

ATM's Role in Improving Environmental Performance

Dr. Tom G. Reynolds



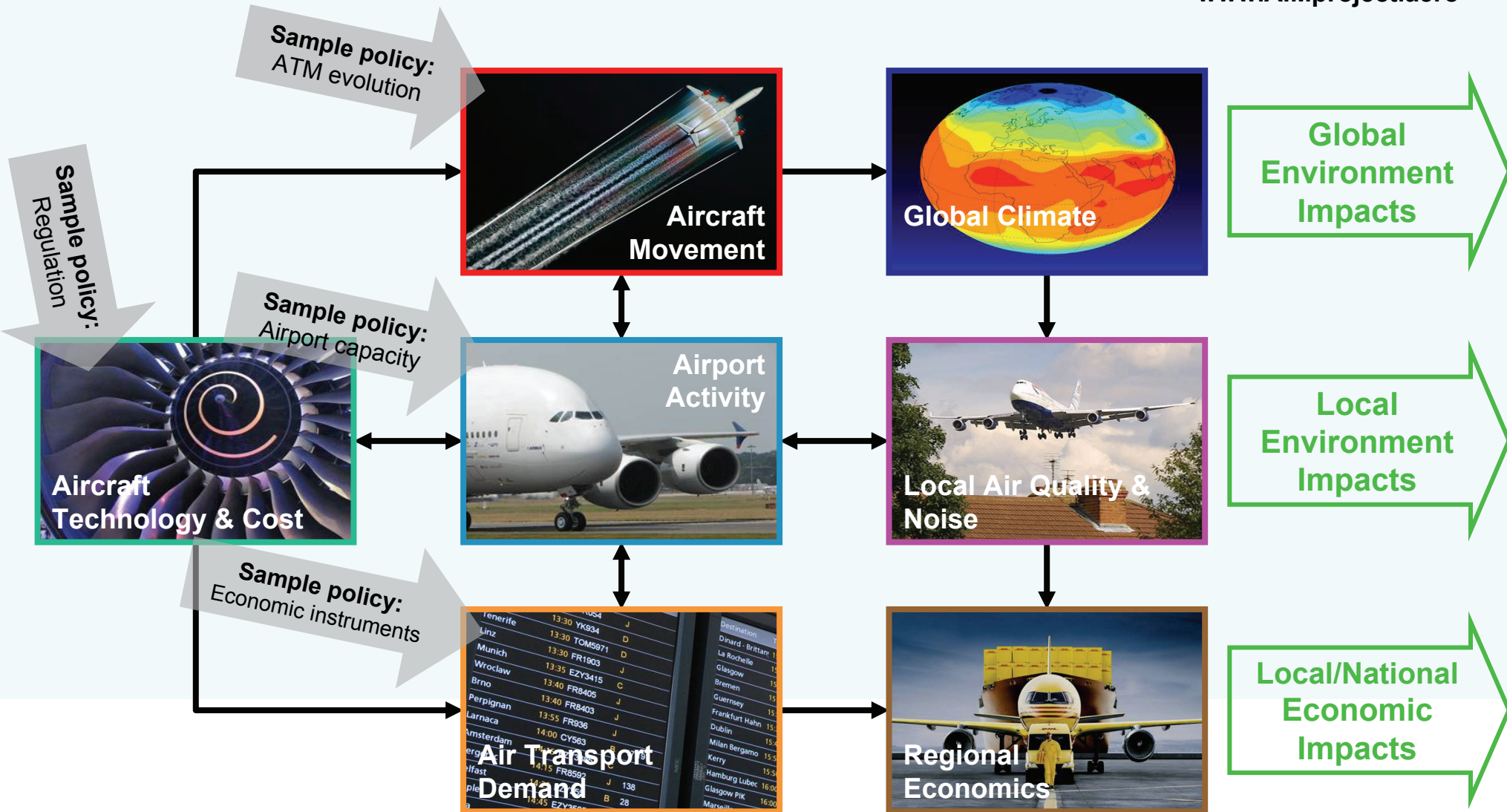
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Aviation in a Sustainable World

System-Wide Analysis

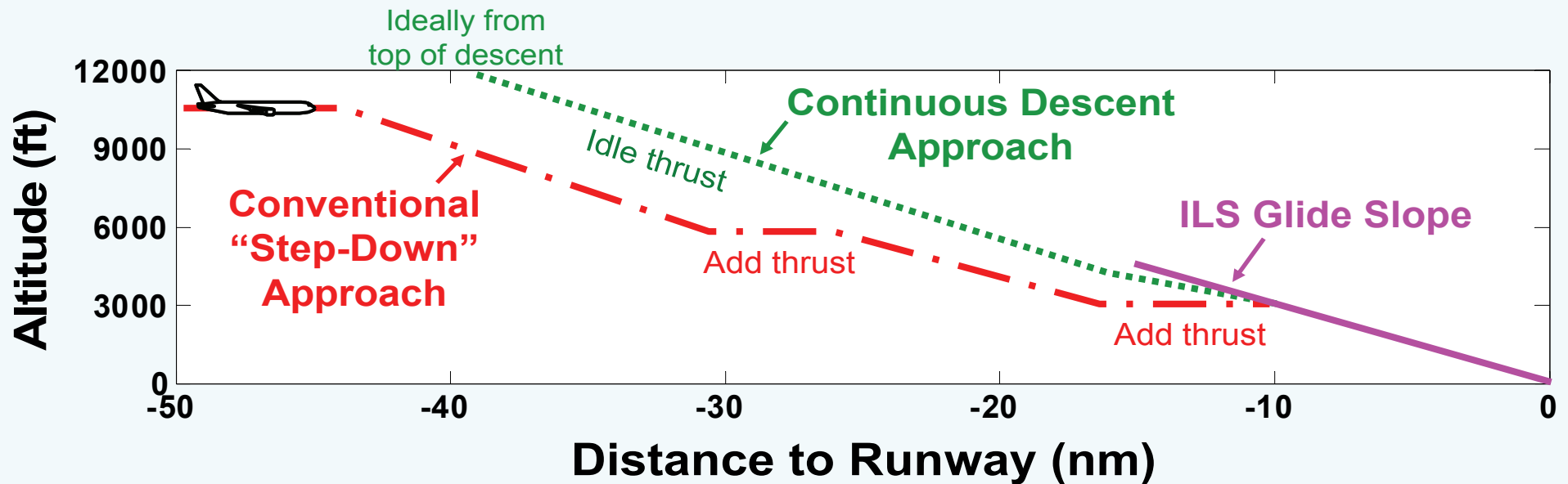


Environmental Mitigation Strategies

	Mitigation Strategy	Environmental Impact			Relative Economic Cost or Benefit	Time-frame	Impact
		Noise	Air Quality	Global Climate			
Technology	Source shielding	+	Neutral	-	\$ cost	Short	Existing a/c
	Retrofits e.g. winglets, shields	Neutral	Neutral	++	\$ setup cost \$\$ fuel benefit	Short	Existing a/c
	Alternative fuels	Neutral	+	++	\$\$ cost	Med	Existing a/c?
	All-new designs	++	++	++	\$\$\$ setup cost \$\$ fuel benefit	Long	New fleet
Operations	CDA	+	+	Neutral	\$ fuel benefit	Short	Airport
	De-rated thrust	+	+/-	Neutral	\$ benefit	Short	Aircraft
	Steep approach	+	+	Neutral	\$ cost	Med	Airport
	ATM efficiency	+	+	+	\$\$ setup cost \$ fuel benefit	Med	System

Continuous Descent Approaches

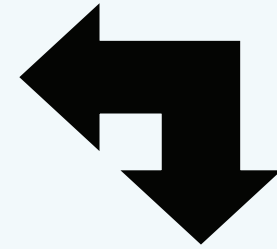
- Keep aircraft high, at low thrust and clean configuration for as long as possible: saves noise, fuel and emissions



