage
- Specific customer service needs that often increase with passenger load

Currently, identifying these **high-difficulty flights** relies heavily on personal experience and local team knowledge. This **manual approach is inconsistent, non-scalable**, and risks missing opportunities for **proactive resource planning** across the airport.

Our objective:

Design a **data-driven framework** that calculates a **Flight Difficulty Score** for each flight and identifies **primary operational drivers** to enable **proactive planning and optimized resource allocation**.

EXPLORATORY DATA ANALYSIS (EDA) - KEY FINDINGS

8,099

8,099 Total Flights Analyzed

687K

687K Total PNR Records

51K

51K Total Special Service Requests

Analysis Period: August 1-15, 2025

Question 1: Flight Delay Analysis

- Average departure delay: **21.2 minutes**
- Flights departing late (>15 min): **26.7%**
- Flights departing early (≤15 min): **73.3%**

Question 2: Ground Time Analysis

- Flights with tight ground time (<20% buffer): **16.1%**
- Flights below minimum turn time: **7.8%**
- Average ground time buffer: **135.7 minutes**
- Average ground time ratio: **3.96**

Question 3: Baggage Analysis

- Average transfer bag ratio: **0.601 (60.1%)**
- Average checked bag ratio: **0.399 (39.9%)**
- Average bags per flight: **78.8**
- Total transfer bags: **397,124**
- Total checked bags: **290,121**

Question 4: Passenger Load Analysis

- Average load factor: **1.024 (102.4%)**
- High load flights (>80%): **88.1%**
- Load factor vs delay correlation: **-0.150**
- Total passengers: **1,040,553**

Question 5: Special Services Analysis

- Average special services per flight: **48.75**
- High special service flights (3+): **99.9%**
- Top service types: **Airport Wheelchair (45,738), Manual Wheelchair (3,641), Unaccompanied Minor (1,706)**

FLIGHT DIFFICULTY SCORE — METHODOLOGY

Approach: Developed a *systematic daily-level scoring approach* that resets every day and incorporates multiple *operational complexity factors*.

Feature Engineering Categories:

<p>Ground Time Constraints (35% weight)</p> <ul style="list-style-type: none"><i>Ground Time Pressure:</i> Scheduled vs minimum turn time ratio<i>Ground Time Risk:</i> Actual vs scheduled ground time comparison	<p>Aircraft Characteristics (15% weight)</p> <ul style="list-style-type: none"><i>Aircraft Size Complexity:</i> Based on total seats<i>Carrier Complexity:</i> Mainline vs Express distinction	<p>Passenger Service Needs (25% weight)</p> <ul style="list-style-type: none"><i>Load Factor:</i> Passenger count vs aircraft capacity<i>Special Service Complexity:</i> Absolute count of special requests<i>Children Complexity:</i> Ratio of children and lap infants<i>Stroller Complexity:</i> Stroller user ratio<i>Basic Economy Complexity:</i> Basic economy passenger ratio
<p>Baggage Complexity (10% weight)</p> <ul style="list-style-type: none"><i>Baggage Complexity:</i> Absolute total bag count<i>Transfer Bag Complexity:</i> Transfer bags × 2 (<i>higher complexity multiplier</i>)	<p>Historical Performance (15% weight)</p> <ul style="list-style-type: none"><i>Departure delay as proxy for historical difficulty</i>	

Scoring Process:

1. Normalize all features to **0-1 scale** using *min-max normalization*
2. Apply *weighted composite scoring* (weights sum to **1.0**)
3. Scale final scores to **0-100** for interpretation
4. **Create daily rankings** (highest score = most difficult)
5. Classify into *Difficult/Medium/Easy* using *percentile-based thresholds*

Results:

- Score range: **0.47 - 52.34**
- Average difficulty score: **16.77**
- Classification distribution: **33.4% Difficult, 33.4% Medium, 33.2% Easy**

DESTINATION DIFFICULTY ANALYSIS

Top 5 Most Difficult Destinations:

