Business Case Study

GLOBAL AIR TRANSPORT NETWORK
Structural Risk & Resilience Assessment

Understanding single-point-of-failure risk in global aviation networks

Executive Context

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Power BI • SQL • Excel • Data Modeling • DAX

Why this matters now

Global air transport is designed for **efficiency and scale**, not resilience.

Recent disruptions have shown that:

- *Airport shutdowns*
- *Fleet groundings*
- *Geopolitical restrictions*

can cascade rapidly across countries and airlines.

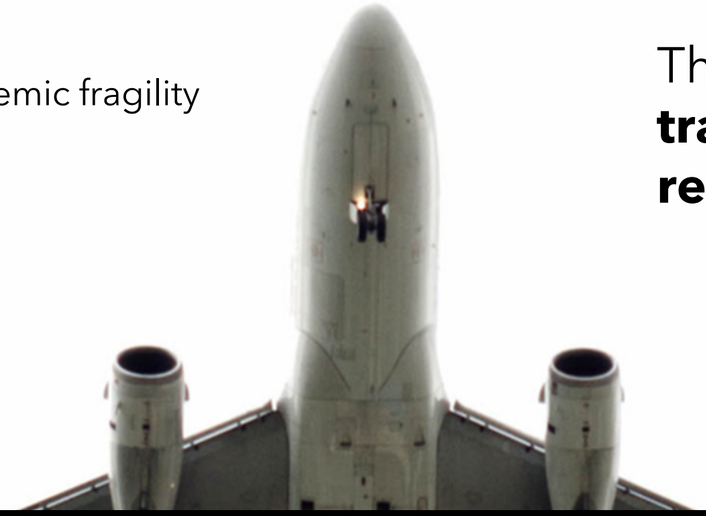
The question is not if disruptions happen – but where the system breaks first.

Core Business Question

If one critical node fails, how much of the air transport network is exposed?

Business Risk

- Over-concentration increases systemic fragility
- Failures propagate non-linearly
- Size does not equal resilience



This risk is often **invisible in traditional volume-based reporting**.

Decision Gaps Today

What leaders often see

- Passenger volumes
- Revenue by route
- On-time performance
- Load factors

What is usually missing

- Structural dependency
- Network concentration risk
- Hidden single points of failure

This gap delays proactive risk mitigation

Scope of This Business Case

In Scope

- Country dependence on key airports
- Airport-level network dominance
- Airline reliance on primary hubs
- Fleet concentration by aircraft family

Explicitly Out of Scope

- Demand forecasting
- Delay prediction
- Revenue modelling
- Machine learning

The goal is **risk exposure**, not prediction

Analytical Approach
(High Level)