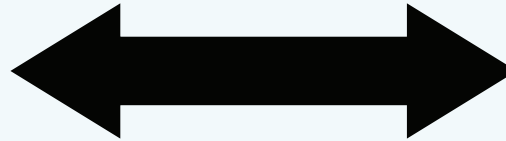
CDA Required System Trade-Offs



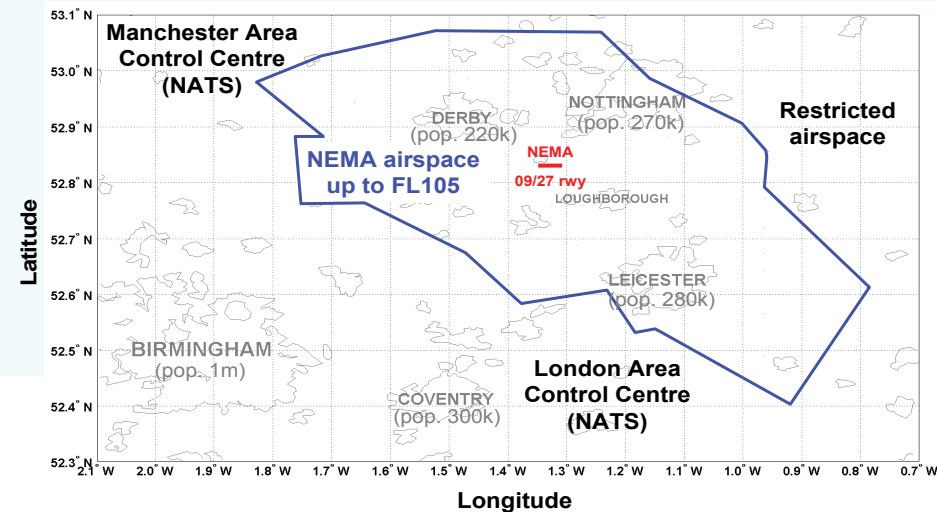
Environmental benefits



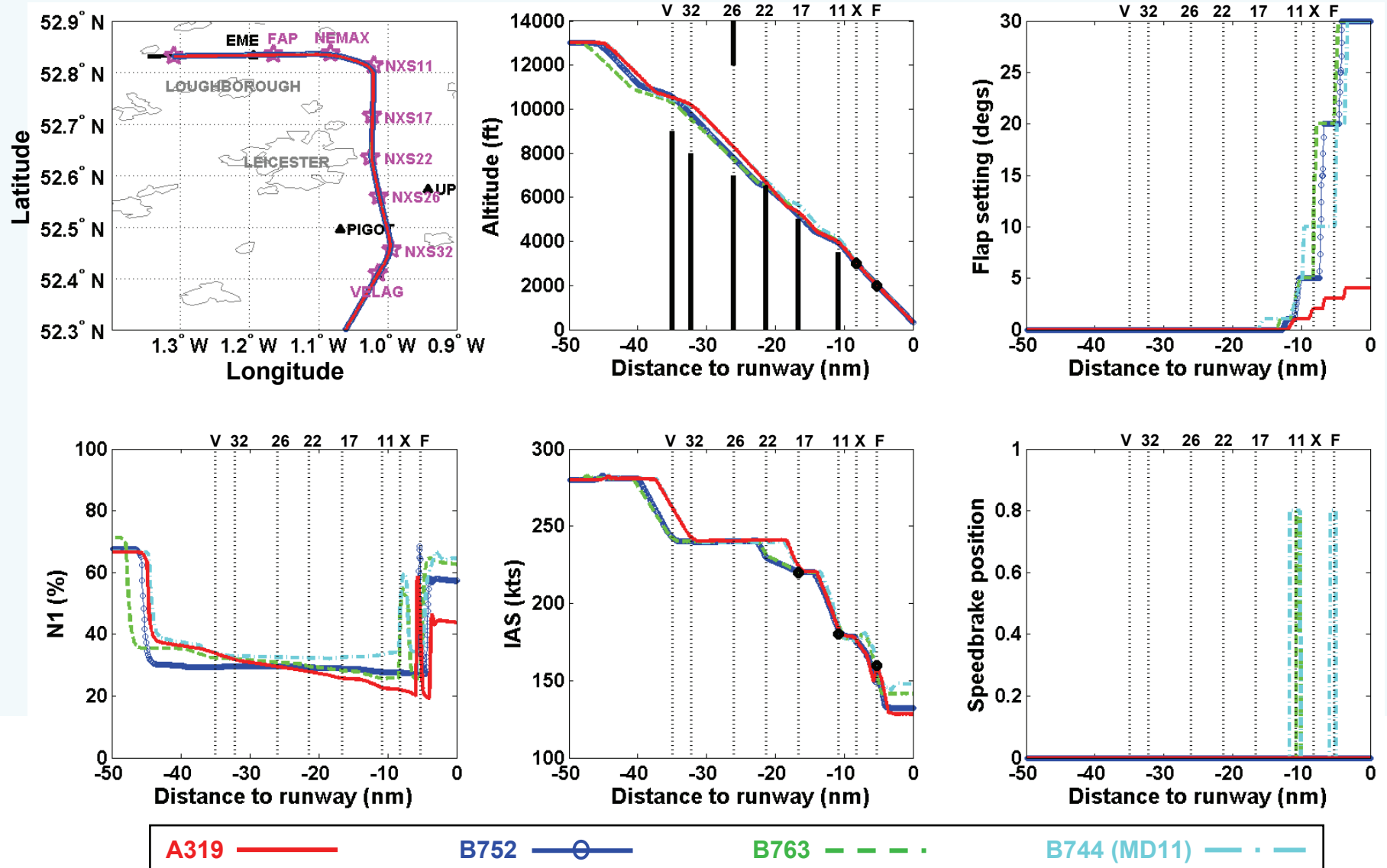
Aircraft-compatible



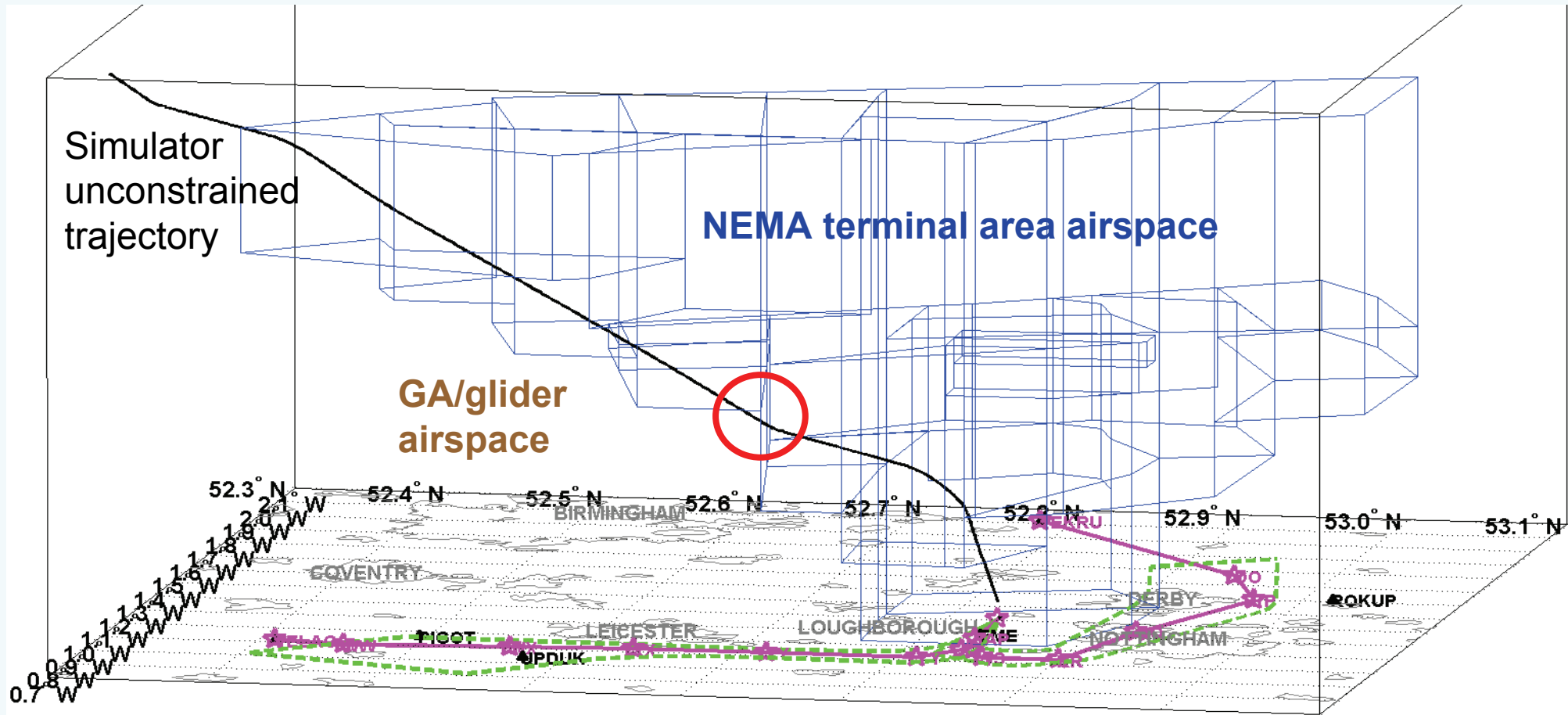
Airspace-compatible



Aircraft-Compatibility



Airspace-Compatibility



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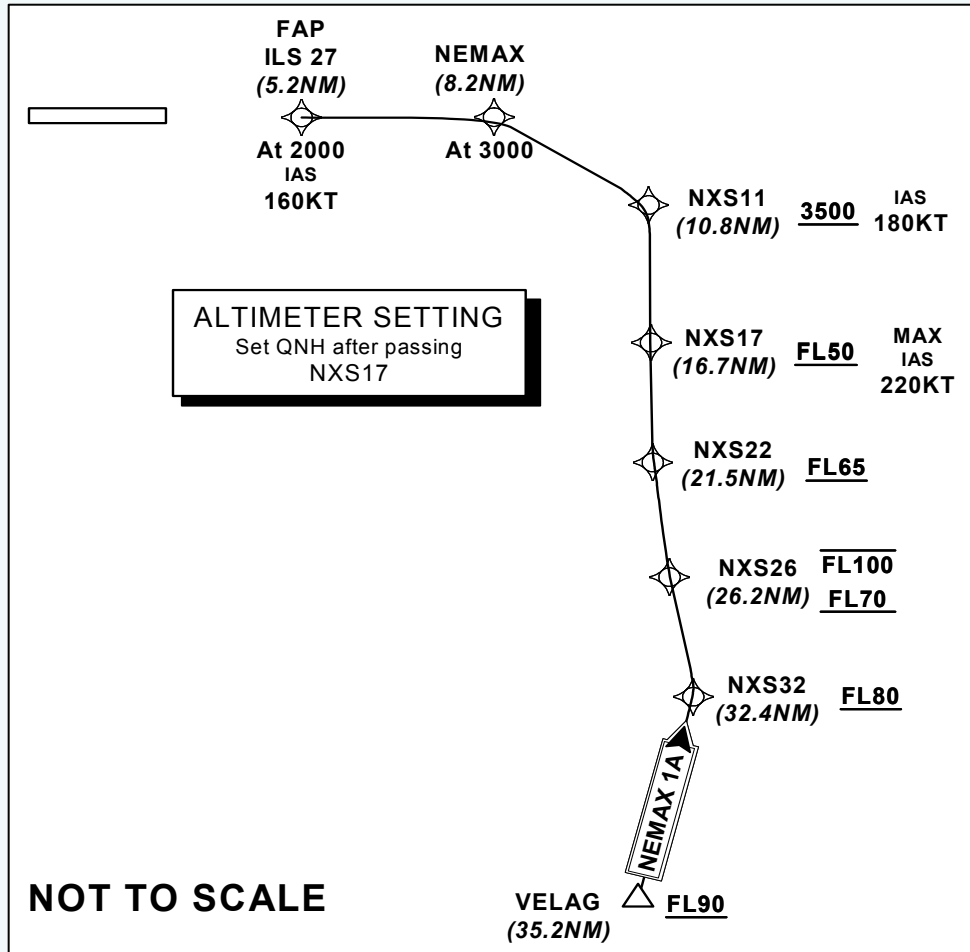
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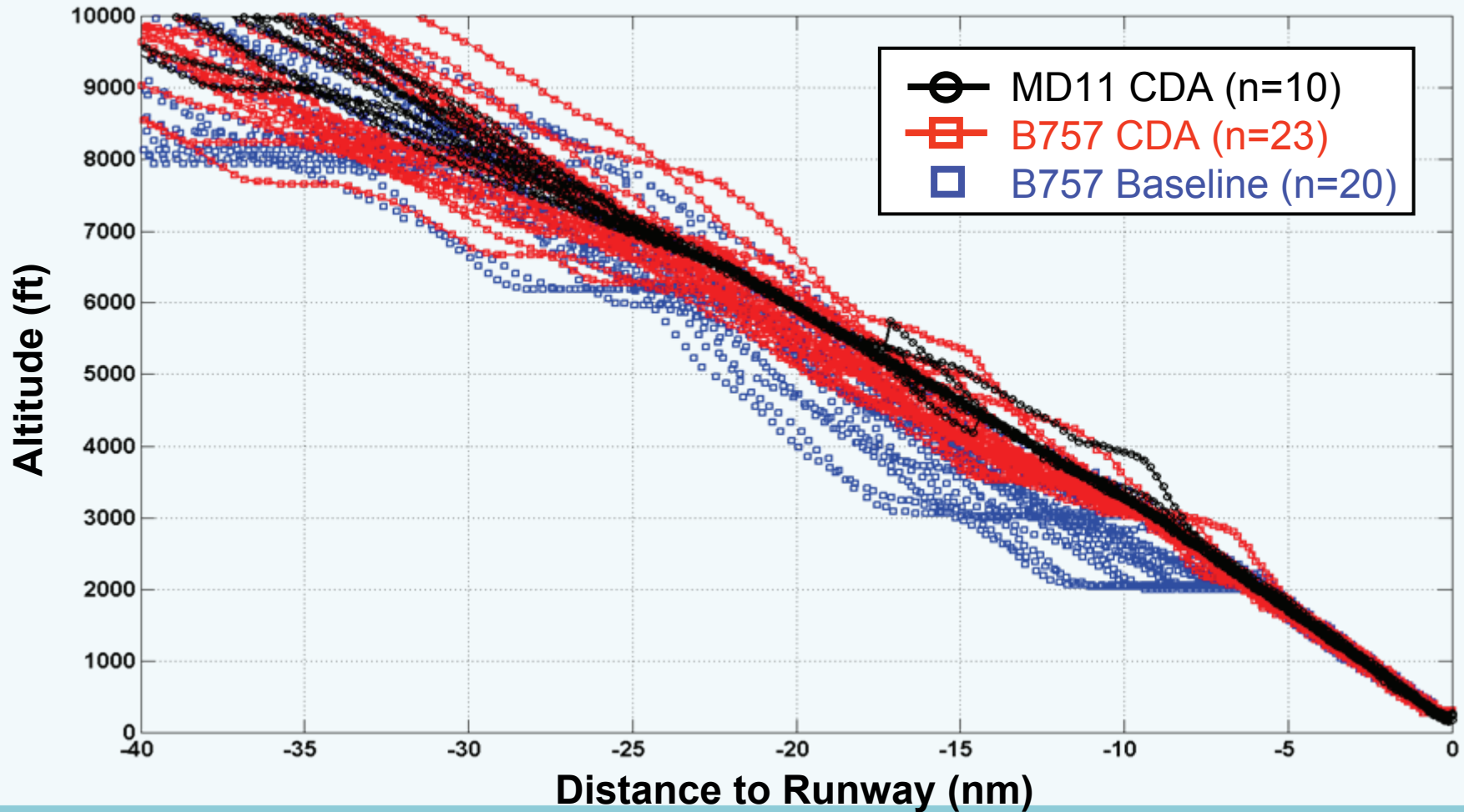