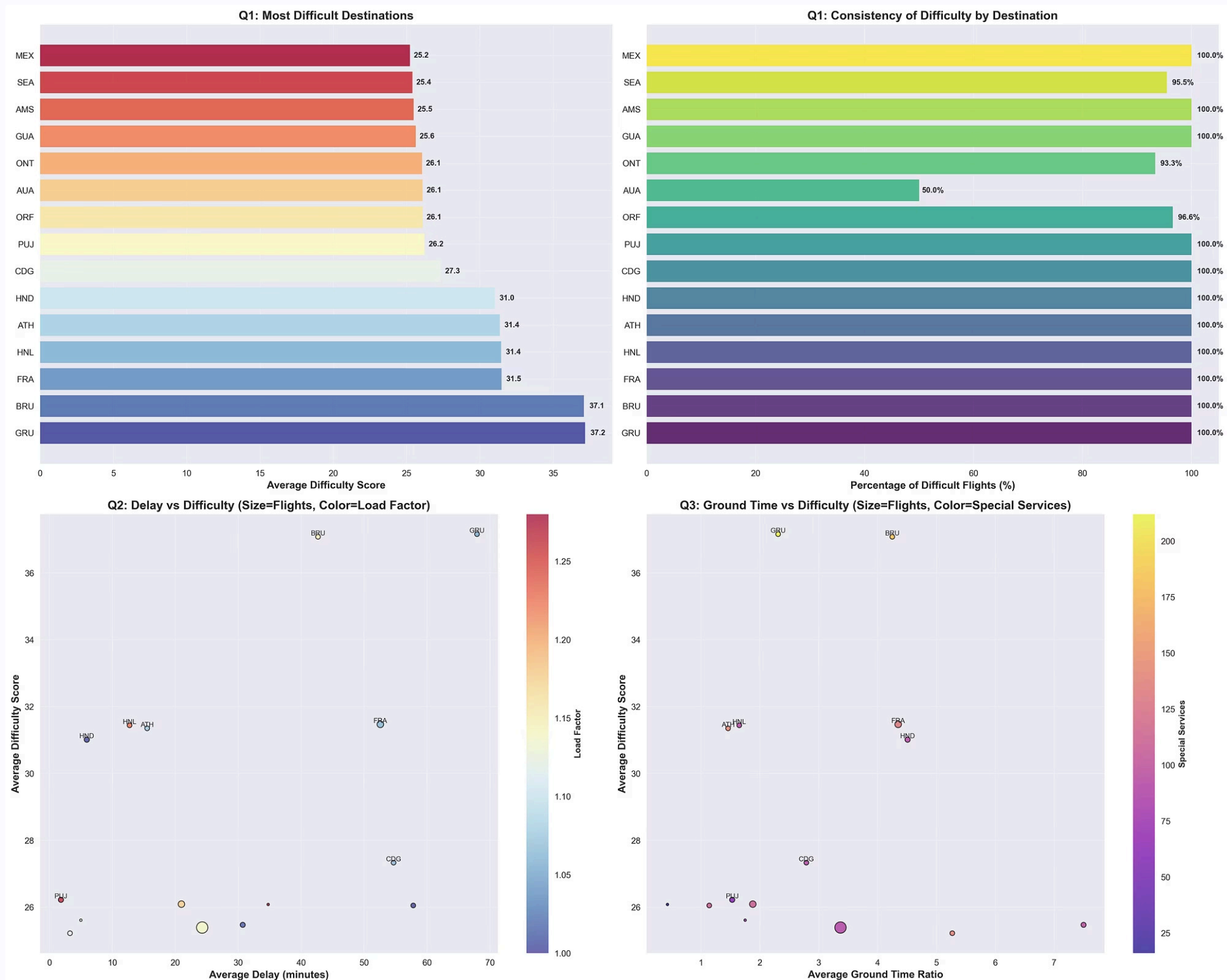
1	GRU (São Paulo)	Avg Score 37.16 , 100% difficult flights, 15 total flights
2	BRU (Brussels)	Avg Score 37.08 , 100% difficult flights, 15 total flights
3	FRA (Frankfurt)	Avg Score 31.47 , 100% difficult flights, 30 total flights
4	HNL (Honolulu)	Avg Score 31.44 , 100% difficult flights, 15 total flights
5	ATH (Athens)	Avg Score 31.35 , 100% difficult flights, 15 total flights

Additional Consistently Difficult Destinations:

- HND (Tokyo): **100%** difficult flights, Avg score: **31.01**
- CDG (Paris): **100%** difficult flights, Avg score: **27.33**
- PUJ (Punta Cana): **100%** difficult flights, Avg score: **26.22**
- ORF (Norfolk): **96.6%** difficult flights, Avg score: **26.09**
- ONT (Ontario): **93.3%** difficult flights, Avg score: **26.05**