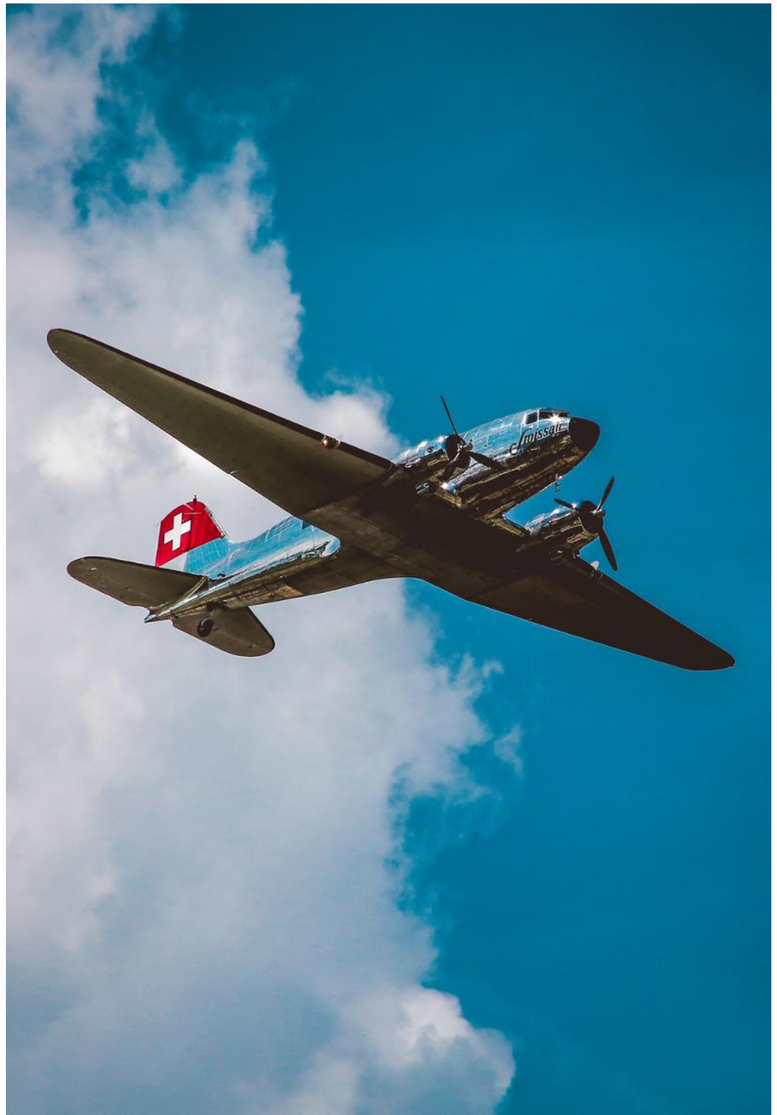
How the problem was approached

- Treat air transport as a **network**, not a collection of routes
- Measure **dependency ratios**, not absolute size
- Focus on **failure impact**, not operational efficiency

This ensures insights remain:

- Explainable
- Auditable
- Decision-ready

Data Foundation



Inputs Used

- Global airports
- Airlines
- Directional routes
- Aircraft / equipment
- Countries

Reality Check

- Data is incomplete and messy
- Routes are directional
- Many routes operate multiple aircraft families

This mirrors **real operational complexity.**

DATASOURCE

OpenFlights.org

https://openflights.org/data

Risk Measurement Logic

Core Principle

Risk = concentration of dependency

Examples

- Country risk → reliance on one airport
- Airline risk → reliance on one hub
- Fleet risk → reliance on one aircraft family

Ratios were used to ensure:

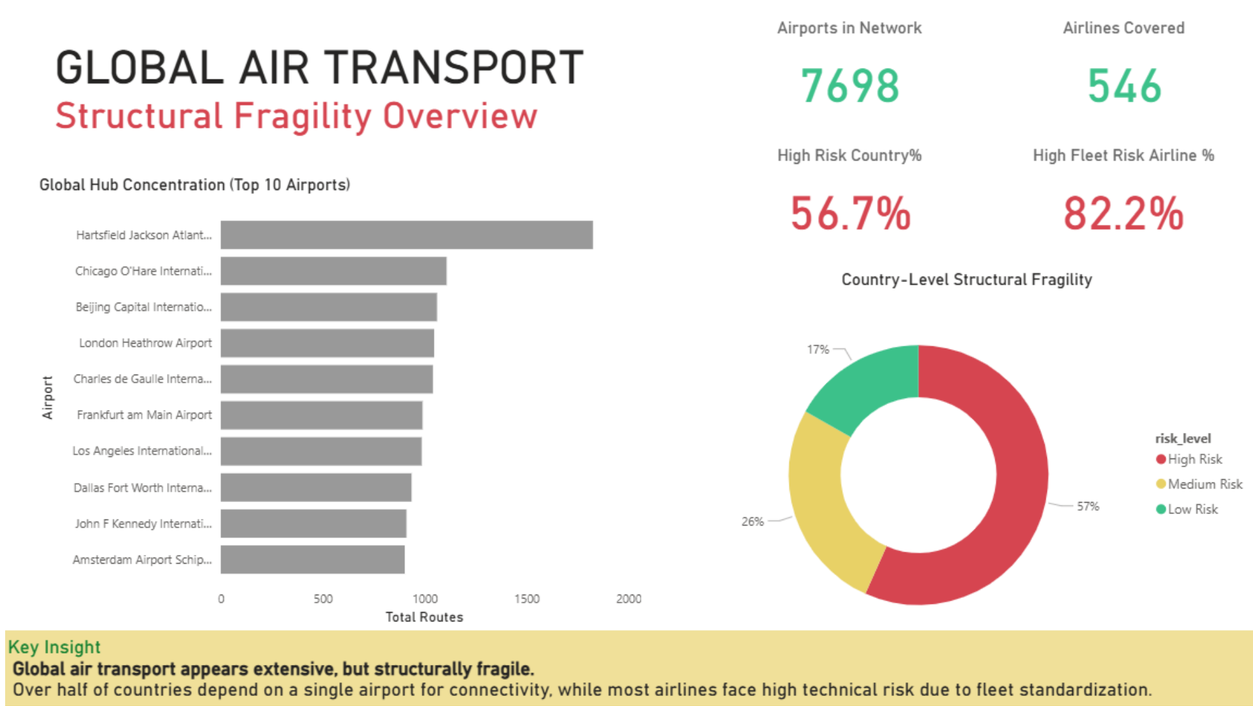
- Comparability across sizes
- Focus on fragility, not scale

Executive View: **Network Fragility**

Key Finding (Executive Level)

- A significant share of countries depend on **one dominant airport**
- Most airlines exhibit **high fleet concentration**
- Global hubs act as **systemic choke points**

The network is large – but not evenly resilient.



