Air Transportation Systems Lab

UCL

Air Transportation and the Environment

Andreas W. Schäfer

(a.schafer@UCL.AC.UK)

Air Transportation Systems Laboratory, UCL Energy Institute,

University College London

66th LCA Discussion Forum

LCA of Mobility solutions: approaches and findings

Wednesday, 30 August 2017, ETH Zürich, Alumni Pavilion

www.ATSLab.org

Air Transportation Systems Lab

Home News Research Team Data & Tools Publications Events Contact

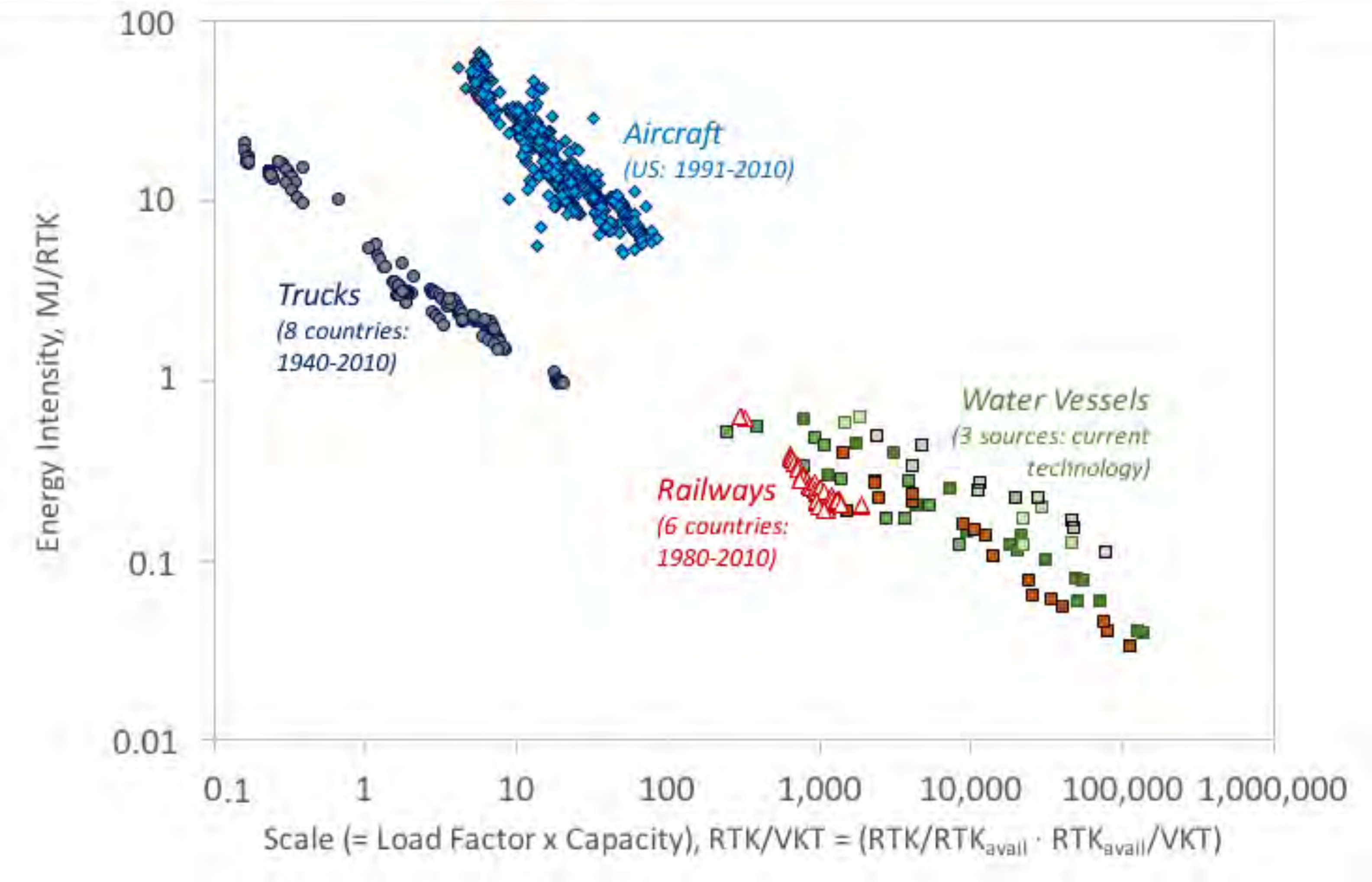
About Air Transportation Systems Lab

Air transportation is a vital enabler of growth in the economy and quality of life through empowering trade and tourism. At the same time, its large and still growing scale generates undesirable effects, such as air traffic delays and environmental impacts at the local, regional, and global level. Emerging from the Institute for Aviation and the Environment at the University of Cambridge, the Air Transportation Systems Laboratory at University College London (UCL) explores the interaction between air transportation, the economy, and the environment.