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Factors in CDA Design



- Lateral profile for:
 - ❑ Low population exposure
 - ❑ Approach zone compliance
 - ❑ Controlled airspace compliance
- Vertical constraints for:
 - ❑ CDA profile
 - ❑ Airspace compliance
- Speed constraints for:
 - ❑ Low Power/Low Drag

Sample Vertical Profiles



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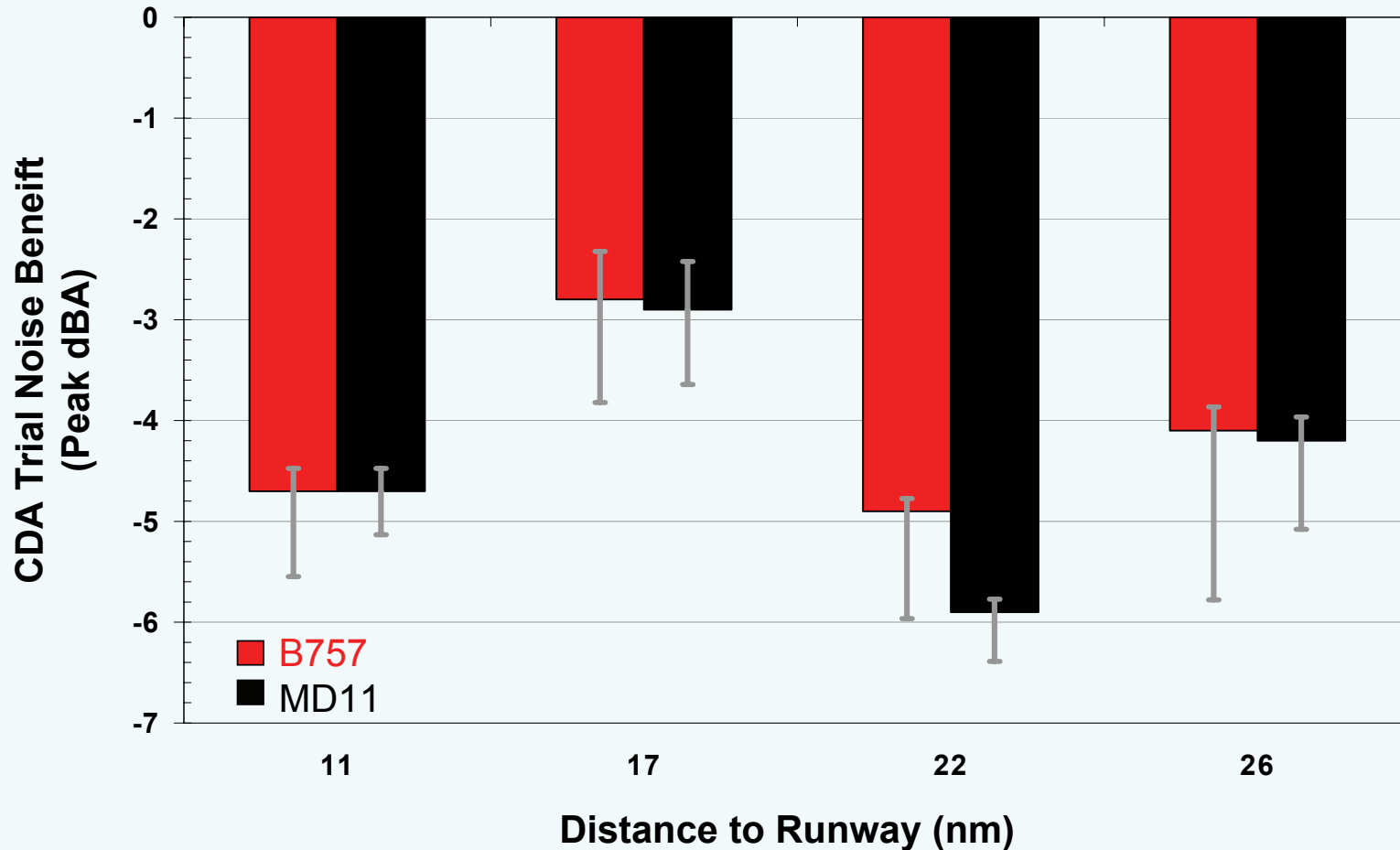
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CDA Sample Noise Reductions



