Environmental Challenges for Aviation

~ An Overview ~

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Outline

1. Importance of Trade-offs

2. Environmental Challenges and Mitigation Options
   - Noise
   - Air Quality
   - Global Climate

3. System-Wide Perspective
   - Accounting for Trade-Offs
   - Looking for “Win-Wins”

4. Summary

Importance of Trade-Offs

- Environmental challenges must be set into context of multiple system trade-offs, e.g. between areas…

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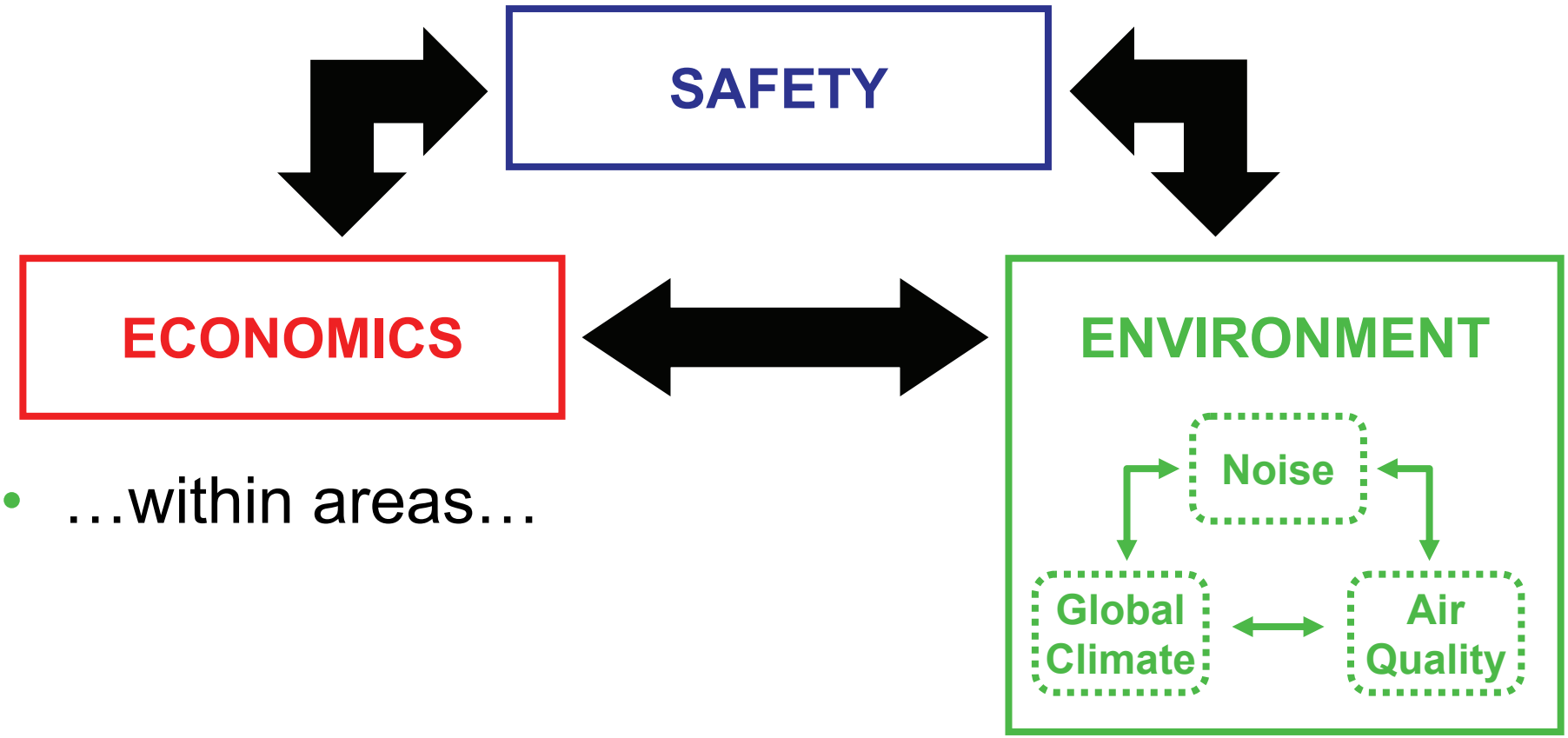


