Aviation and Oil Depletion

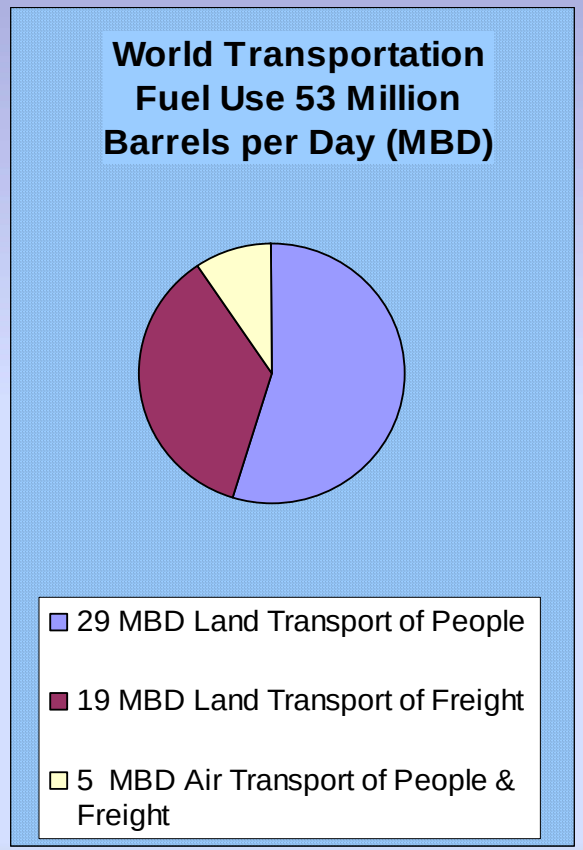
Energy Institute

7 November 2006

By Christopher Smith
Captain, BA Connect

The Aviation Industry

- Aviation is one of the fastest growing industry sectors in the world
- Aviation is growing at 2.4 times the rate of growth of average world GDP
- Aviation consumes 5 million barrels of oil per day