Business Impact: **Country & Airport Risk**

What the analysis shows

- Many countries lose most connectivity if one airport fails
- A small set of airports disproportionately supports global routing
- Local disruptions can become **national access failures**

Business Implication

- Infrastructure redundancy is uneven
- National resilience is often overstated

Airport & Country Single-Point-of-Failure Risk

Global Hub Concentration — Top Connectivity Airports

airport_name	city	country_name	total_routes	connectivity_rank
Hartsfield Jackson Atlanta International Airport	Atlanta	United States	1826	1
Chicago O'Hare International Airport	Chicago	United States	1108	2
Beijing Capital International Airport	Beijing	China	1061	3
London Heathrow Airport	London	United Kingdom	1047	4
Charles de Gaulle International Airport	Paris	France	1041	5
Frankfurt am Main Airport	Frankfurt	Germany	990	6
Los Angeles International Airport	Los Angeles	United States	986	7
Dallas Fort Worth International Airport	Dallas-Fort Worth	United States	936	8
John F Kennedy International Airport	New York	United States	911	9

Key Insight
Many countries exhibit near-total dependence on a single airport, indicating extreme vulnerability to localized disruptions despite appearing globally connected.

Country-Level Single-Point-of-Failure Exposure

country_name	top_airport	top_airport_routes	country_total_routes	top1_dependency_ratio	risk_level
Albania	Tirana International Airport Mother Teresa	72	72.00	100%	High Risk
American Samoa	Pago Pago International Airport	2	2.00	100%	High Risk
Anguilla	Clayton J Lloyd International Airport	12	12.00	100%	High Risk
Antigua and Barbuda	V.C. Bird International Airport	69	69.00	100%	High Risk
Aruba	Queen Beatrix International Airport	90	90.00	100%	High Risk
Bahrain	Bahrain International Airport	170	170.00	100%	High Risk
Barbados	Sir Grantley Adams International Airport	46	46.00	100%	High Risk
Belarus	Minsk National Airport	108	108.00	100%	High Risk
Benin	Cadjehoun Airport	80	80.00	100%	High Risk
Bermuda	L.F. Wade International International Airport	30	30.00	100%	High Risk
Bhutan	Paro Airport	10	10.00	100%	High Risk
Burundi	Bujumbura International Airport	27	27.00	100%	High Risk
Central African Republic	Bangui M'Poko International Airport	6	6.00	100%	High Risk

Business Impact: **Airline Operational Risk**

What the analysis shows

- Airline size ≠ operational resilience
- Many airlines depend heavily on one hub
- Hub shutdowns can halt large portions of operations

Business Implication

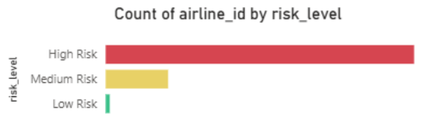
- Operational diversification is weaker than perceived
- Hub dependency is a strategic risk, not just a cost choice

Airline Operational & Fleet Single-Point-of-Failure Risk

Airline Hub Concentration Risk

airline_name	primary_hub	primary_hub_routes	airline_total_routes	top1_hub_dependency_ratio	risk_level
Eurowings	Hamburg Airport	1	2.00	0.50	High Risk
Atlantic Air Cargo	Ketchikan International Airport	3	10.00	0.30	Medium Risk
Fly One	Quatro de Fevereiro Airport	3	10.00	0.30	Medium Risk
Kam Air	Hamid Karzai International Airport	3	10.00	0.30	Medium Risk
Rossiya-Russian Airlines	Pulkovo Airport	3	10.00	0.30	Medium Risk
Zip	Djibouti-Ambouli Airport	3	10.00	0.30	Medium Risk
Royal Falcon	Queen Alia International Airport	4	14.00	0.29	Low Risk
Euro Exec Express	Juan Santamaria International Airport	9	34.00	0.26	Low Risk
Hong Kong Airlines	Hong Kong International Airport	25	98.00	0.26	Low Risk
40-Mile Air	Healy River Airport	1	4.00	0.25	Low Risk
ABSA - Aerolinhas Brasileiras	Oslo Lufthavn	3	12.00	0.25	Low Risk

Key Insights
Many airlines appear diversified by routes but remain structurally fragile — relying on either a single operational hub or a single aircraft family creates hidden systemic failure risk.