- …within areas…

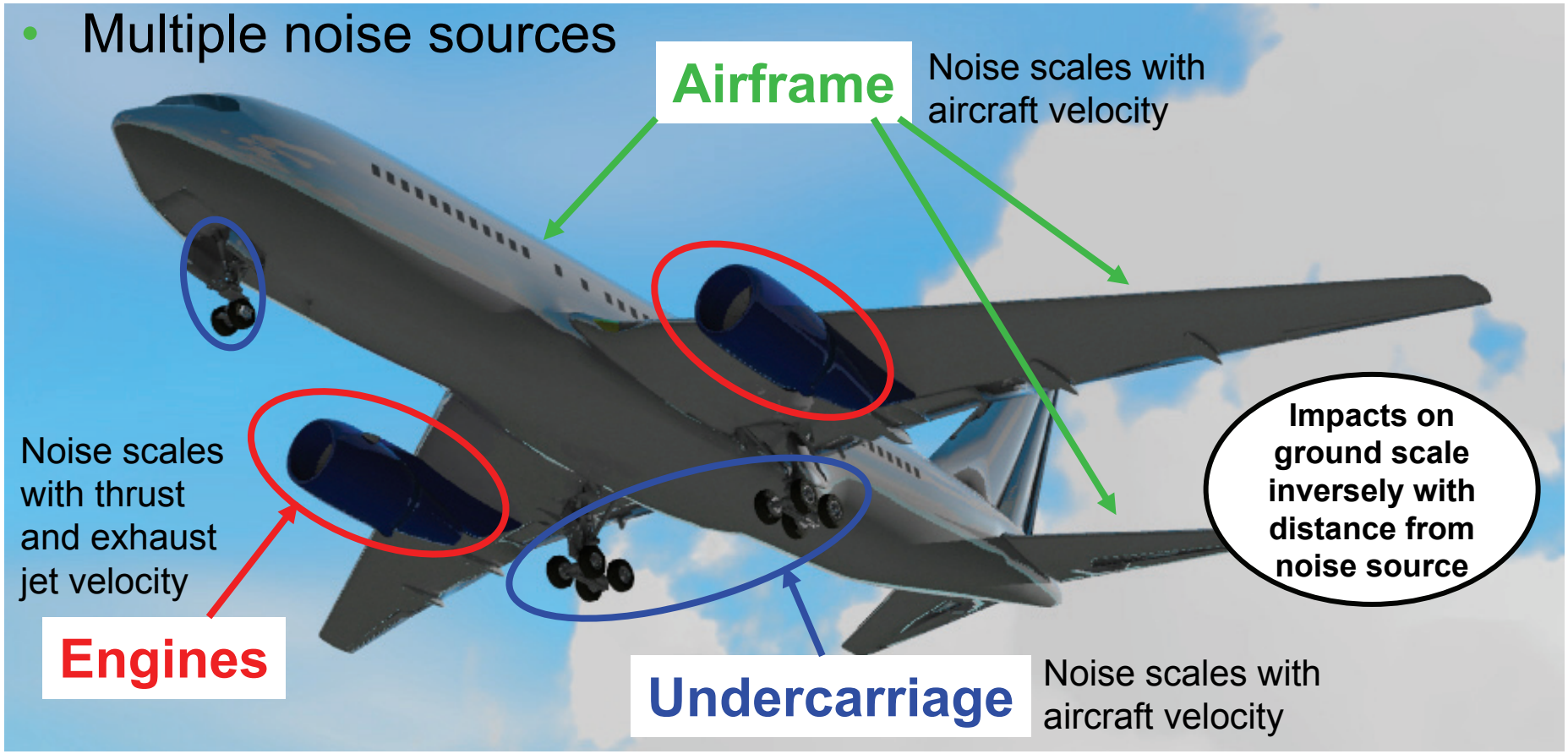
Importance of Trade-Offs

- Environmental challenges must be set into context of multiple system trade-offs, e.g. between areas…

- …within areas…
- …within specific issues

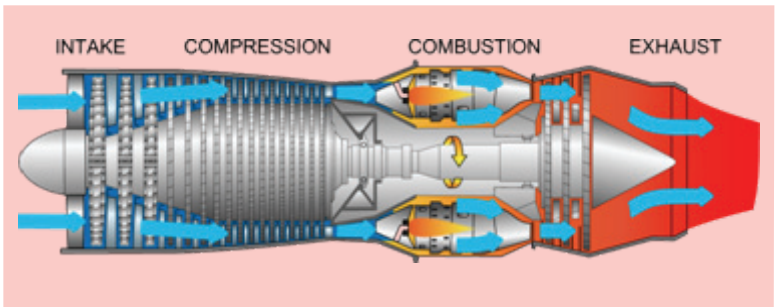
Environmental Challenges: Noise

- Historically main environment focus (obvious impacts)
- Impacts: quality of life, possible health effects
- Multiple noise sources