What Makes Air Transportation Different?

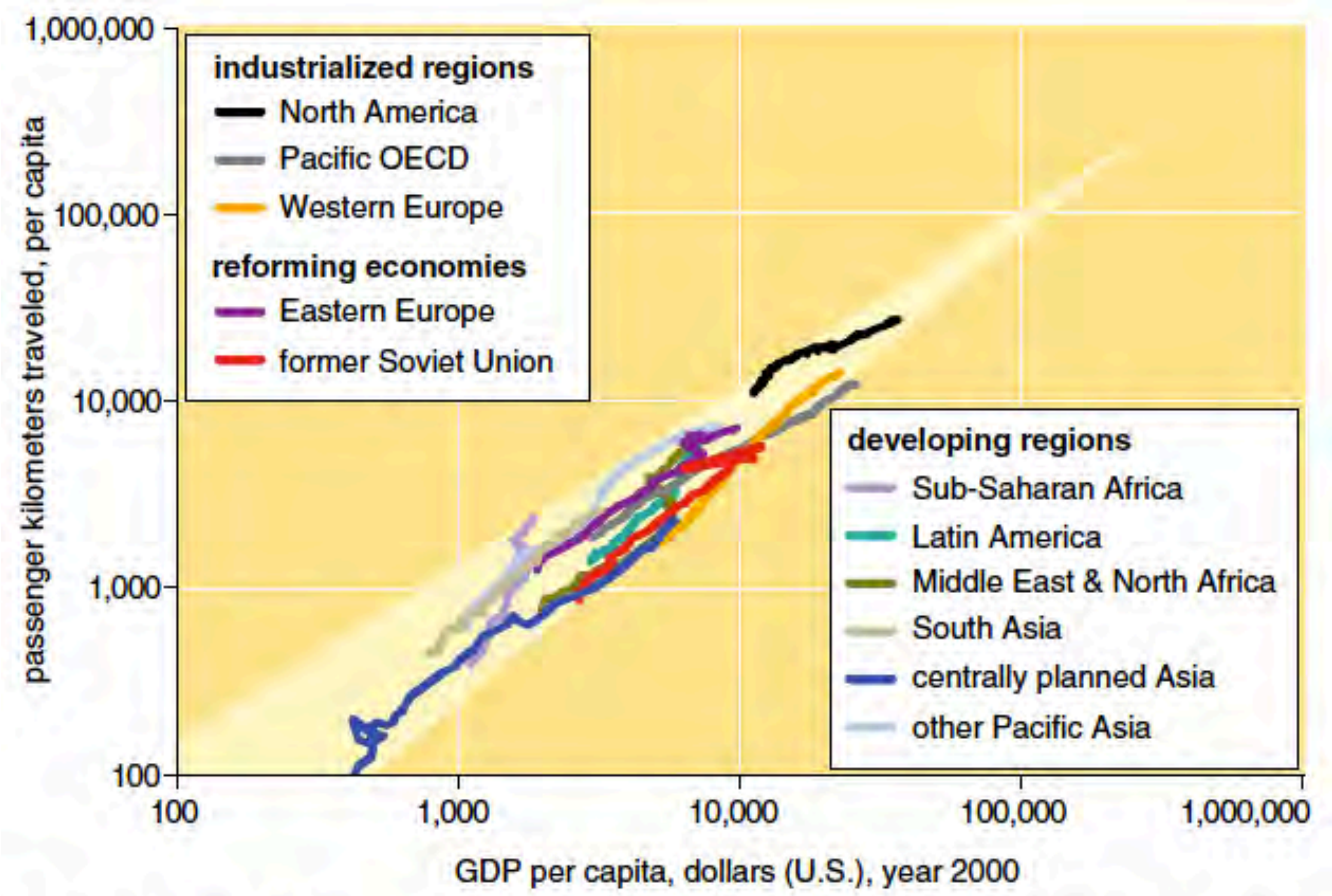
- Comparatively small share in CO_2 emissions (≈ 2.5%) but high growth in demand (≈ 5.3%/yr) and fuel use (≈ 3.6%/yr, since 1980)
- Warming impact of non-CO_2 emissions ≈ CO_2 emissions
- Aircraft noise and LAQ are additional, important concerns
- (Potentially) higher energy intensity than surface modes
- Significantly reducing emissions more challenging
  - Saving fuel imperative for industry survival
  - Numerous design trade-offs under binding environmental constraints
  - Reliance on high-energy density fuels → limited opportunities for fuel switching
  - Very high capital intensity

Energy Intensity and Systems Scale



Gucwa M., Schäfer A., 2013. The impact of scale on energy intensity in freight transportation, Transportation Research Part D: Transport and Environment, August.