Source: Scientific American Aug 06

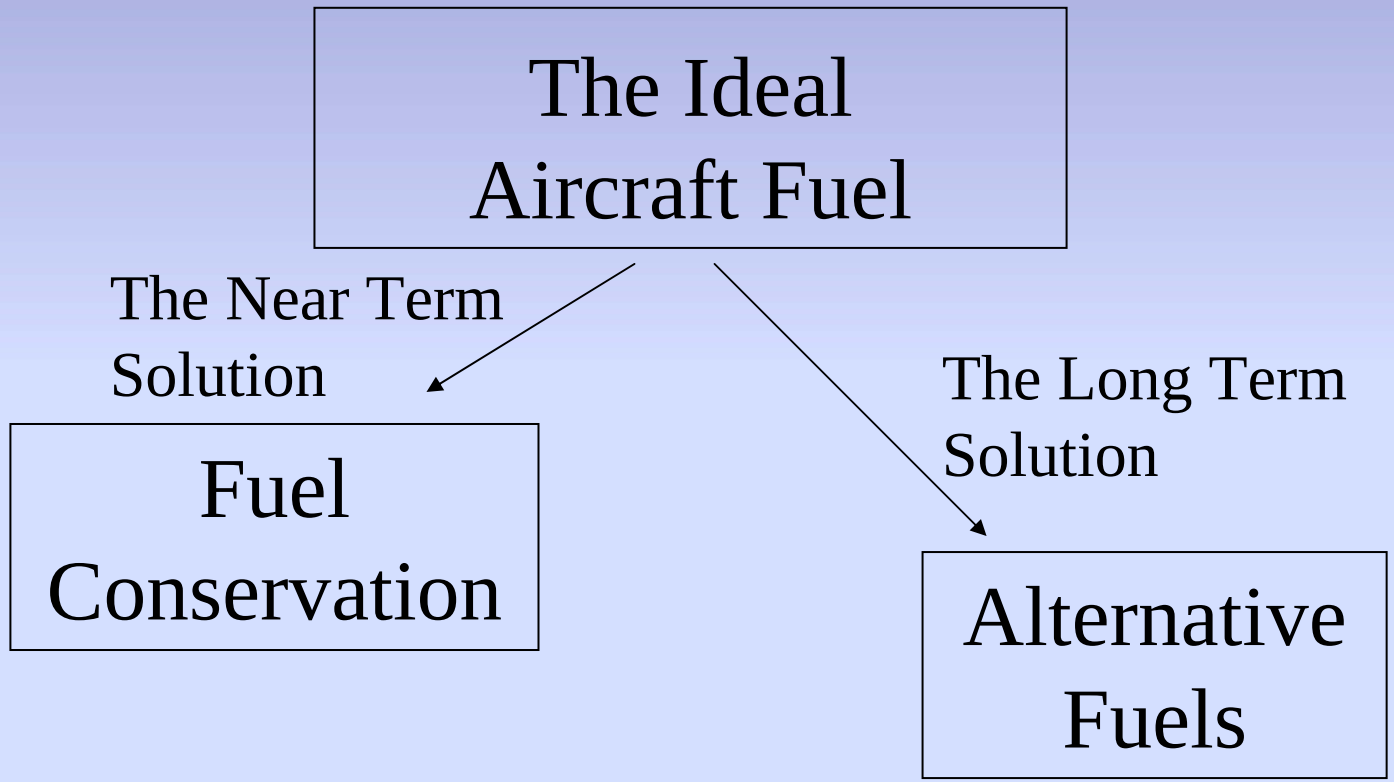
The UK Aviation Industry

- UK aviation is growing at 5% per year
- UK aviation fuel consumption is growing at 3% per year
- The difference is due to efficiency improvements in aircraft and engine design, Air Traffic Control and passenger load factor

Aviation Energy Issues

- There is currently no alternative to the use of kerosene in jet aircraft engines.
- Global Warming emissions from aviation are increasing in line with increasing fuel use.
- Fuel is one of the largest costs an airline faces (10 – 35%)
- The industry would like a cheaper, less damaging source of energy.

Aviation and Oil Depletion



The Ideal Aircraft Fuel

- High Specific Energy
- Specific Safety Criteria
- Minimal Global Warming Emissions
  - Carbon Dioxide
  - Water Vapour
  - Contrails

The Ideal Aircraft Fuel
High Specific Energy

- MegaJoules of energy / Kilogram of fuel
- We also want a high energy density measured in MegaJoules / Cubic Metre
- Affects the total size & weight of the aircraft
- 1 Kg of extra aircraft structure mass results in a 3 Kg increase in maximum take-off mass

The Ideal Aircraft Fuel

Specific Safety Criteria

- High flash point to minimize flammability and explosion hazard within the fuel tank and in aircraft accidents.
- Low freezing point (-40° C). The outside air temperature at jet cruising levels is in the vicinity of –60 degrees Celsius. Water and ice crystals will clog up filters
- Lubrication, Cooling, Balance Trim