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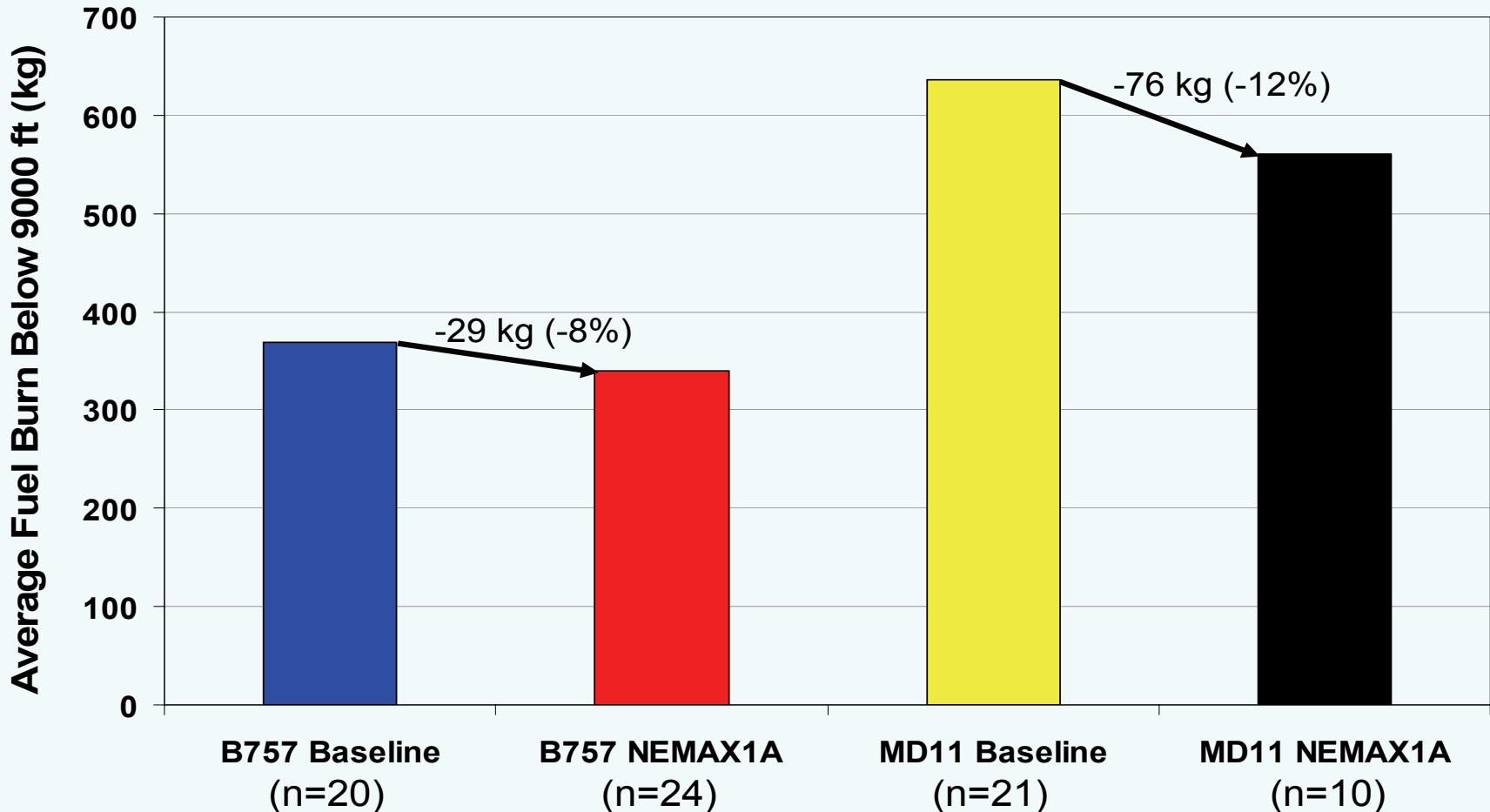
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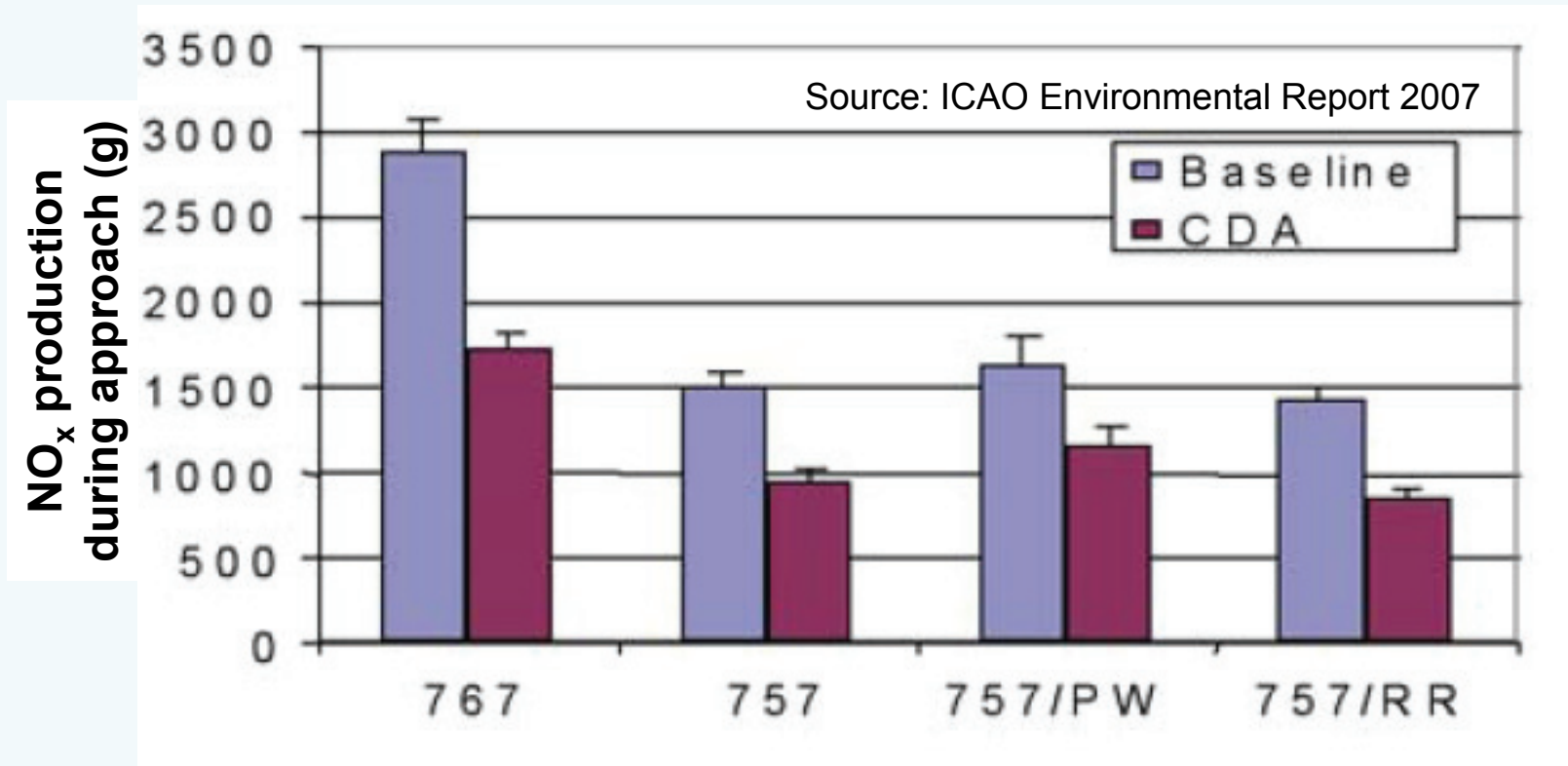
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CDA Sample Fuel Burn Reductions