Fleet Concentration Risk (Aircraft Dependency)

airline_name	primary_aircraft_family	primary_family_routes	airline_total_routes	top1_fleet_dependency_ratio	risk_level
Eurowings	CRJ Family	1	1.00	100%	High Risk
Hankook Airline	CRJ Family	6	6.00	100%	High Risk
Northern Dene Airways	CRJ Family	16	16.00	100%	High Risk
Severstal Air Company	CRJ Family	18	18.00	100%	High Risk
Ibex Airlines	CRJ Family	32	32.00	100%	High Risk
Airlines Of Tasmania	CRJ Family	34	34.00	100%	High Risk
Aerocondor	CRJ Family	40	40.00	100%	High Risk
Huaxia	CRJ Family	90	90.00	100%	High Risk
Askari Aviation	De Havilland Dash	2	2.00	100%	High Risk

Business Impact: **Fleet Concentration Risk**

What the analysis shows

- Fleet standardisation is widespread
- Many airlines rely almost entirely on one aircraft family
- Grounding events can instantly disable operations

Business Implication

- Efficiency gains increase technical single-point-of-failure risk
- Fleet decisions have systemic consequences

Airline Operational & Fleet Single-Point-of-Failure Risk

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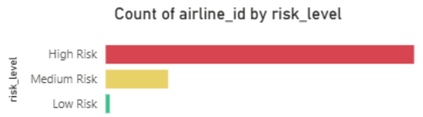

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Strategic Implications

For Airlines

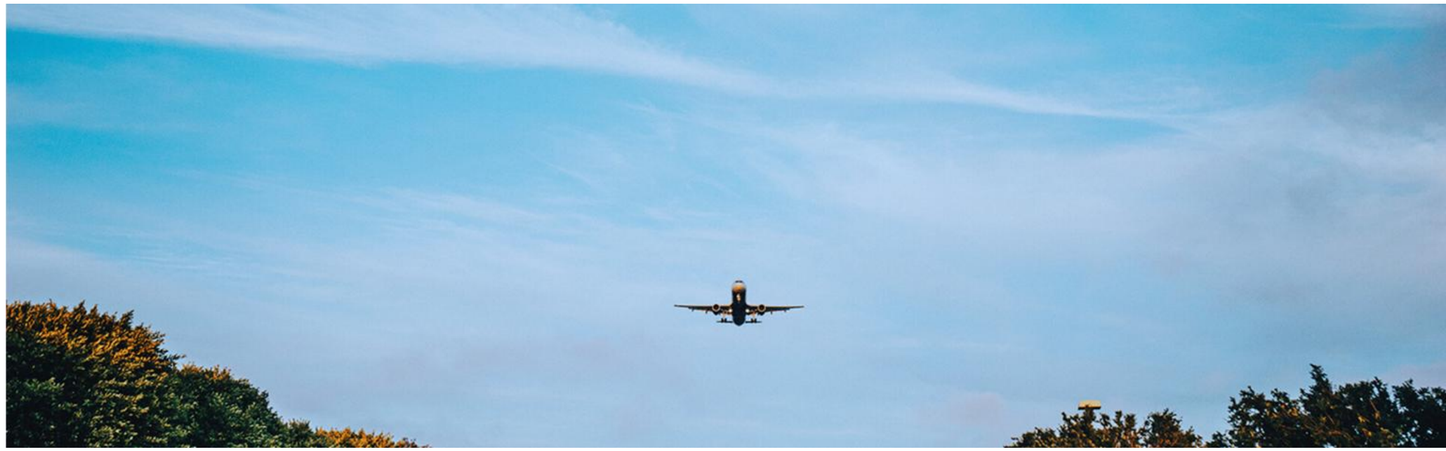
- Balance efficiency with resilience
- Stress-test hub and fleet strategies

For Regulators

- Identify systemic choke points
- Prioritise redundancy investments

For Investors

- Hidden concentration risk affects downside exposure



Key Takeaways

- Structural fragility exists even in mature systems
- Concentration, not scale, drives risk
- Single-point-of-failure risk is widespread
- Resilience requires deliberate design choices

Value of This Analysis

This case study demonstrates:

Network-level risk thinking

Translation of raw data into strategic insight

Explainable analytics suitable for executive decisions

A proactive approach to systemic risk

EFFICIENCY BUILDS SCALE
RESILIENCE REQUIRES FORESIGHT

This analysis surfaces where the global air transport system is most vulnerable — ***before the next disruption exposes it***