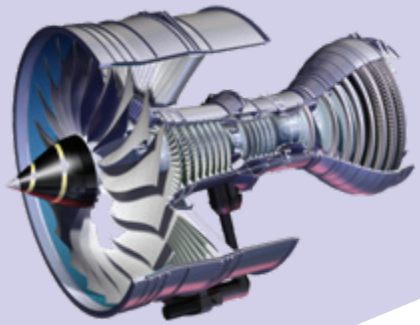


Noise Mitigation Options: Advanced Technologies

- Reduce and/or shield noise sources



Turbojets



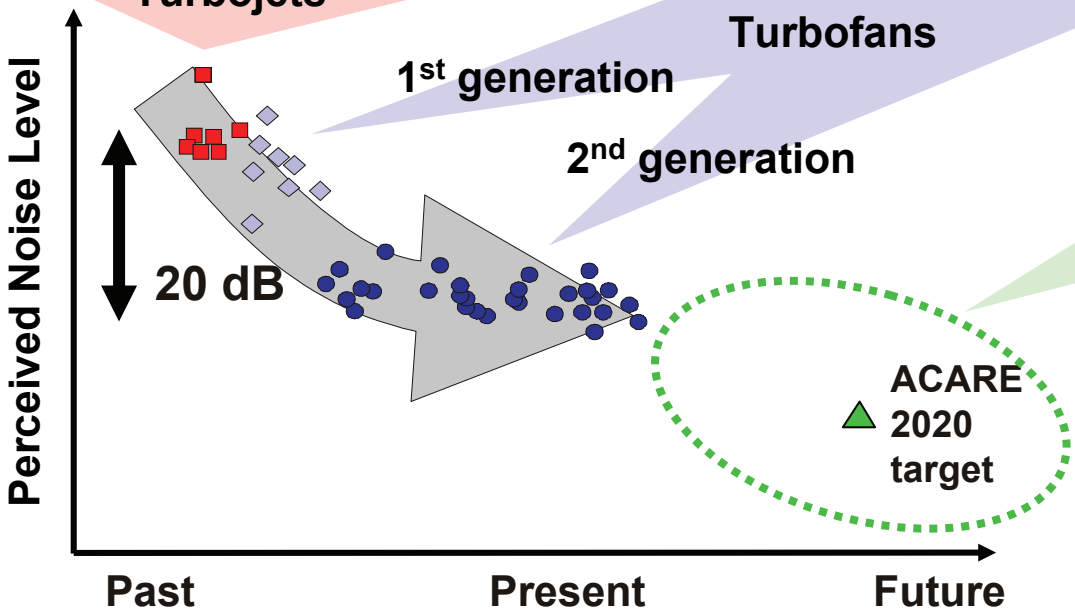
Turbofans

Shielded gear

Engine chevrons

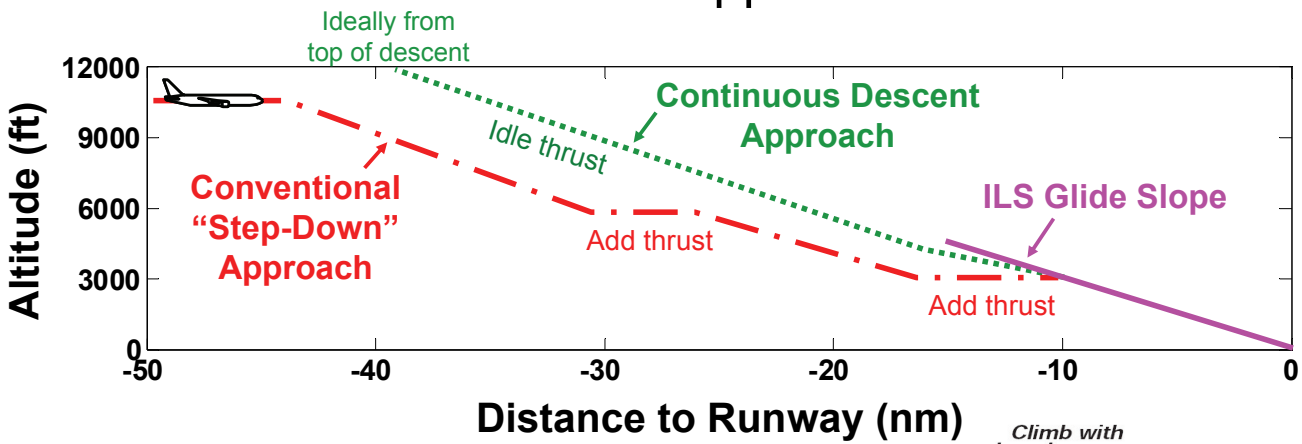
Ultra-high bypass ratio

Advanced airframe & engines



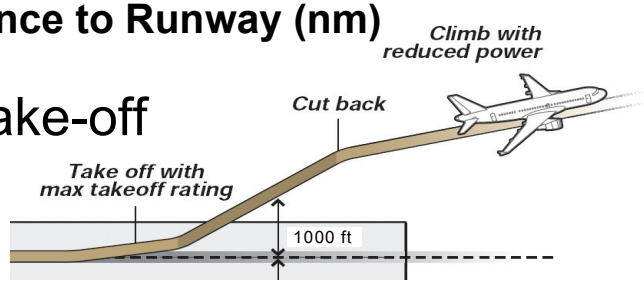
Noise Mitigation Options: Advanced Operations