Key Patterns:

- **International destinations show consistently higher difficulty**
- *Long-haul routes* (GRU, BRU, FRA, HND) **are most challenging**
- Domestic destinations (HNL, ORF, ONT) **also show high complexity**
- All top destinations have **90%+** difficult flight rates



DIFFICULTY DRIVERS & OPERATIONAL INSIGHTS

Top 5 Difficulty Drivers (Impact Analysis):

1	Baggage Complexity: Impact 86.74	<ul style="list-style-type: none">Difficult flights: 125.7 bags averageEasy flights: 39.0 bags average3.2x fold increase, 222.5% impact increase
2	Transfer Bag Complexity: Impact 73.94	<ul style="list-style-type: none">Difficult flights: 129.2 transfer bags averageEasy flights: 55.2 transfer bags average2.3x fold increase, 133.9% impact increase
3	Special Service Complexity: Impact 57.10	<ul style="list-style-type: none">Difficult flights: 78.9 special services averageEasy flights: 21.8 special services average3.6x fold increase, 261.9% impact increase
4	Ground Time Risk: Impact 16.03	<ul style="list-style-type: none">Difficult flights: 16.4 risk score averageEasy flights: 0.4 risk score average41.6x fold increase, 4,063% impact increase
5	Ground Time Pressure: Impact 11.88	<ul style="list-style-type: none">Difficult flights: 12.4 pressure score averageEasy flights: 0.5 pressure score average26.0x fold increase, 2,497% impact increase

Key Insights:

- Baggage volume is the primary operational complexity driver
- Transfer bags create 2x more complexity than origin bags
- Special services require significant additional resources
- Ground time constraints are critical operational bottlenecks

OPERATIONAL RECOMMENDATIONS & IMPLEMENTATION

HIGH PRIORITY ACTIONS (0-3 months):

Special Service Management

- Pre-allocate additional ground crew for high special service flights
- Create special service alerts and dedicated crew assignments
- **Expected Impact: 57.1 difficulty score reduction**

Ground Time Optimization

- Implement buffer time monitoring and early warning systems
- Create alerts for flights with negative ground time buffer
- **Expected Impact: 16.0 difficulty score reduction**

Dynamic Ground Time Allocation

- Adjust minimum turn times based on aircraft type and historical performance
- Implement aircraft-specific turnaround procedures
- **Expected Impact: 11.9 difficulty score reduction**

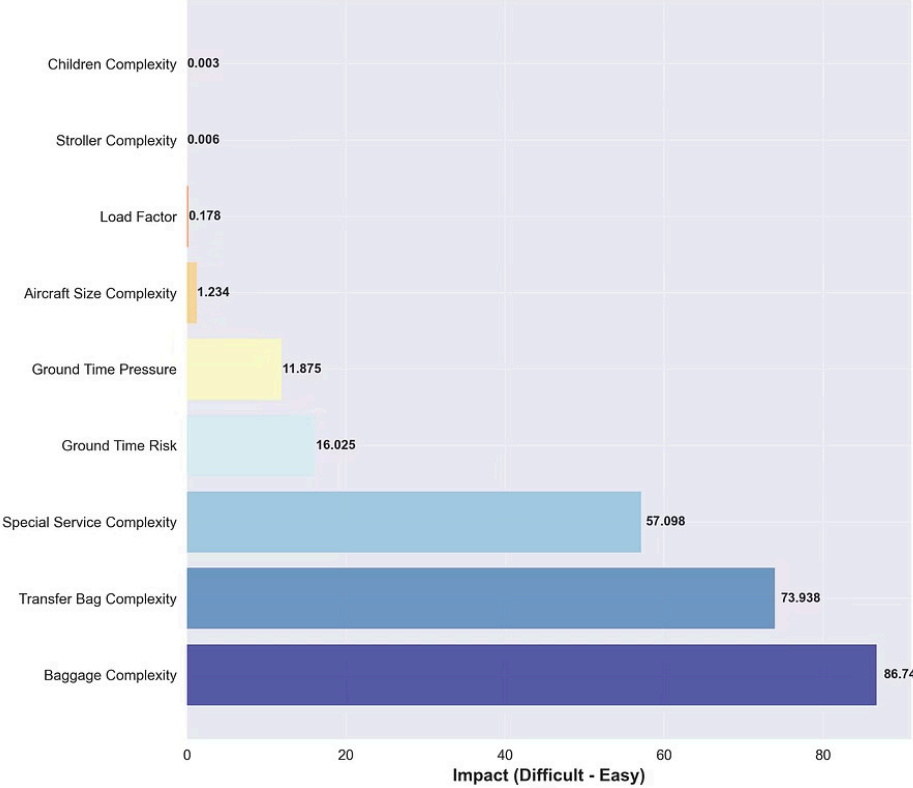
MEDIUM PRIORITY ACTIONS (3-6 months):