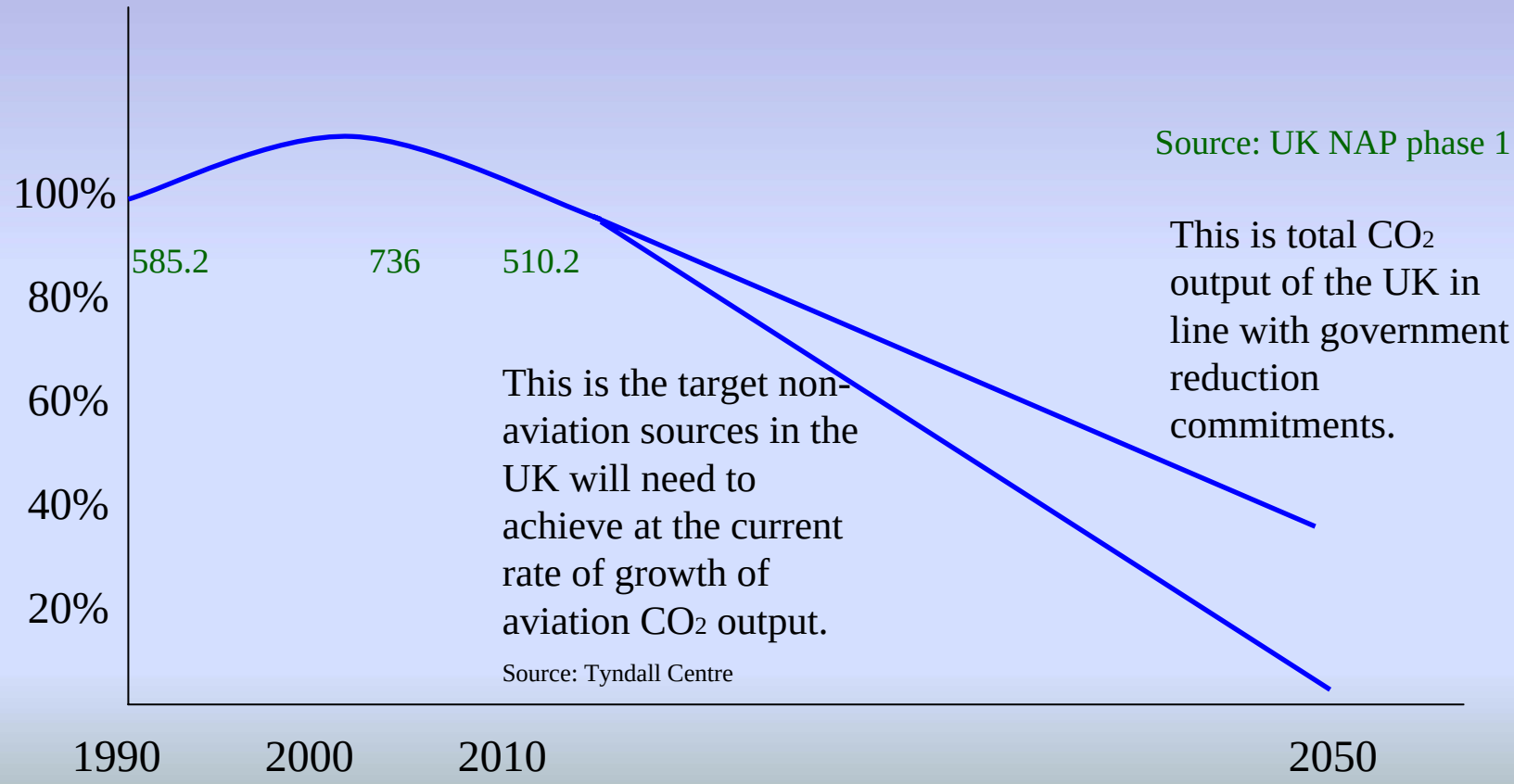
The Ideal Aircraft Fuel

Carbon Dioxide

- In 2000, aviation accounted for 5% of UK CO_2 emissions. (Dept for Transport)
- In 2020, 10 – 12% and could rise to 40% by 2050 if not checked. (Environmental Audit Committee)
- If aviation CO_2 emissions continue to grow unchecked, every other industry and home in the UK will need to become carbon neutral by 2050. (Tyndall Centre)