- Keep aircraft high, low thrust and "clean" as long as possible
- Current options:
  - Continuous Descent Approach

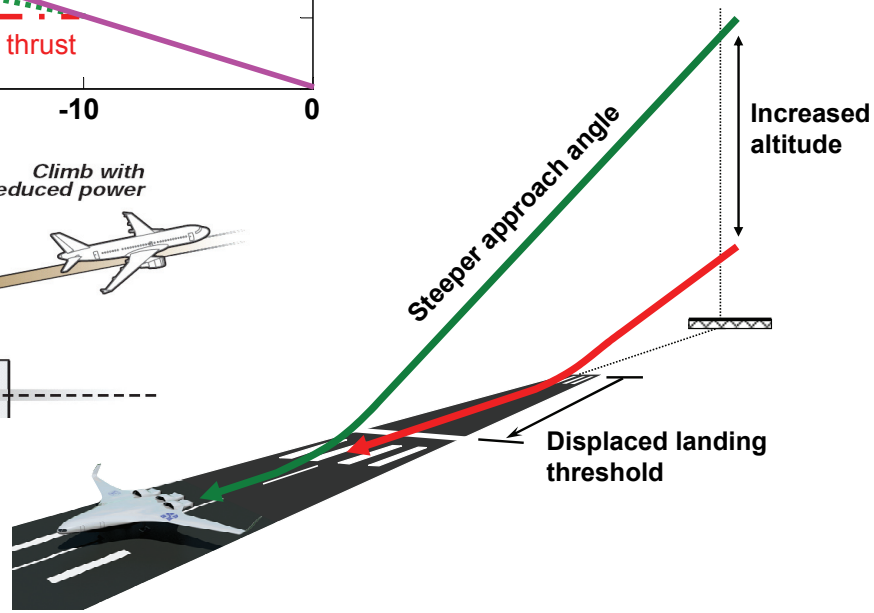


  - Low Power/Low Drag

  - De-rated thrust take-off



- Future options:
  - Steeper, displaced approaches



Environmental Challenges: Air Quality

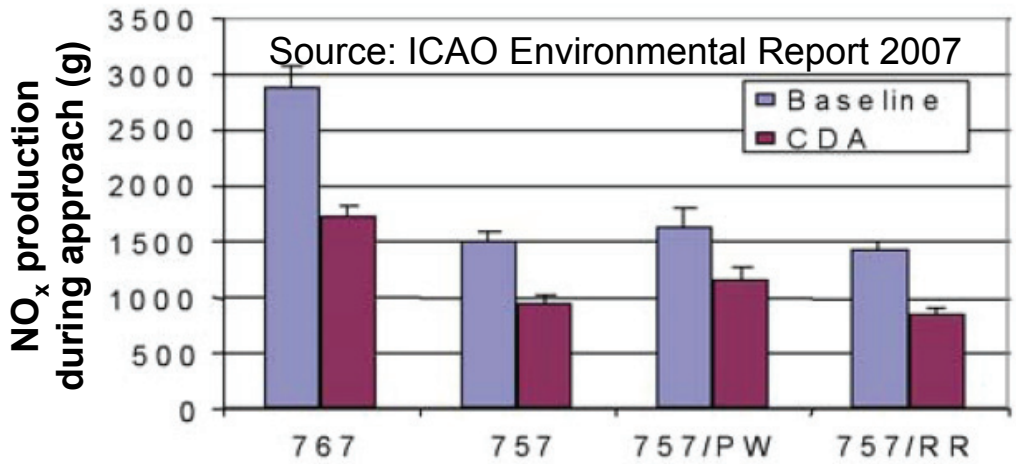
- Increasingly important (regulatory limits, awareness)