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CDA Sample NO_x Reductions



ATM Consequences

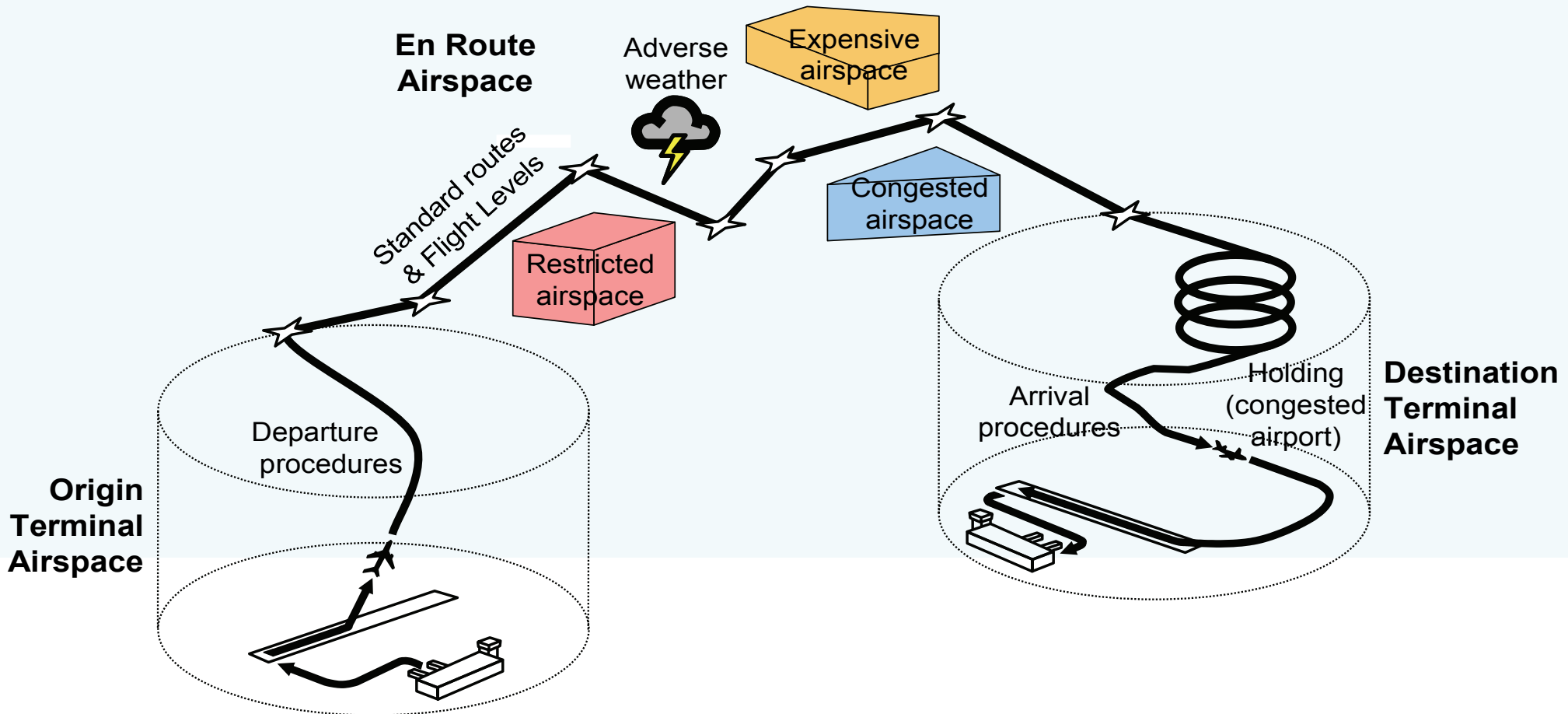
- Removes periods of predictable altitude and speed
- Aircraft behaviour depends on type, weight, winds, etc.
- Reduction in control authority (if CDAs flown on FMS)
- Added controller uncertainty + reduced control authority = larger separations and lower runway capacity
- SOLUTION: 4D control automation (ground and air, e.g. SAS “Green Approaches”)

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Flight Efficiency Studies

- Use flight (in)efficiency to identify scope for improvement from current and future ATM systems



Inefficiency Metrics

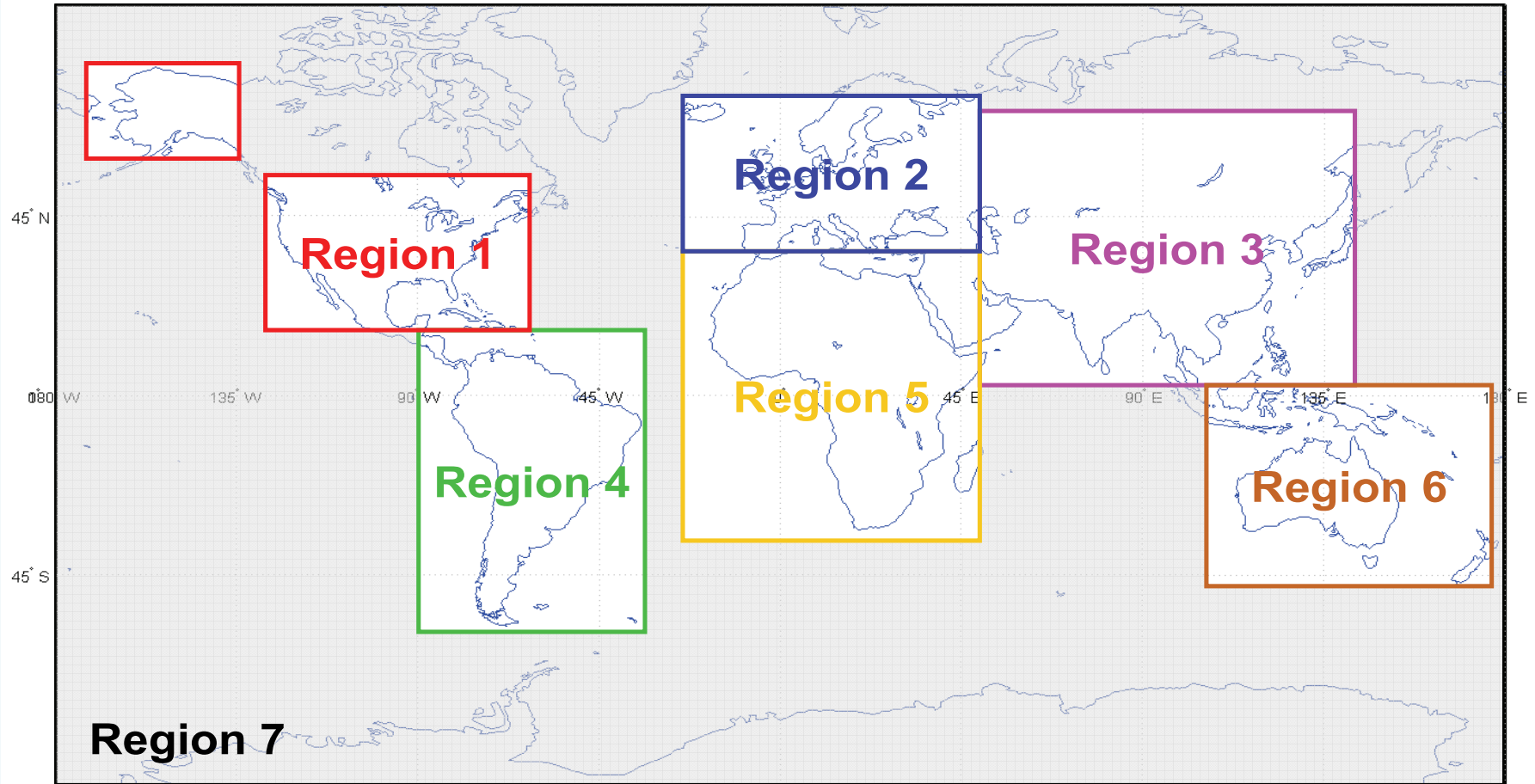
$$\text{Inefficiency Metric (\%)} = \frac{\text{Actual} - \text{Optimal}}{\text{Optimal}} \times 100\%$$

Sample Inefficiency Metric	“Actual” Parameter	“Optimal” Parameter
Lateral inefficiency 1	Actual total flight distance	Great circle total distance
Lateral inefficiency 2	Actual en route flight distance	Wind-optimised shortest distance
Vertical inefficiency 1	Actual time at/above threshold altitude	Optimal time at/above threshold altitude
Time inefficiency 1	Actual block time	Optimal block time
Fuel inefficiency 1	Actual fuel use	Optimal fuel use

Global Inefficiency Analysis Methodology

1. Characterise inefficiencies in current **global** ATM system via literature search and flight data analysis
2. Assess environmental impacts of current inefficiencies
3. Undertake critical review of future inefficiencies with ATM evolution
4. Determine environmental impact of ATM evolution