The Ideal Aircraft Fuel

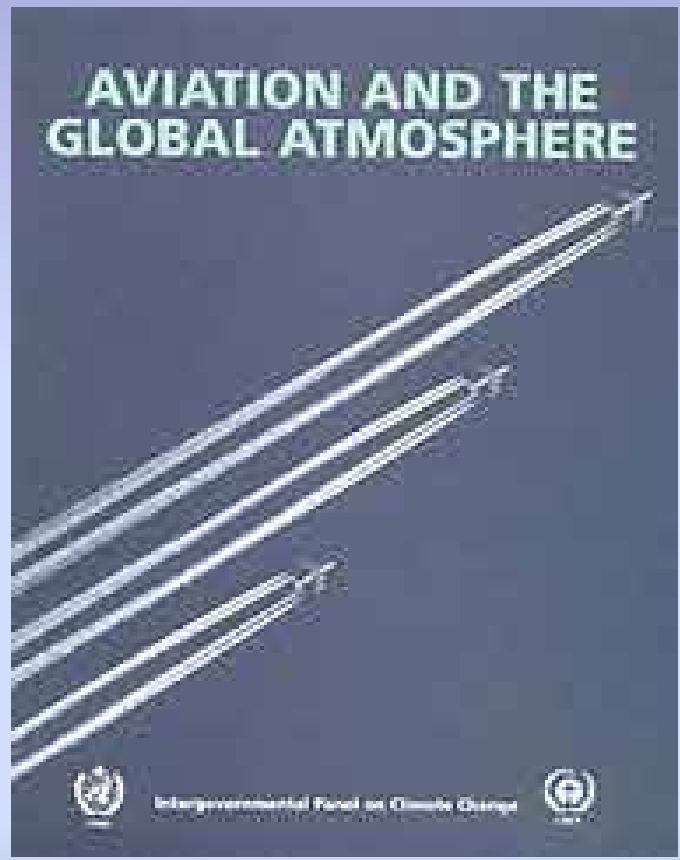
Carbon Dioxide



The Ideal Aircraft Fuel

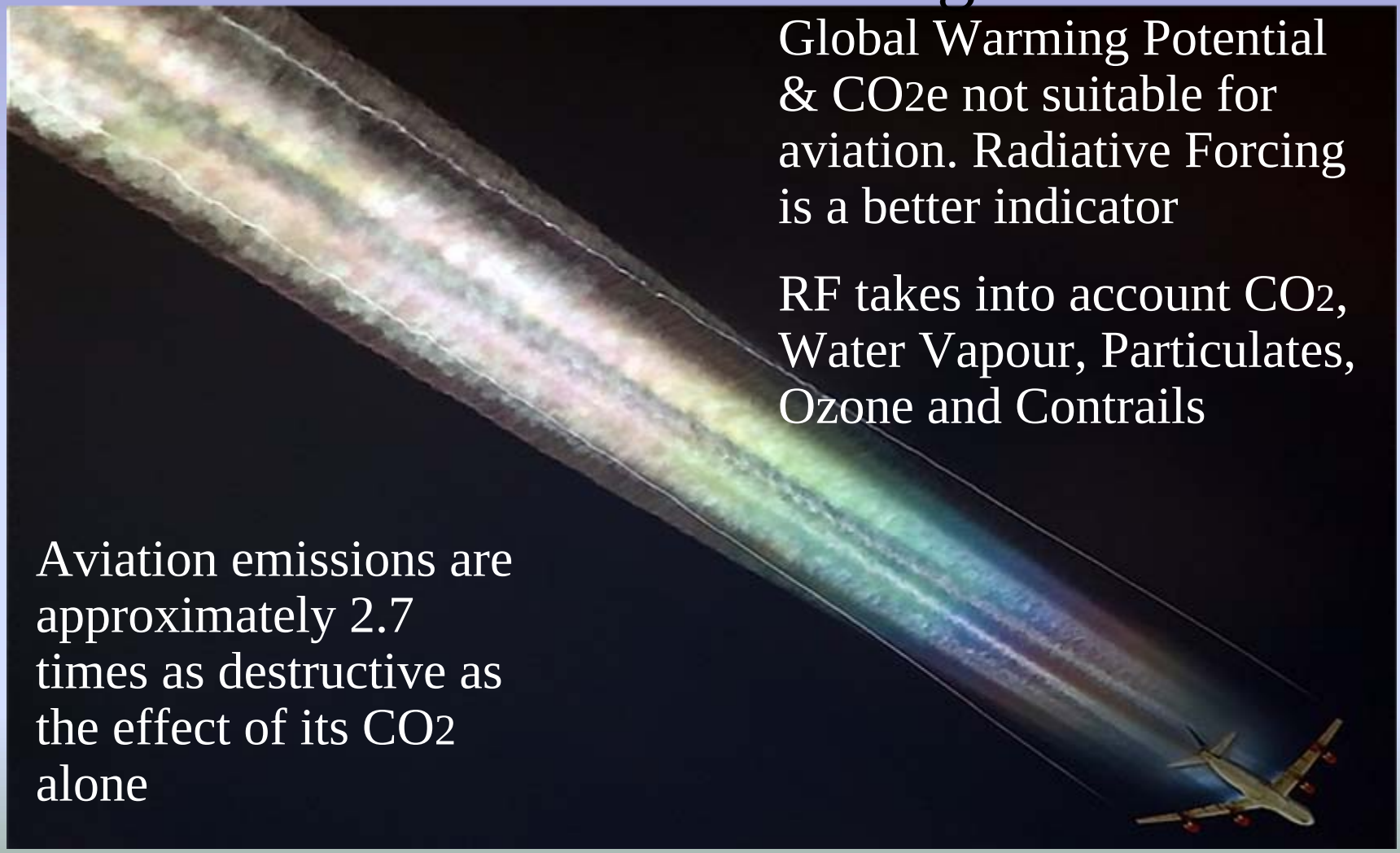
Radiative Forcing

- A study produced by the Intergovernmental Panel on Climate Change (IPCC)
- United Nations Framework Convention on Climate Change (Kyoto Protocol)