- Primary species of interest:
  - NO_x (Nitrogen Oxides: NO, NO_2)
  - O_3 (Ozone)
  - PM (Particulate Matter/Smoke)
  - UHC (Unburned Hydrocarbon)
  - CO (Carbon monoxide)
  - Sulphur species

- Impacts:
  - Premature mortality and morbidity, primarily from PM & O_3
  - Building and vegetation impacts, primarily from NO_x

Air Quality Mitigation Options

- Reduce fuel burn
  - Advanced technologies: engines & airframes
  - Advanced operations
    - Continuous Descent Approach
    - De-rated take-off and climb



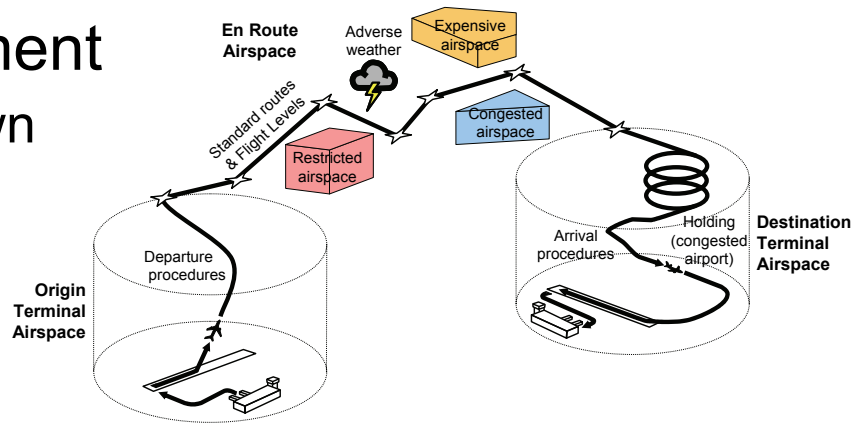
- Reduce amount of pollutants per kg fuel burnt
  - Change "emissions indices"
    - Engine technology, e.g. low NO_x combustors
    - Low sulphur fuels

Environmental Challenges: Global Climate

- Increasingly important (awareness: politics & media)
  - Aviation accounts for <5% anthropogenic CO_2 emissions
- Primary species of interest: Greenhouse Gases
  - CO_2 (Carbon Dioxide)
  - NO_x chemistry: O_3 production, CH_4 reduction
  - Contrails (uncertain impact: warming and cooling effects)
  - Sulphate/soot particles
- Lifetimes very different
  - CO_2: decades
  - Contrails: minutes
- Importance of metrics

Global Climate Mitigation Options

- Reduce fuel burn
  - Advanced technologies
    - Retrofits, e.g. winglets
    - New engines & airframes
  - Improved Air Traffic Management
    - Reduce extra track distance flown
    - More cruise altitudes (RVSM)
    - “4D” control to minimise holding
    - Avoidance of contrail regions?



- Reduce amount of pollutants per kg fuel burnt
  - Change “emissions indices”
    - Engine technology, e.g. low NO_x combustors
    - Alternative fuels

System-Wide Perspective

- Air transport system is large, complex and multi-disciplinary involving numerous stakeholders with different agendas