Global Flight Data Analysis



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Global Flight Data Analysis

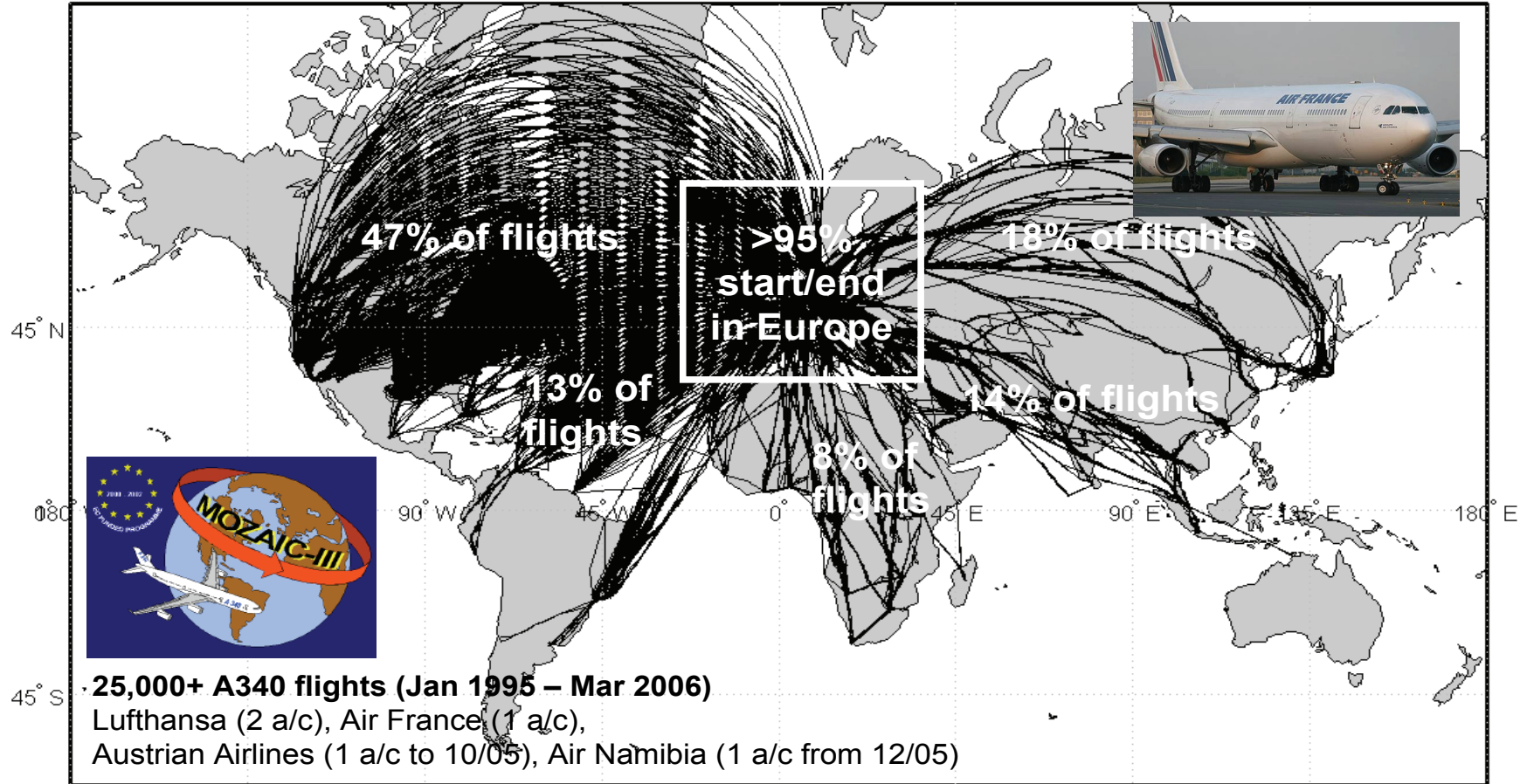
Dest Origin	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Region 1	NAm domestic	NAm + Ocean+ Eur	NAm + Ocean + Asia	NAm + SAM	NAm + Ocean + Afr	NAm + Ocean + Aus
Region 2	"	Eur domestic	Eur + Asia	Eur + Ocean + SAM	Eur + Afr	Eur + Asia + Aus
Region 3	"	"	Asia domestic	Asia + Ocean + SAM	Asia + Ocean + Afr	Asia + Aus
Region 4	"	"	"	SAM domestic	SAM + Ocean + Afr	SAM + Ocean + Aus
Region 5	"	"	"	"	Afr domestic	Afr + Ocean + Aus
Region 6	"	"	"	"	"	Aus domestic

Key: ETMS MOZAIC Airline data

Full coverage

Partial coverage

Flight Data



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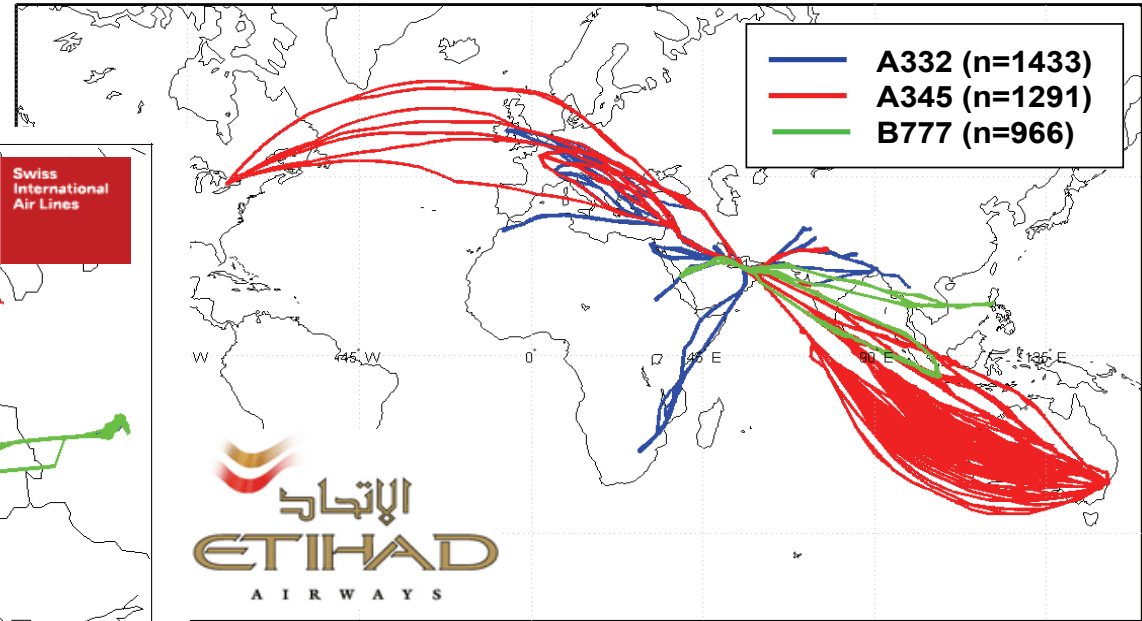
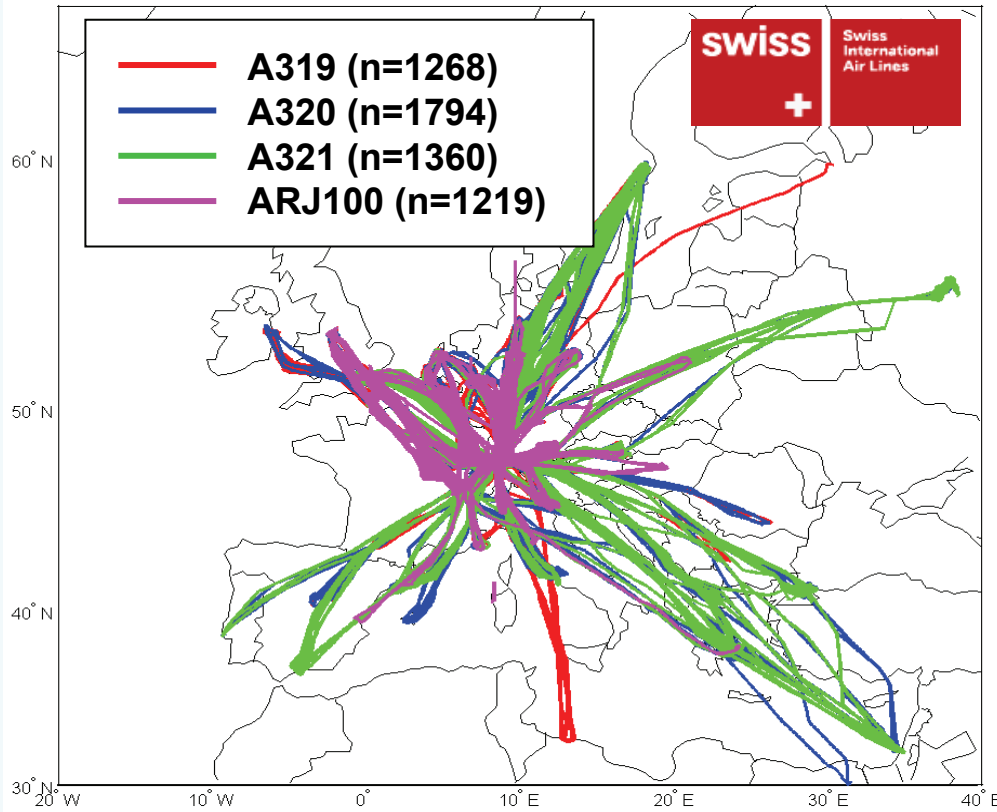
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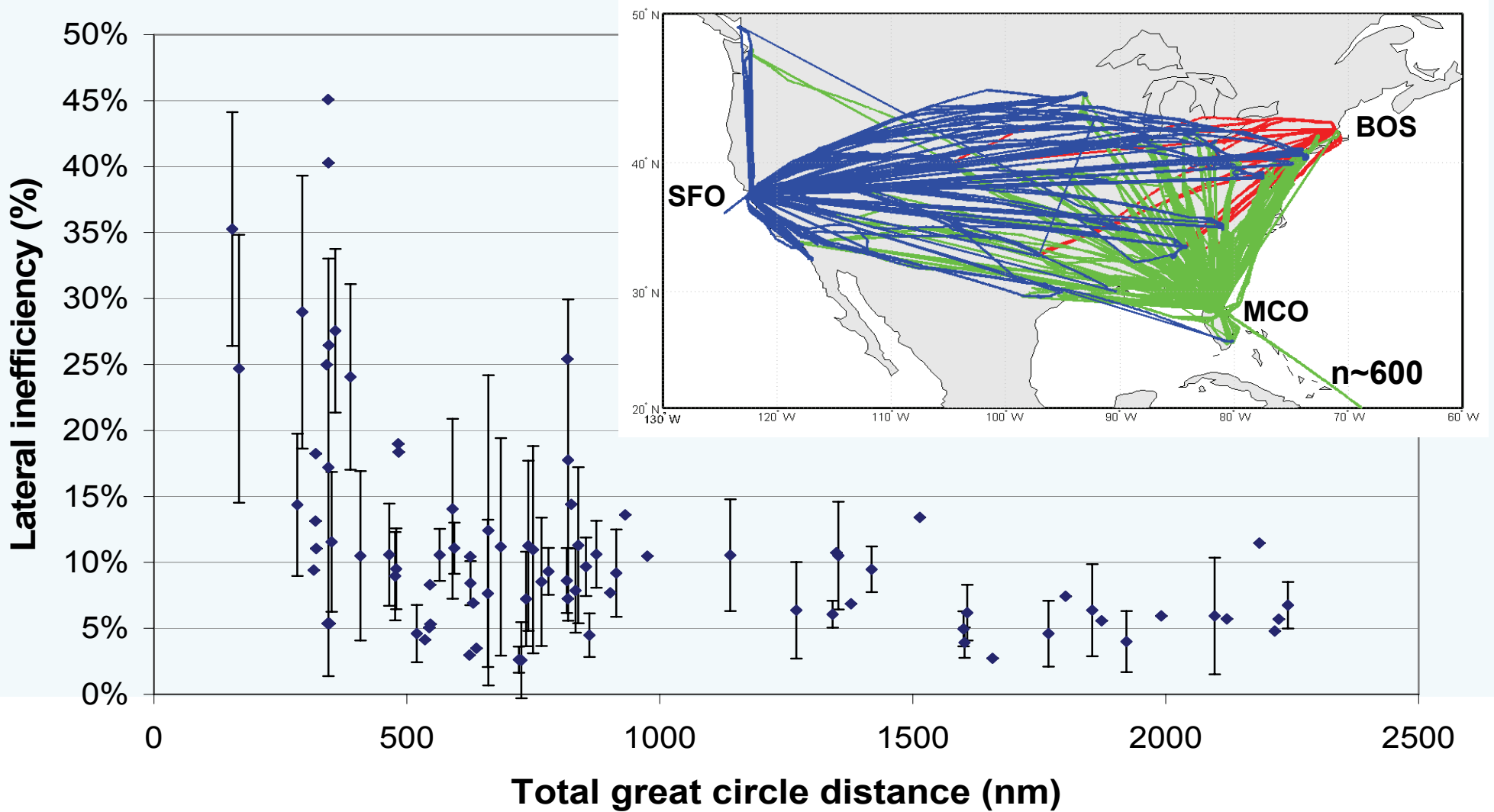
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Flight Data