- The first in-depth analysis of the climate change effects of aviation



The Ideal Aircraft Fuel

Radiative Forcing



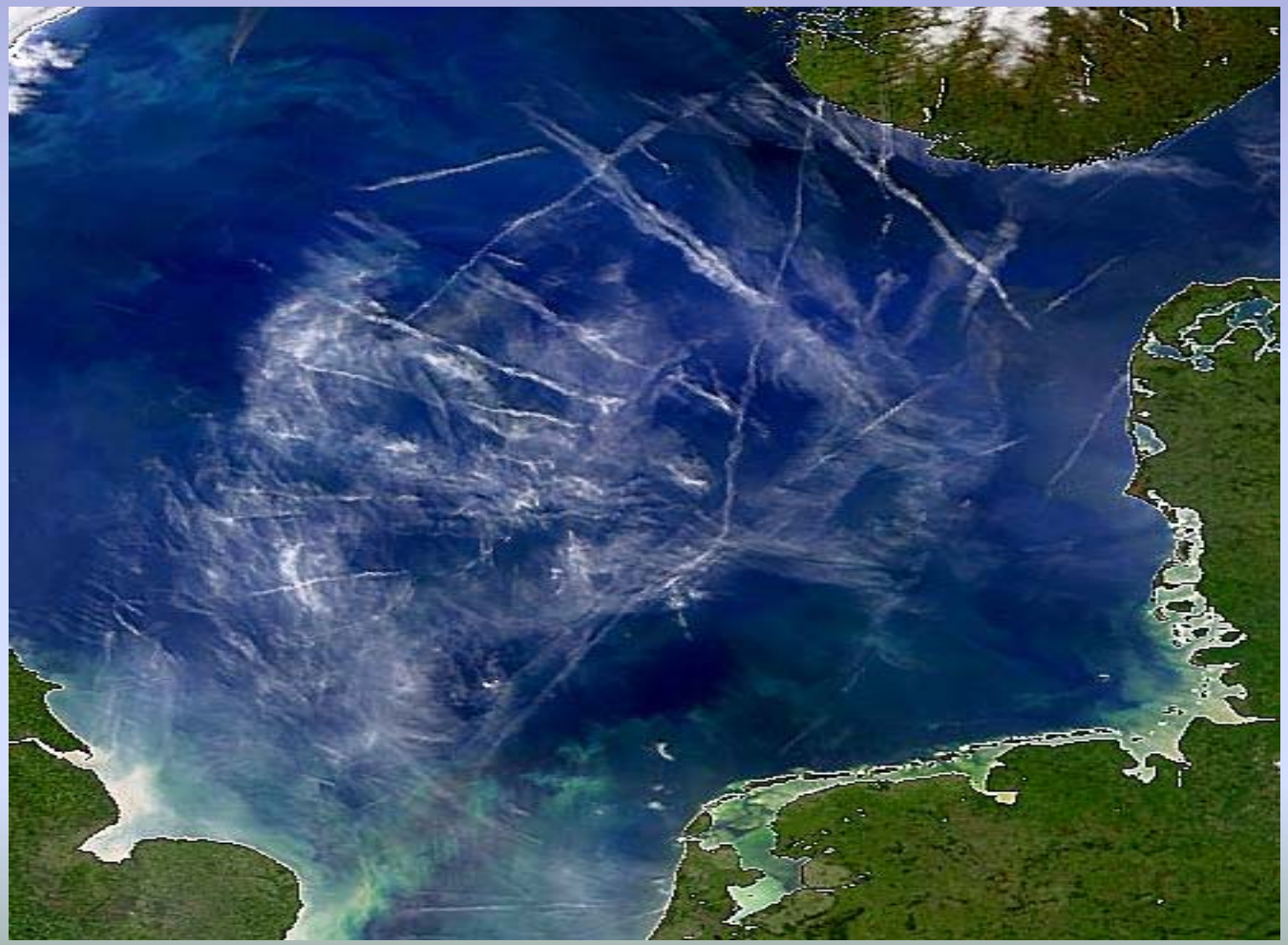
Global Warming Potential & CO_2e not suitable for aviation. Radiative Forcing is a better indicator