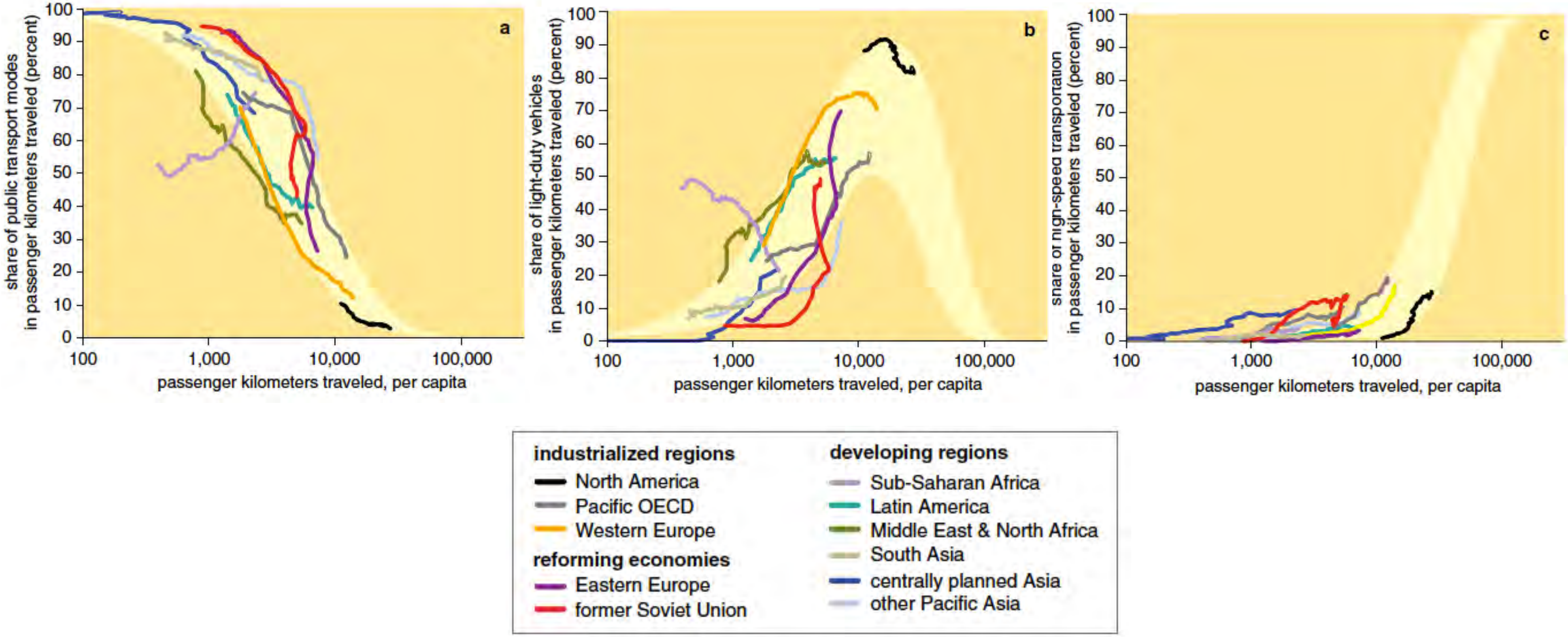
Total Passenger Mobility Growth (1950-2005)



Schäfer A., Heywood J., Jacoby H.D., Waitz I.A., 2009. The other Climate Threat, American Scientist, Nov-Dec.

Shift Toward Faster Modes (1950-2005)

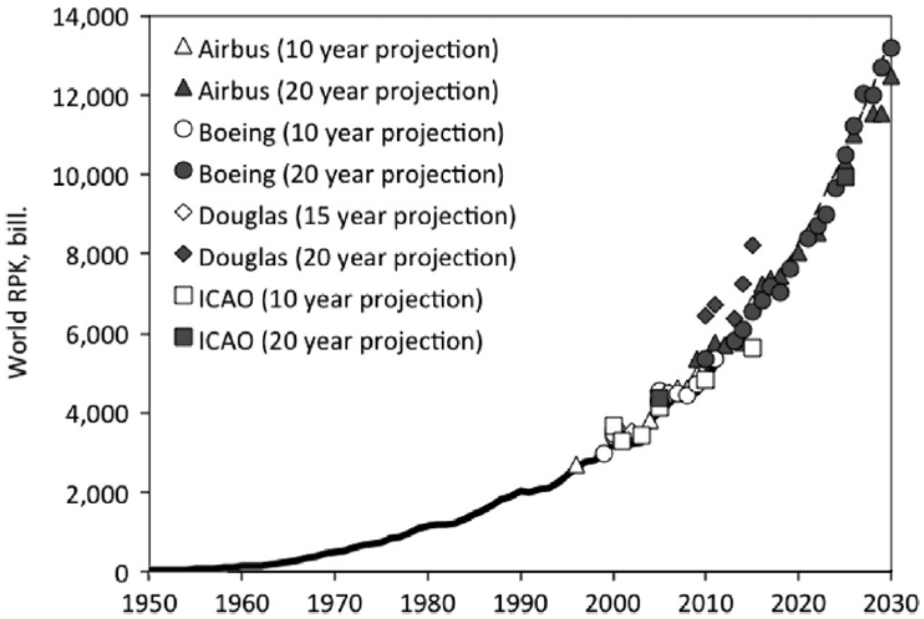
Public Transport Modes (%PKT) | Light-Duty-Vehicles (%PKT) | Aircraft (%PKT)