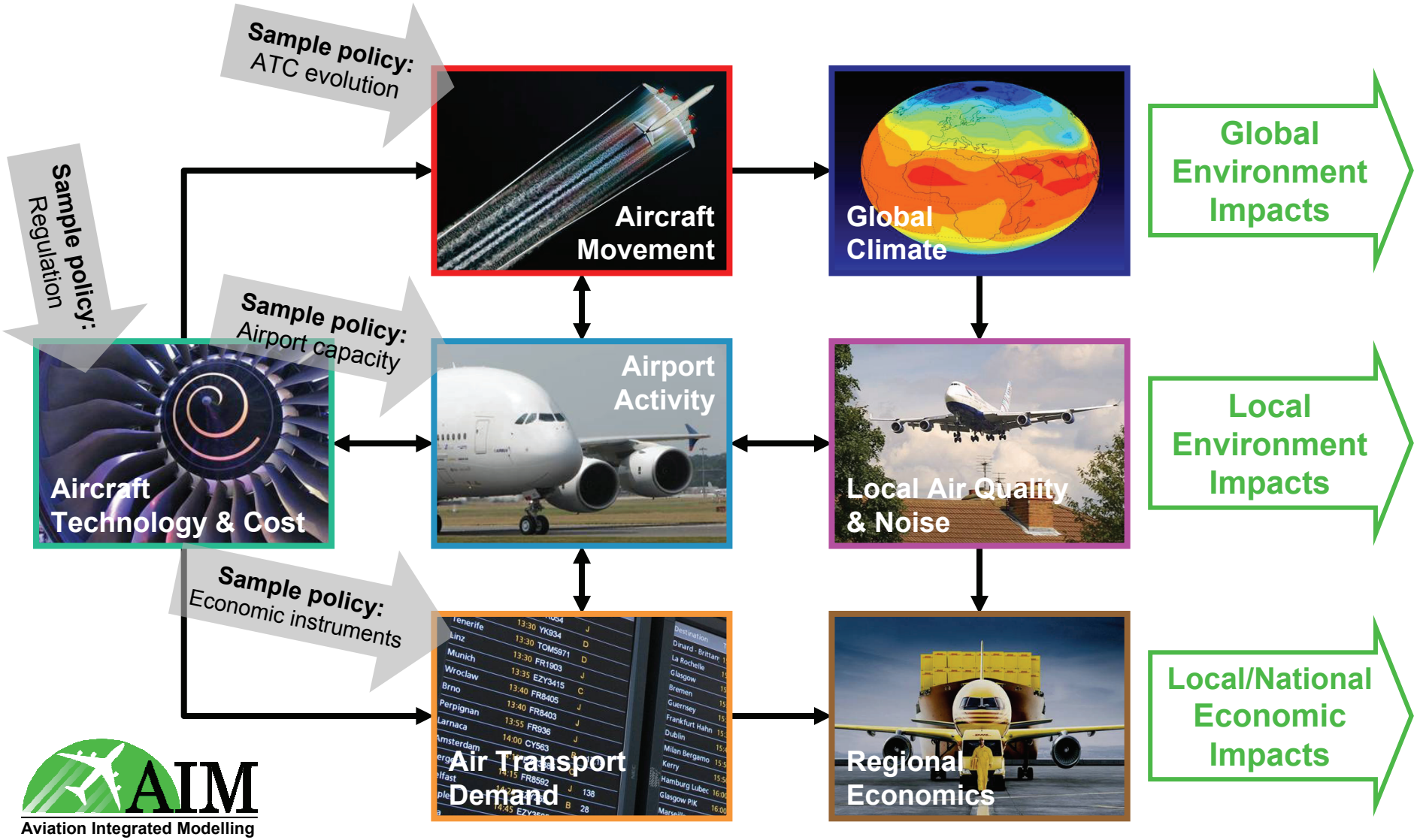
- Range of future trends
  - Developing regions (India, China,…)
  - Developing sectors (VLJ, SSBJ,…)
  - Developing technologies

- Increasing (and range of) environmental pressures

- Need for tools to analyse trade-offs & assist policymakers

AIM
Aviation Integrated Modelling
www.AIMproject.aero

AIM Trade-Off & Policy Assessment



Looking for "Win-Wins"

	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

Regulation/Market-Based Measures

	Noise	Air Quality	Global Climate
Regulation	• ICAO certifications standards • Local airport standards (e.g. quota counts)	• ICAO certifications standards • Local regional standards	• Future fuel burn standards?
Market-Based Measures	• Noise charges	• Emissions charges	• Emissions trading system? • Environmental levies?

Summary

- Environmental challenges becoming increasingly important for aviation
- Variety of technological and operational mitigation options
- Stricter regulation and market-based measures on the horizon
  - Good science needs to be incorporated
- Importance of system trade-offs cannot be underestimated