- Optimize boarding processes for high-baggage flights
- Standardize large aircraft procedures
- Implement load factor-based resource allocation

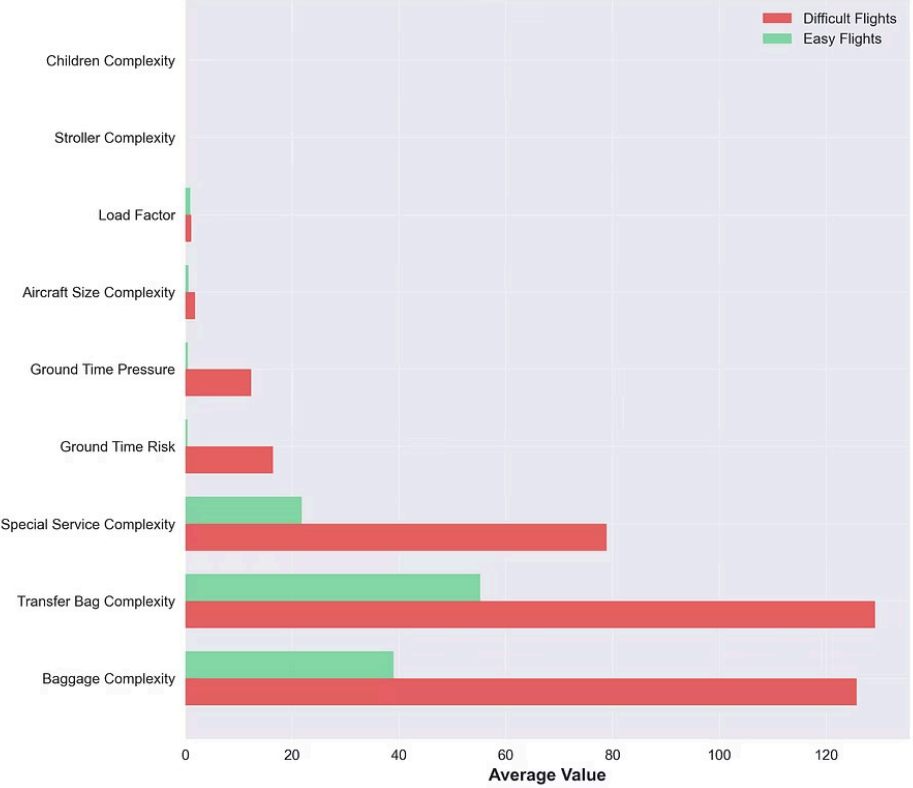
LONG-TERM STRATEGIC INITIATIVES (6-12 months):

- Develop destination-specific operational procedures
- Focus on top difficult destinations: GRU, BRU, FRA, HNL, ATH
- Create predictive difficulty models for proactive planning