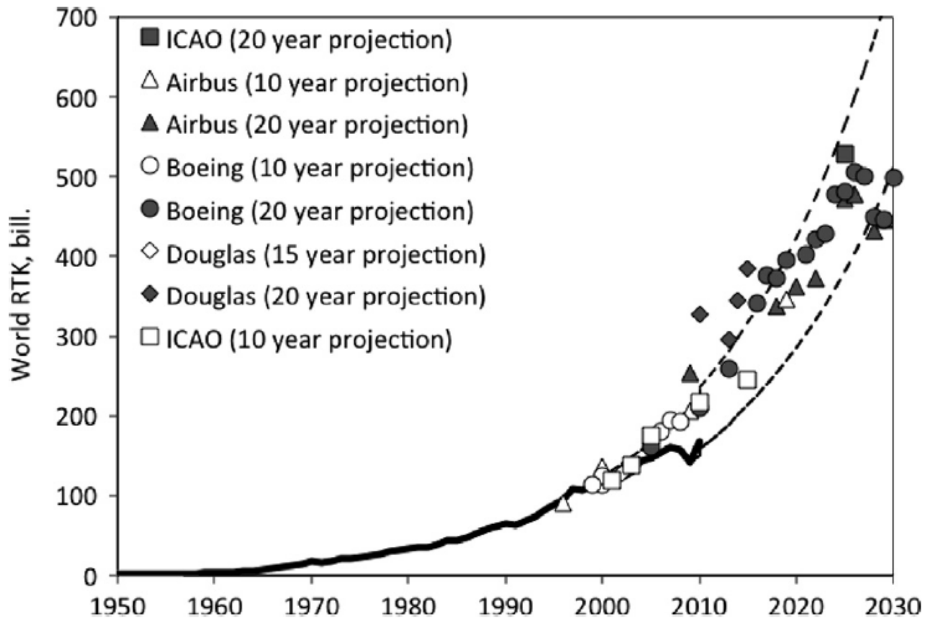
Schäfer A., Heywood J., Jacoby H.D., Waitz I.A., 2009.
The other Climate Threat, American Scientist, Nov-Dec.

Air Transportation Demand Projections

Passenger



Freight



Schäfer A., Waitz I.A., 2014. Air Transportation and the Environment, Transport Policy 34:1-4.

$$\frac{CO_2}{RPK} = CO_2EF\,\frac{Q \cdot SFC}{PAX \cdot V \cdot L/D}\,\frac{W_F}{ln(W_0/(W_0 - W_F))}$$

Louis Charles Breguet pilotant son premier aéroplane (Breguet I) en juin 1909 à La Brayelle près de Douai. (Musée de l'Air).

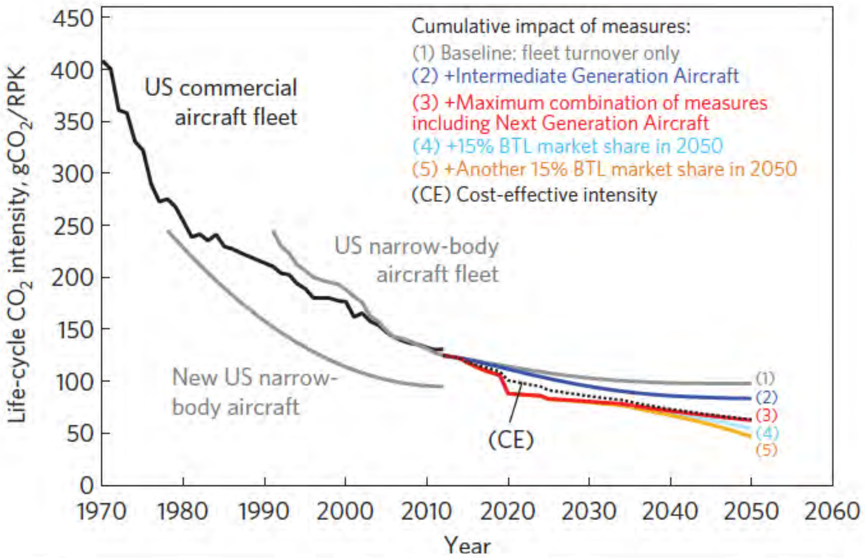
In equation (1), CO_2EF is the CO_2 emissions factor (87.6 $gCO_2\,MJ^{-1}$ for Jet A-1 fuel on a life cycle basis, that is, after accounting for upstream emissions with respect to crude oil extraction, transportation, refining, jet fuel distribution and storage, which represent around 21% of the fuel carbon-related CO_2 emissions[14]), Q is the fuel's lower heating value (42.8 $MJ\,kg^{-1}$ for jet fuel), SFC is the engine-specific fuel consumption (fuel burn per unit thrust), PAX is the number of passengers, V is the aircraft speed, L/D is the lift-to-drag ratio, W_F is the fuel weight before takeoff, and W_0 is the aircraft weight at takeoff. Hence, aircraft CO_2 intensity can be reduced through fuels containing less carbon on a life cycle basis, higher engine efficiency, a larger number of passengers, higher aerodynamic efficiency, and a lower structural weight (a smaller $W_0 - W_F$). Note that the variables in equation (1) are interrelated. Thus, changing one variable will lead to changes in others, typically offsetting part of the impact on CO_2/RPK.