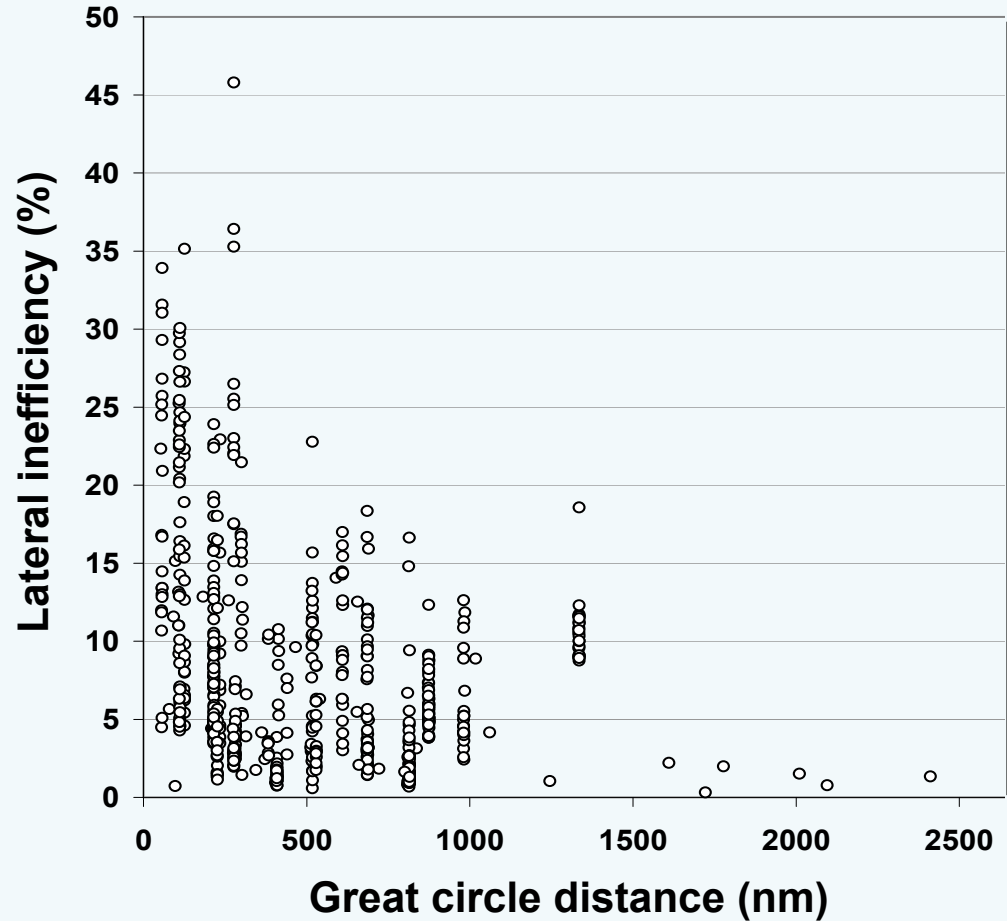


- Airline data: FDR data from >6000 flights

Sample US (ETMS) Results

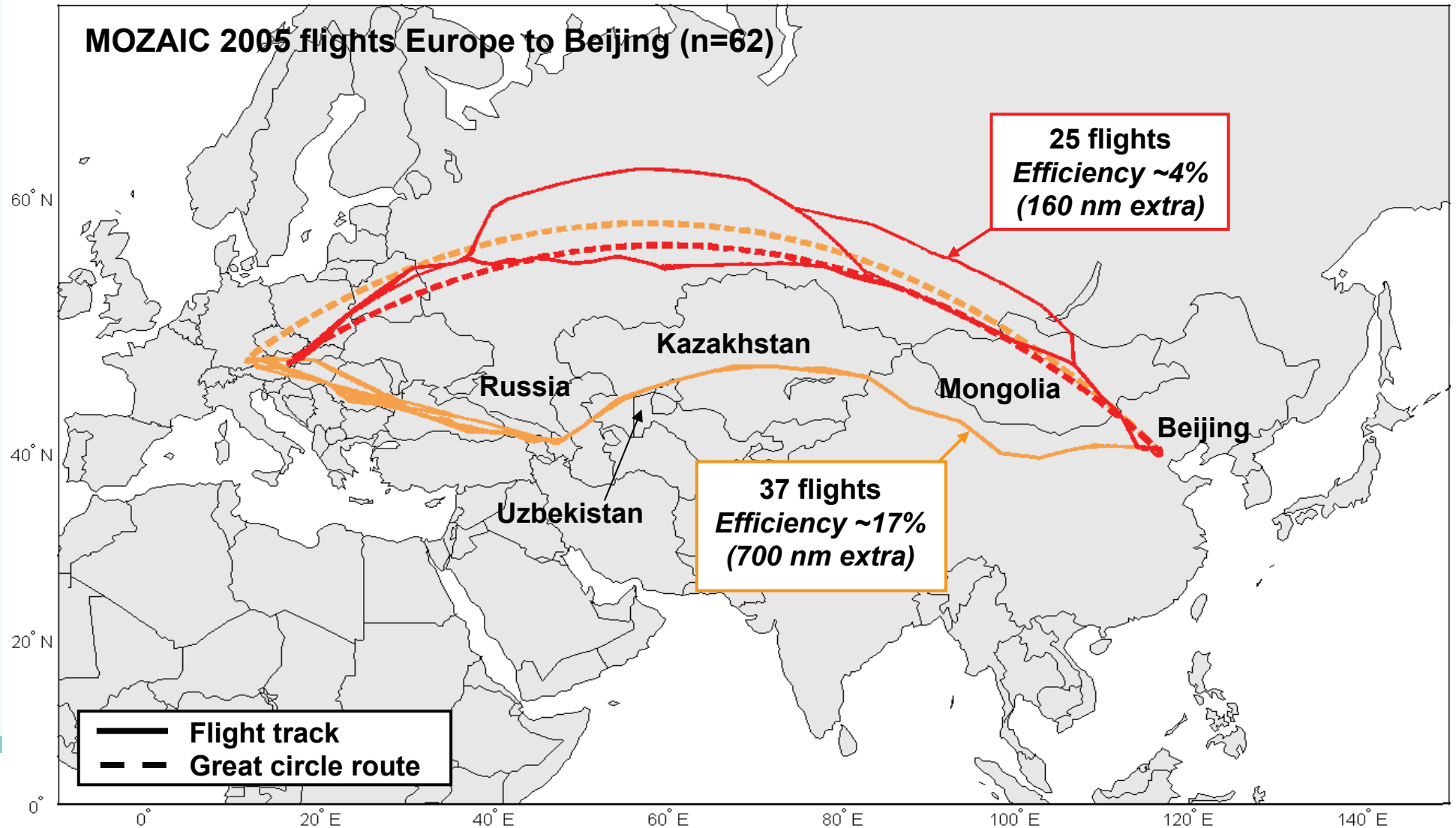


Sample Africa Results



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Sample Asia Results



Impacts of Differential Airspace Charging

BBC NEWS WATCH LIVE BBC News 24

Last Updated: Monday, 3 December 2007, 00:02 GMT

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Extra fuel burnt in air fee dodge

Airlines are deliberately flying longer routes over the Atlantic Ocean to avoid paying air traffic control charges, a BBC Investigation has discovered.