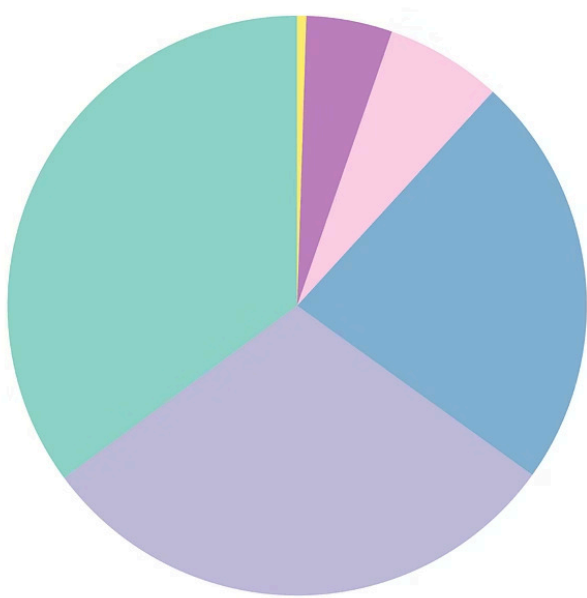
Q2: Driver Impact on Flight Difficulty



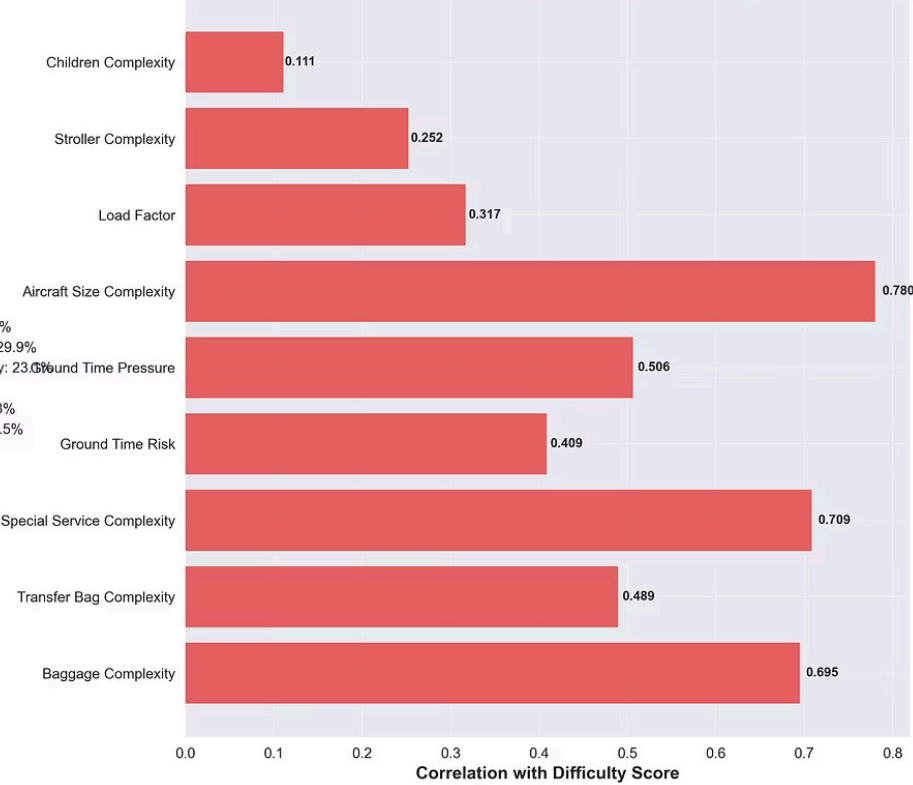
Q2: Driver Values Comparison



Q3: Priority Drivers for Action (by Impact)



Q3: Driver Correlation with Overall Difficulty



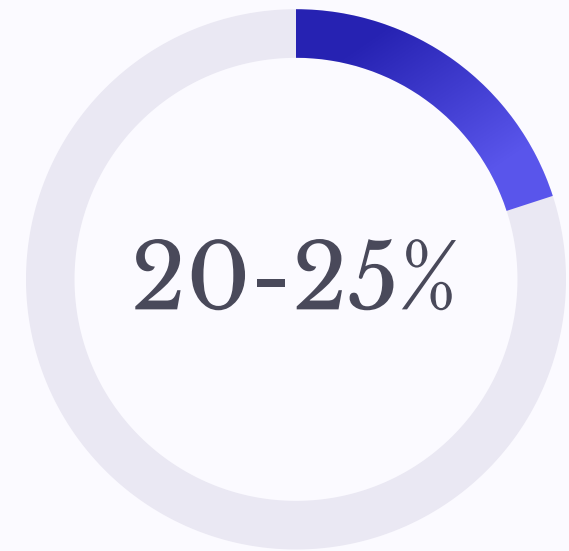
EXPECTED OUTCOMES & IMPLEMENTATION TIMELINE



Reduction in average flight difficulty scores



Improvement in on-time performance



Reduction in ground time delays

Additional Expected Benefits:

- Improved passenger satisfaction scores
- Enhanced operational efficiency and cost savings

Implementation Timeline: Phased approach over 12 months with continuous monitoring and optimization.

Thank You!

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