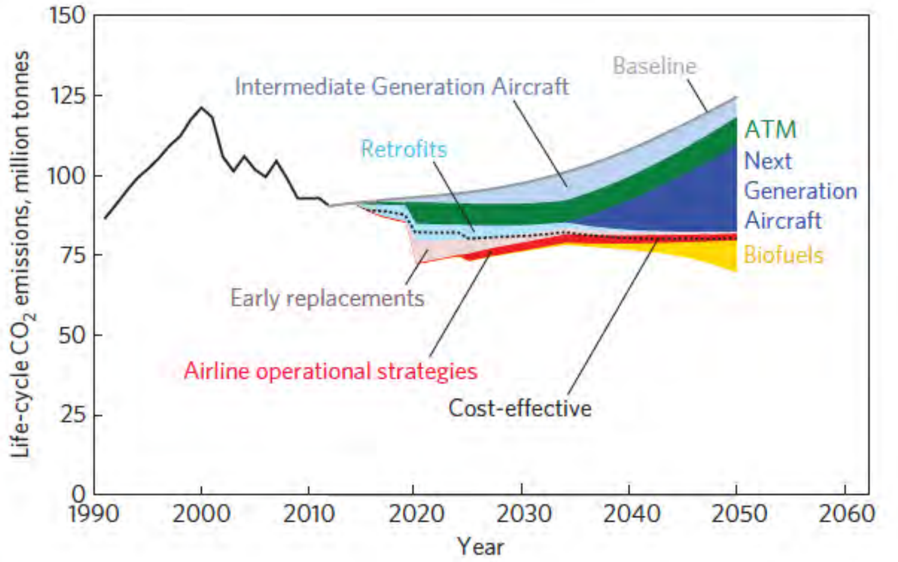
Costs of Mitigating CO_2 Emissions

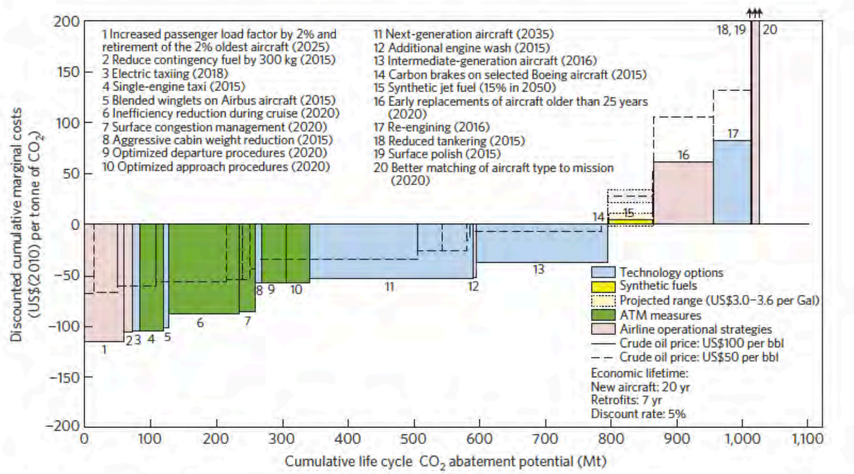
- US Domestic Air Transportation Market
- Narrowbody A/C (B737, A320, Bombardier CSeries)
  - 55% of departures
  - 60% of commercial A/C fleet
  - 75% of fuels and CO_2
  - 80% of RPK
- 20+1 CO_2 mitigation measures
  - Technology retrofits and new aircraft
  - Synthetic cellulosic biomass-based fuels
  - Operational measures (ground and air)
  - Airline business strategies (incl. early retirement)

CO_2 Intensity, Mitigation Costs, and Stabilization Wedges

(US domestic air transportation, narrow body aircraft)

