LOW-EMISSION AIRCRAFT STUDY

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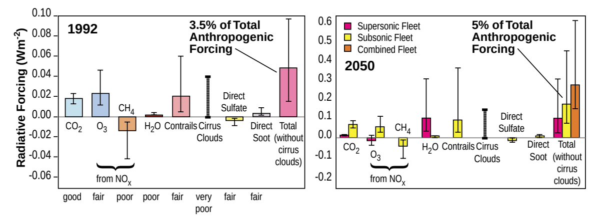
AIR TRAFFIC GROWTH
▼
INCREASING EMISSIONS
▼
ENVIRONMENTAL IMPACT
▼
NEW EMISSIONS LIMITS?

OBJECTIVE

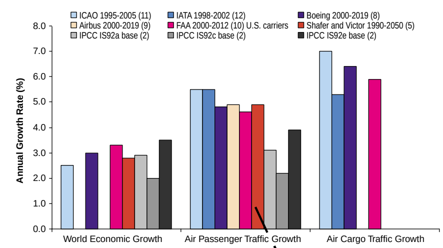
To develop a framework that enables the systematic assessment of cost and emissions impacts of future aircraft technologies designed to reduce greenhouse gas emissions

- **respond to questions posed in a global, multiple transport mode context**
- **a means for value and assumption articulation**
- **enable rational choices to be made among options for aviation technology development**

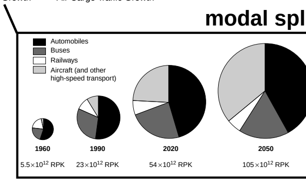
Global atmospheric impacts



Growth

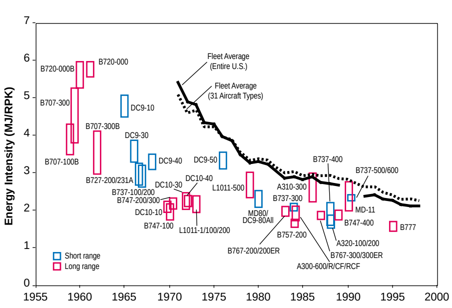


modal split



TRENDS IN TECHNOLOGY, COST, AND EMISSIONS

Historically, growth has outpaced efficiency improvement = increased emissions



1971-1998 U.S. fleet

- **E_I reduced > 60% or ~3.3% per year**
- **RPK grew by ~330% or 5.5% per year**

A semi-empirical model for aircraft energy intensity(E_I):

$$E_I = \frac{Q \cdot W_f}{\#\text{Seats} \cdot \alpha \cdot \text{SL} \cdot \eta_{ft}}$$

$$E_I = \frac{Q \cdot W_f}{\left(W_p / W_i\right)} \cdot \frac{g \cdot \text{SFC}}{V\left(L/D\right)} \cdot \frac{1}{\ln\left(1+\frac{W_f}{W_p+W_s+W_r}\right) \cdot \eta_f}$$

capacity **technology** **operational delays**

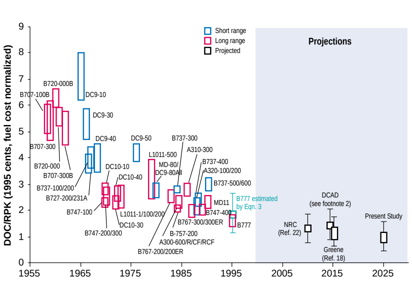
Breakdown of E_I reduction:
57% engine efficiency
22% aerodynamic efficiency
17% capacity efficiency
4% other incl. increased a/c size

η_I	=	fuel efficiency (in RPK/kg or RPK/MJ)
Q	=	lower heating value of jet fuel
SL	=	stage length as calculated using the range equation
α	=	load factor = RPK/ASK
η_{ft}	=	flight time efficiency
V	=	aircraft velocity
L/D	=	lift-to-drag ratio
SFC	=	specific fuel consumption
W_f	=	fuel weight
W_i	=	weight of a passenger + baggage (90.7 kg as specified by Form 41)
W_p	=	payload weight
W_r	=	reserve fuel weight
W_s	=	structural weight

Future expected to show similar trends

- **1.2-2.2% per year reduction in E_I**
- **5-6% per year increase in RPK**

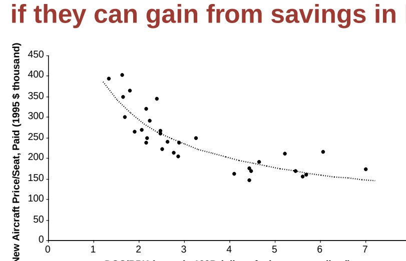
Reduced energy intensity helps reduce airline costs



1959 to 1995 U.S. fleet

- **65% reduction in overall DOC/RPK as newer aircraft models introduced**
- **maintenance, crew, and capital related DOC/RPK accounted for ~75% of reduction, fuel ~25%**

Airlines willing to pay higher acquisition cost if they can gain from savings in DOC



1959 to 1995 U.S. fleet
- **short-range $/seat rose ~50%**
- **long-range $/seat rose ~130%**