Thomas Cook and Monarch frequently burn extra aircraft fuel to avoid higher fees on flights to the Canary Islands.

Tango routes incur fewer aircraft control charges

The 100-mile (160km) diversion, known as the tango route, can produce an extra three tonnes of carbon dioxide.

Both airlines said they used the routes to avoid air traffic congestion and maintain schedules.

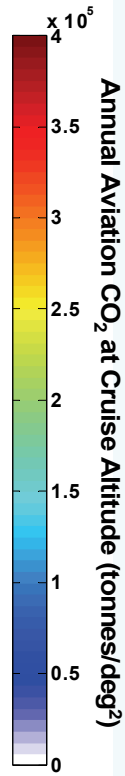
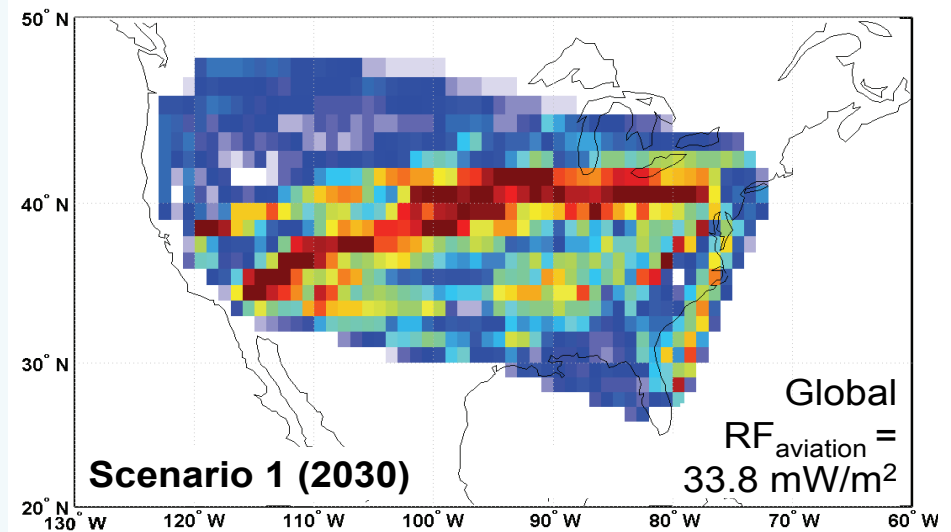
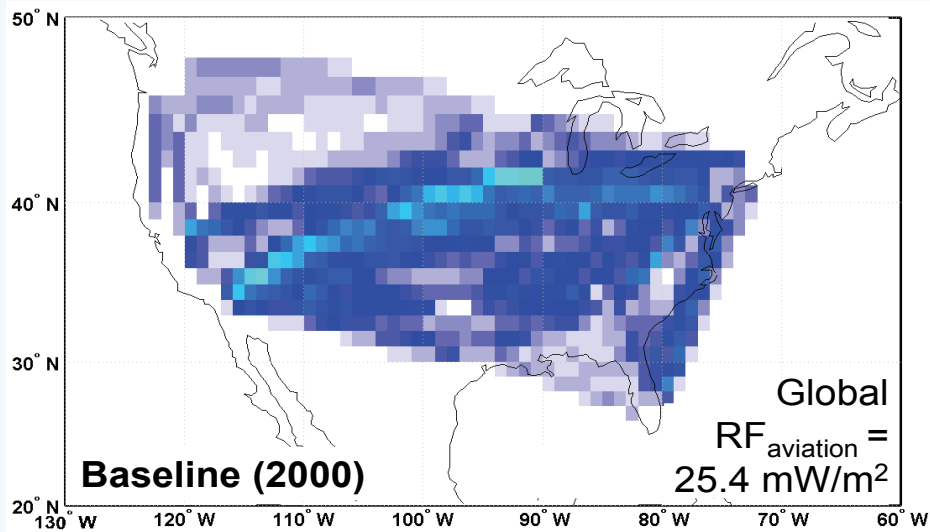
During a month-long investigation the BBC South East team monitored 44 Thomas Cook flights from Manchester, Newcastle and Birmingham flying to the Canary Islands and back.

The direct route, flying over French, Spanish and Portuguese airspace, incurs £1,578 in air traffic control charges.

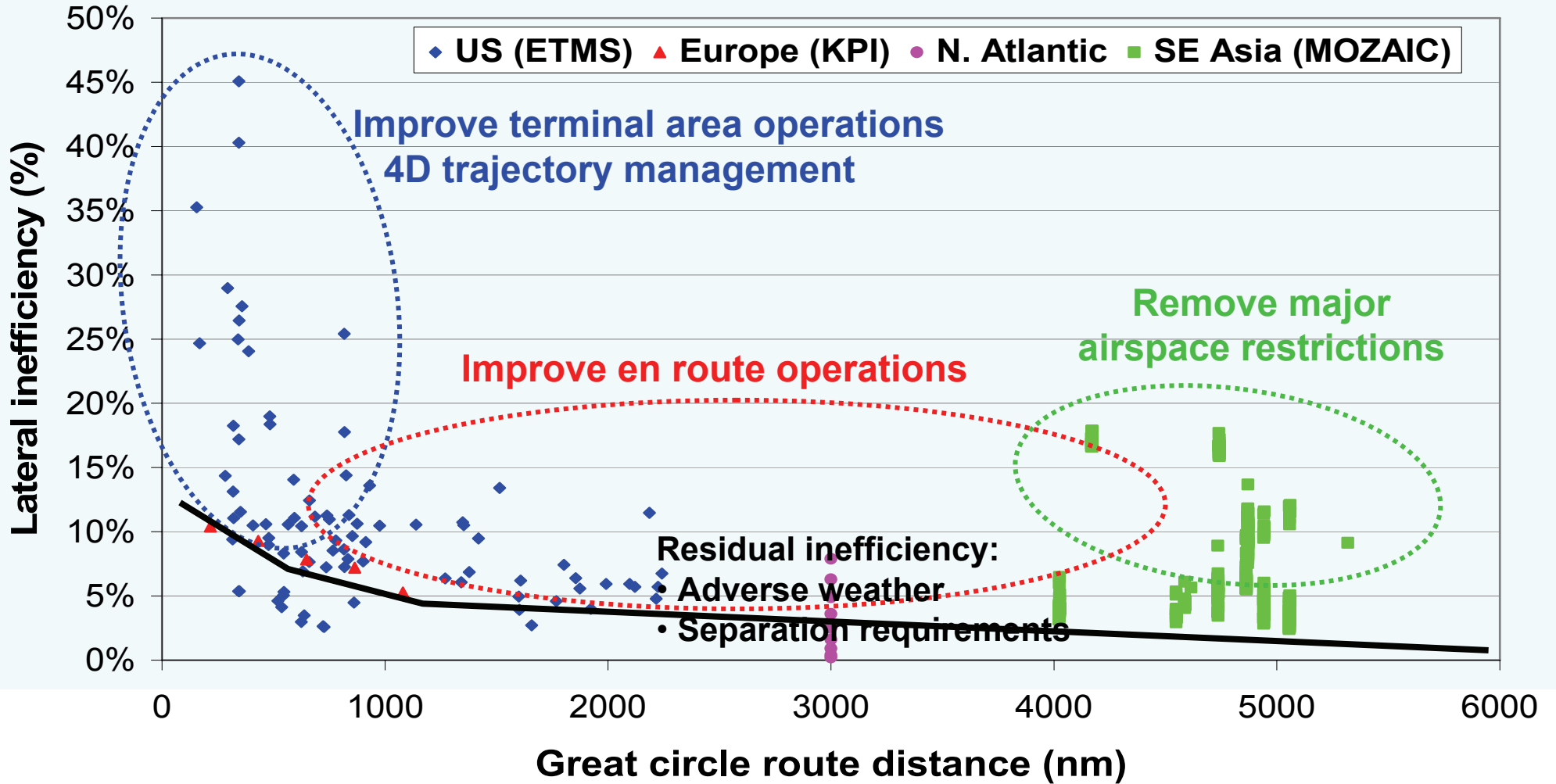
“ Ultimately the environmental impact comes down to whether the travelling public is prepared to pay ”

Environmental Assessment

- RF effects of different “inefficient” aircraft trajectories



Sample Aggregate Results



Omega ATM Studies



- **Climate Related ATM**

- ❑ Characterise inefficiencies in the current European ATM system via literature review and flight data analysis
- ❑ Assess environmental impacts of these inefficiencies in terms of global radiative forcing effects
- ❑ Undertake critical review of ATM system evolution plans into the future
- ❑ Determine environmental impacts of these evolution scenarios
- ❑ Communicate findings and “best practise” recommendations to stakeholders

Omega ATM Studies



- **Environmental effects of aircraft operations and airspace charging regimes**
 - What are the drivers of apparently inefficient flight plans?
 - What proportion of European routes are lengthened because of airspace charging regimes?
 - What is the additional distance travelled?
 - What are the associated environmental costs?