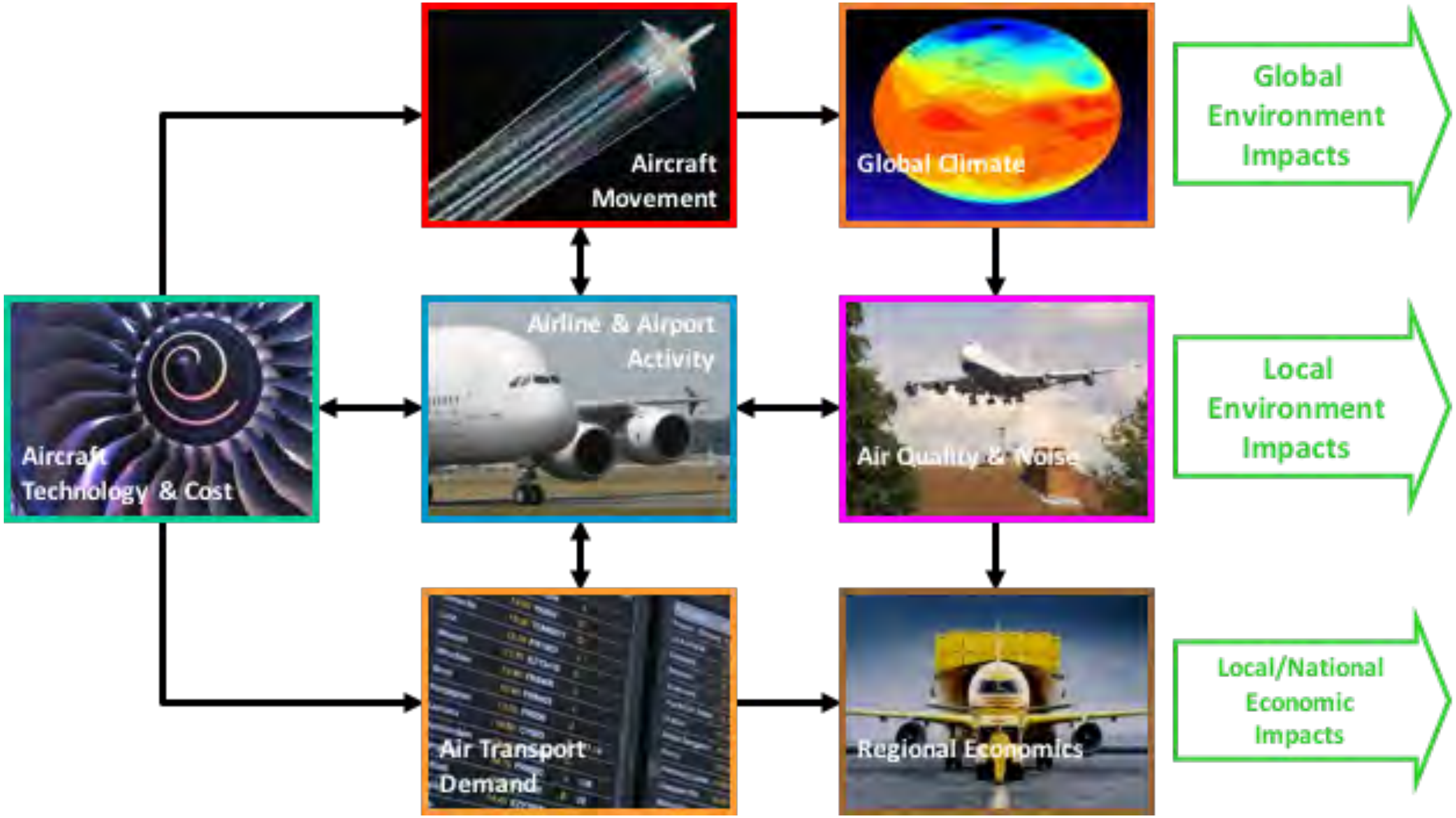




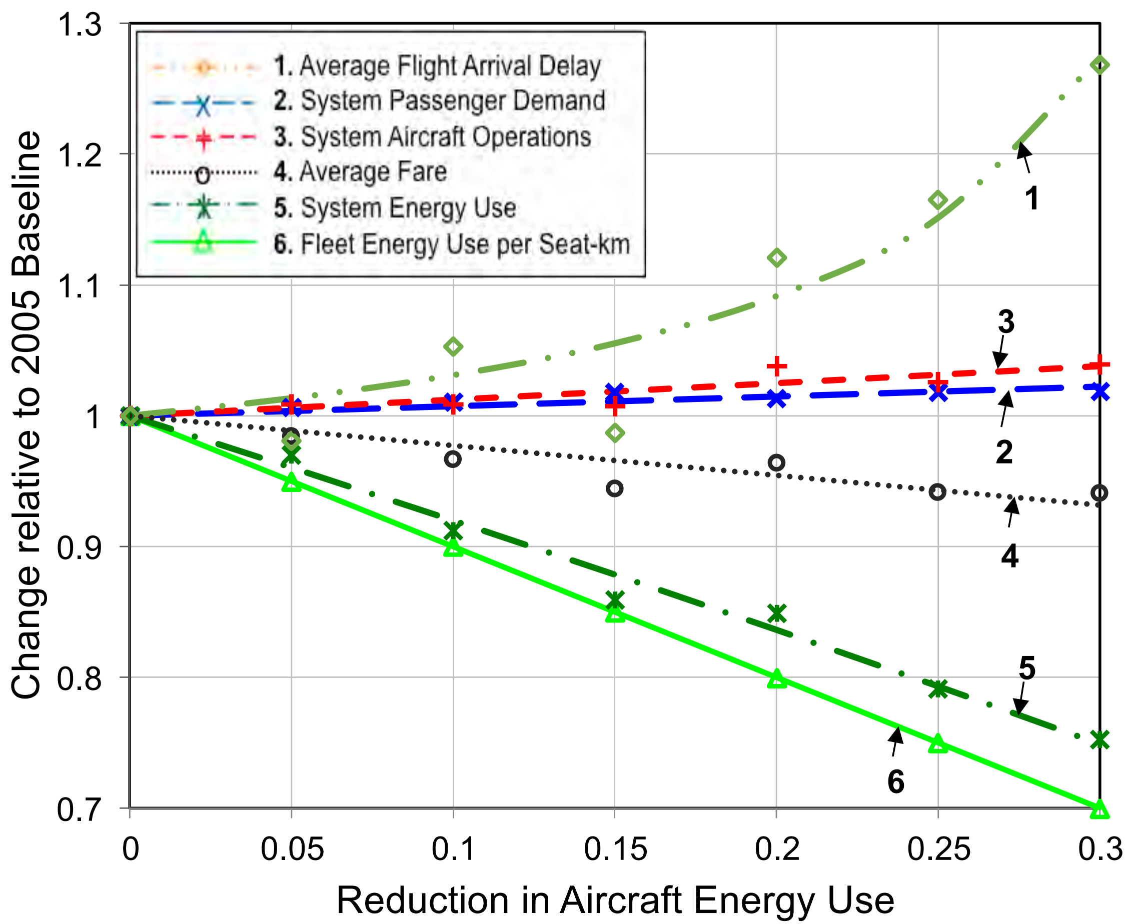


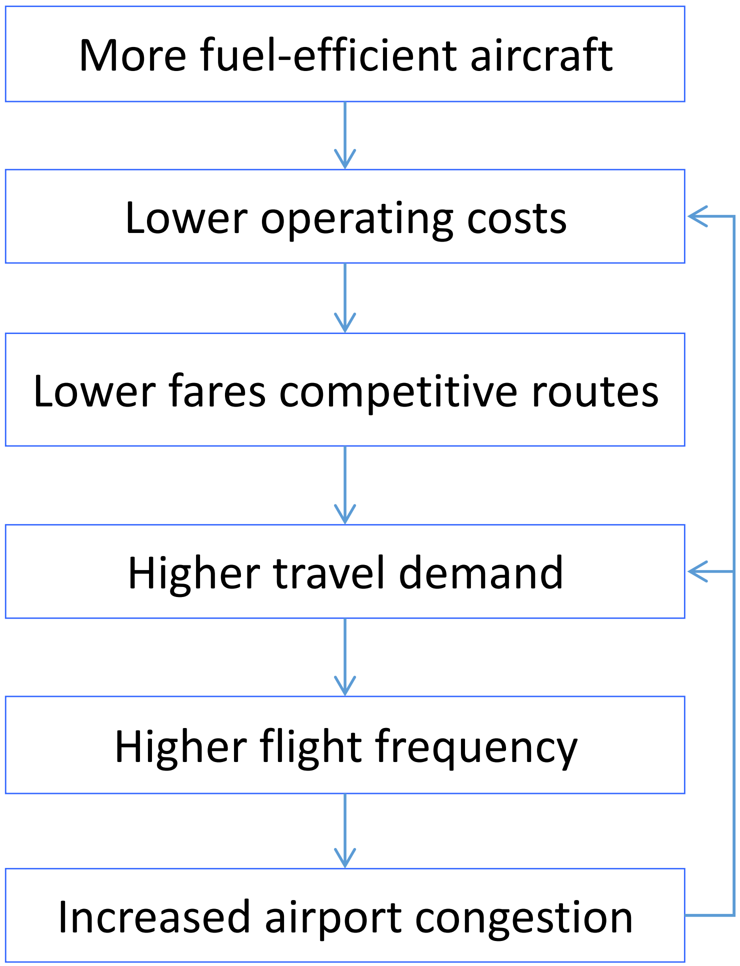
Schäfer A.W., Evans A., Reynolds T.G., Dray L., 2015. Costs of mitigating CO_2 Emissions from Passenger Aircraft, Nature Climate Change, Dec.