RF takes into account CO_2, Water Vapour, Particulates, Ozone and Contrails

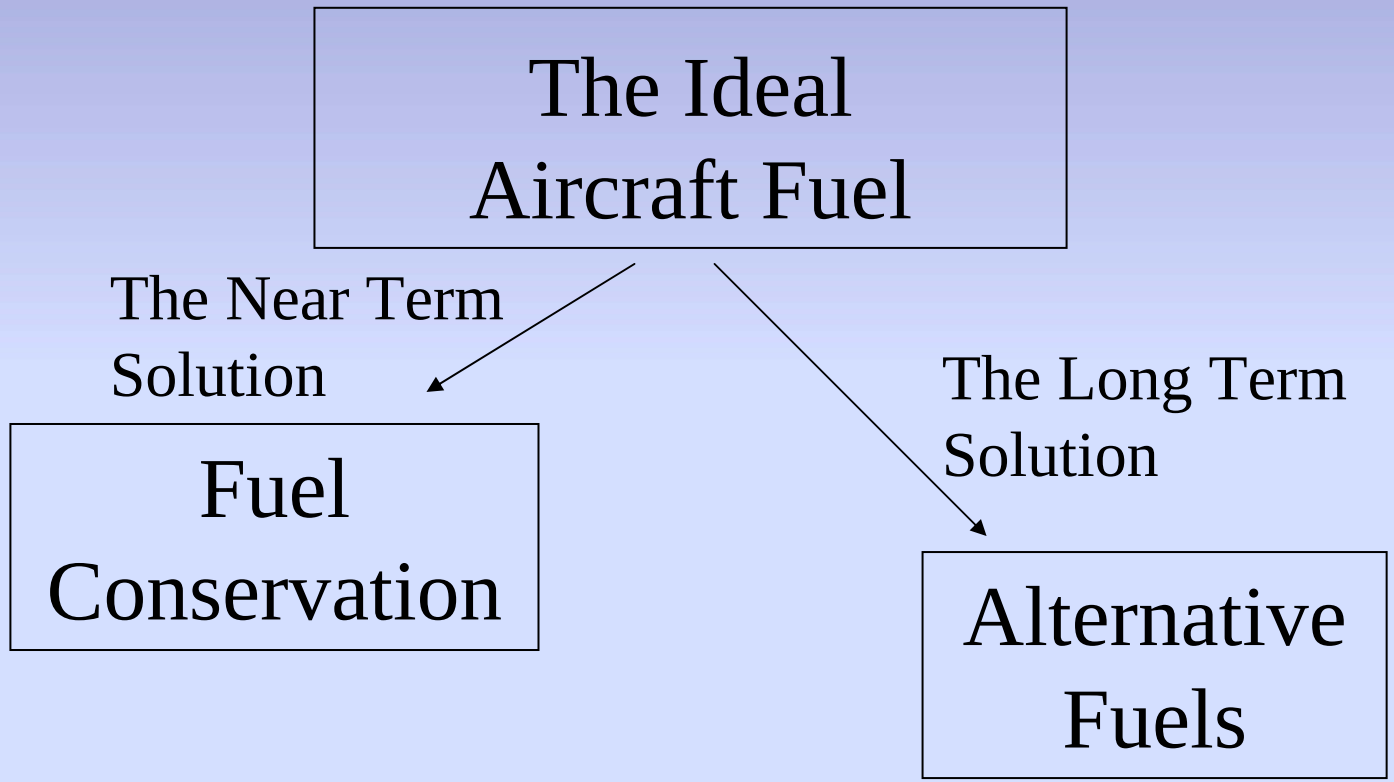
Aviation emissions are approximately 2.7 times as destructive as the effect of its CO_2 alone

The Ideal Aircraft Fuel

Contrails



Aviation and Oil Depletion



Fuel Conservation

Options

- Minimum Fuel
- Air Traffic Control Efficiency
- Aircraft
- Ground Operations
- Shorter Sector Lengths
- Competition

Fuel Conservation

Minimum Fuel

- Carrying less fuel saves fuel.
- Fuel is required to lift the fuel required for the later stages of the flight.
- Modern computer generated Air Plans can be accurate to within one minute and several kilograms of total fuel requirements

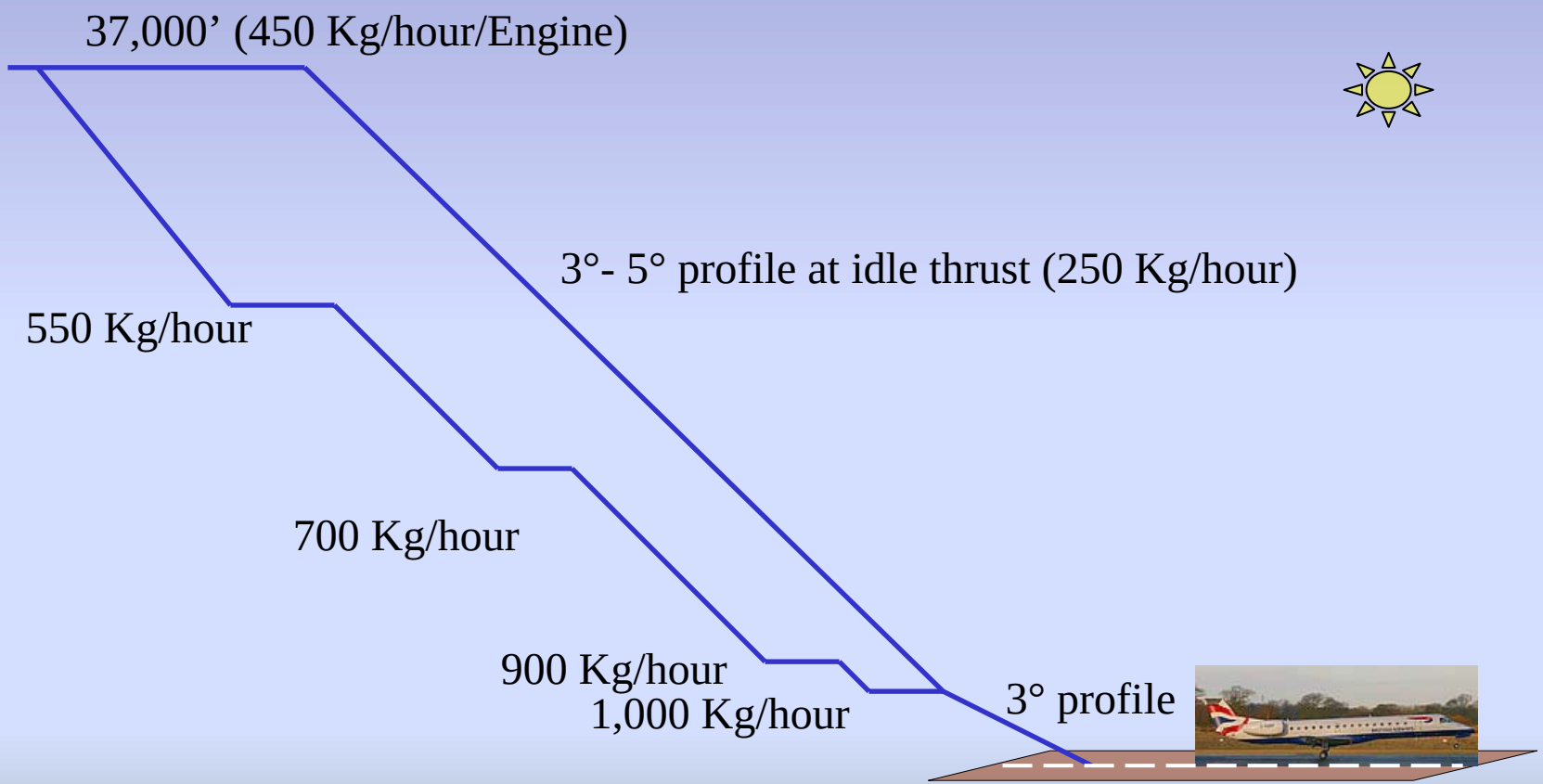
Fuel Conservation

ATC Efficiency

- 6-10% improvement by 2020 through more efficient air routes
- Future Air Navigation (FANS) allows aircraft to travel without using airways