Open Source Aviation Integrated Model



The Rebound Effect in Aviation



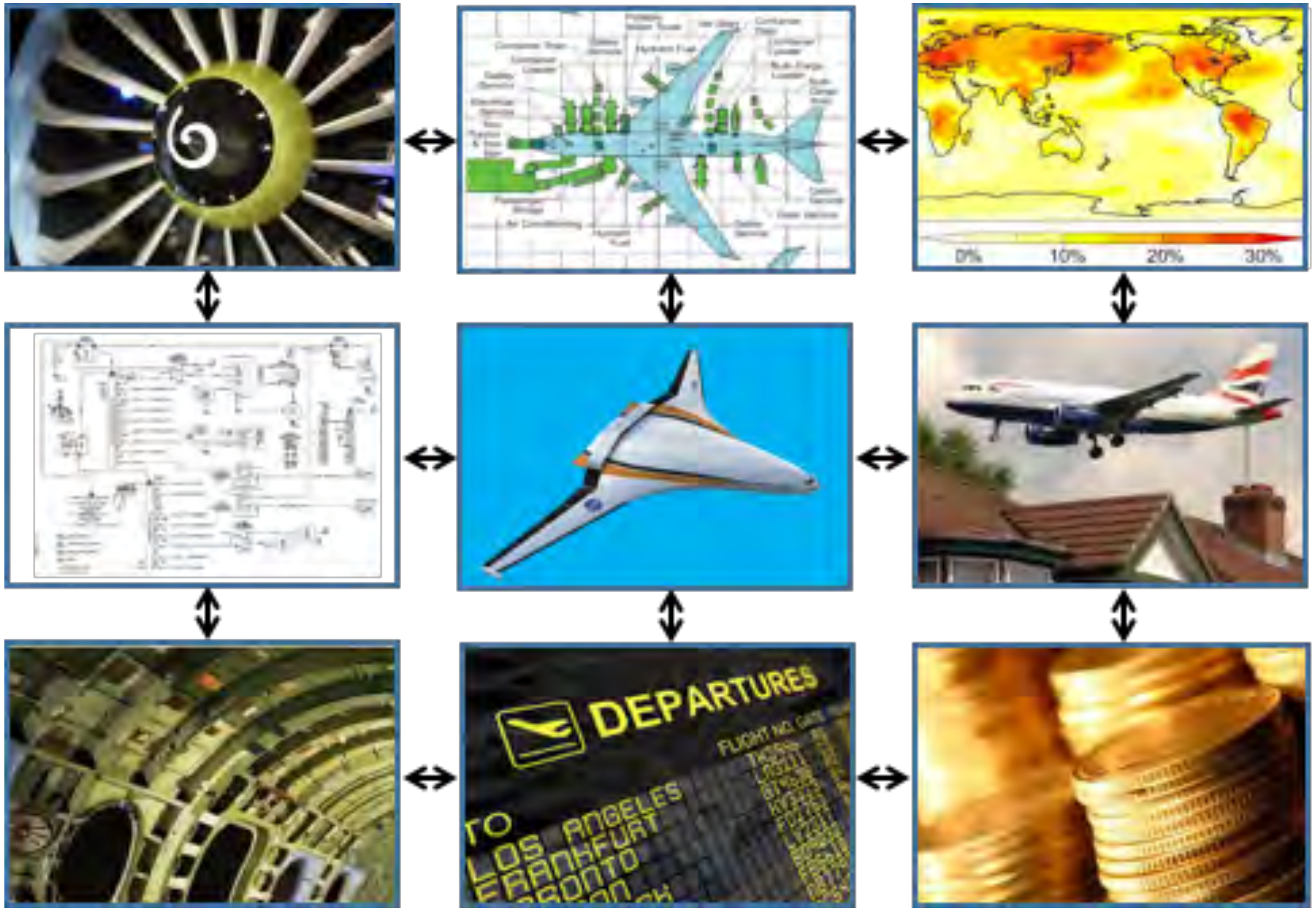


AD Evans, Schäfer A, 2013. The Rebound Effect in the Aviation Sector, Energy Economics 36:158–165.

Other Model Applications

- Environmental and economic implications various carbon tax schemes (recycling, transfers to less developed countries, etc.)
- ACCLAIM: Simulate the local and global implications (air transportation system, economic, environmental) from expanding airport capacity at any airport, world-wide (*in progress*)
- Understanding the environmental impact of (hybrid-) electric aircraft on air transportation related GHG emissions (*in progress*)
- Others, see publications section of website

Electric Aircraft Ecosystem



Emissions
(lifecycle perspective)

Aircraft noise

Fleet adoption
Flight network
Business models
Airline competition
Industrial competitiveness

Projected Electric Aircraft Network (2050)