Fuel Conservation

Step Descent vs. Continuous Descent

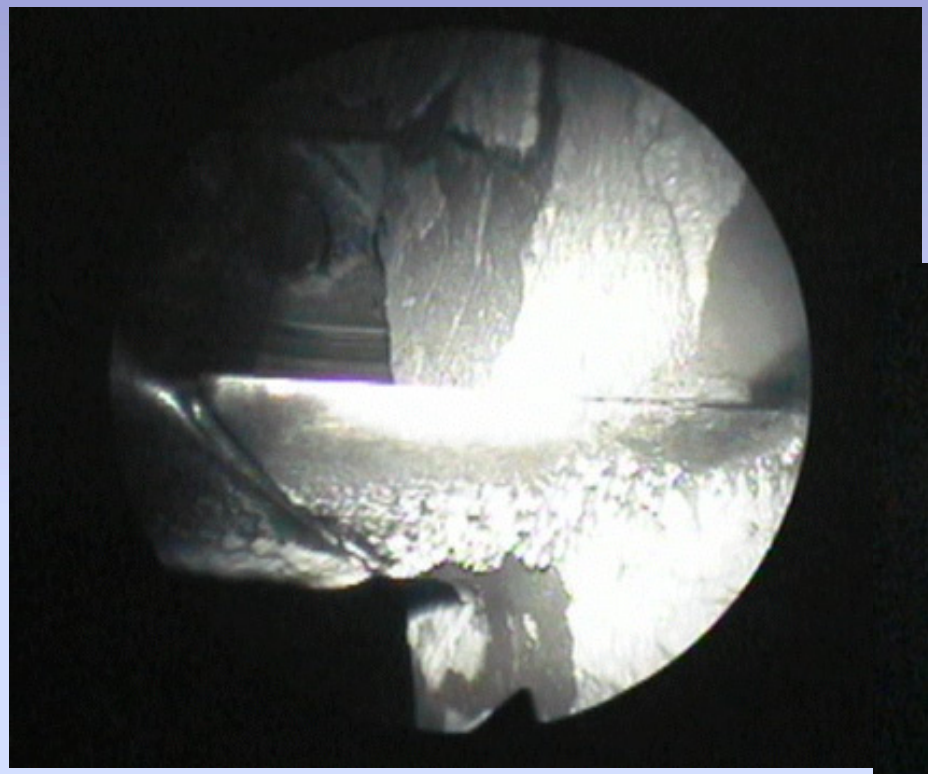


Fuel Conservation

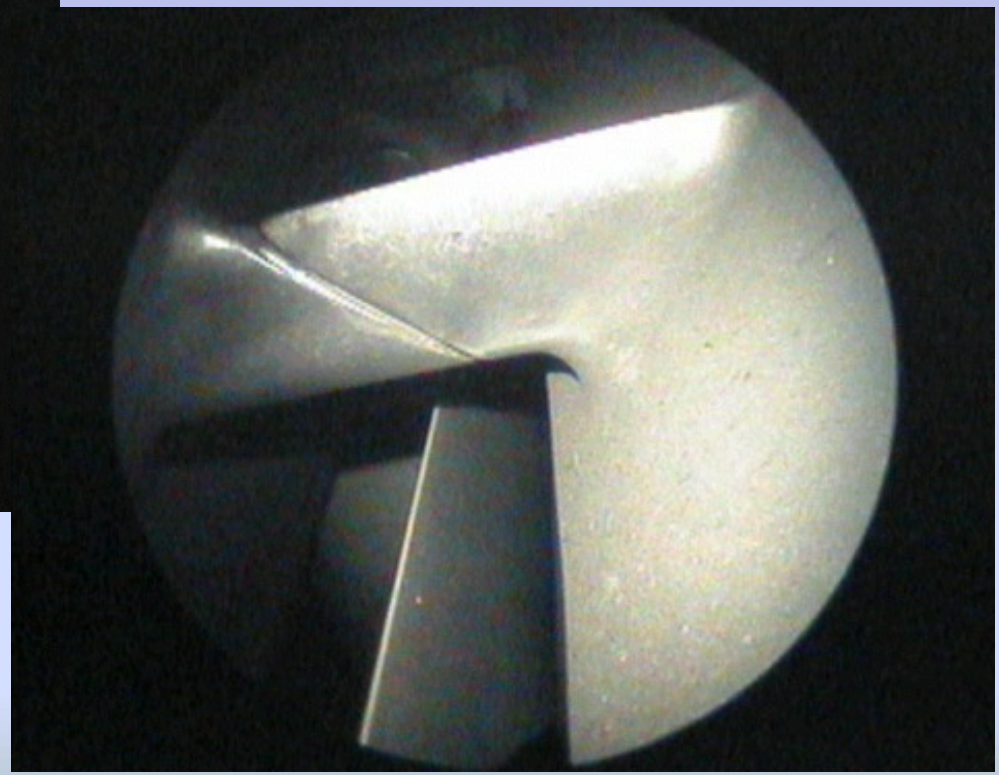
Aircraft Considerations

- Aircraft become less efficient with age
  - (1% per year)
- Care and Maintenance
- Interior Layout
- Large high speed turboprops that can compete with jets on short range flights
- Early Retirement

Before



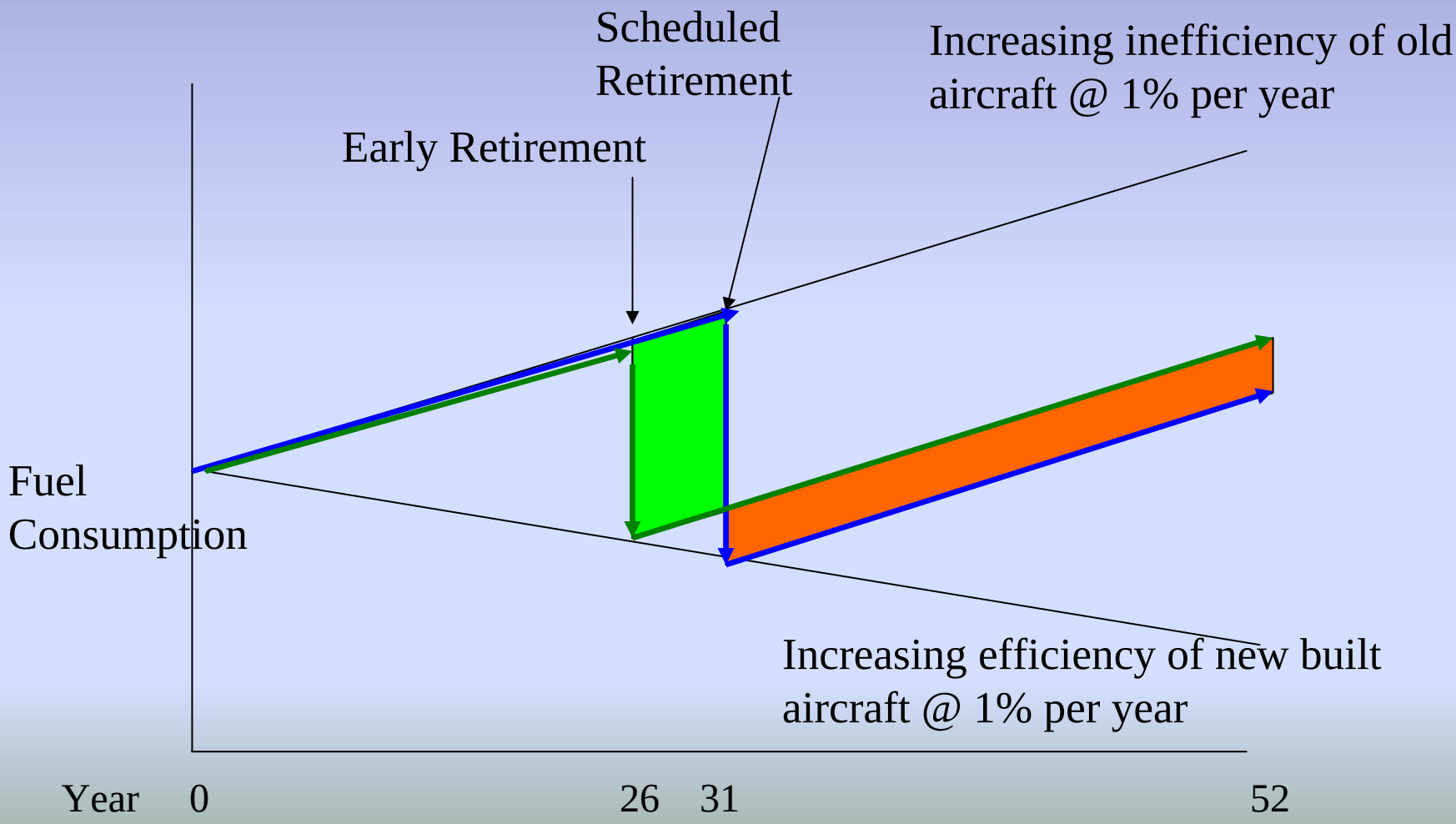
GAS TURBINE EFFICIENCY



After

Fuel Conservation

Benefits of Early Retirement



Fuel Conservation

Ground Operations

- Auxiliary power units
- Service vehicles
- Ground Delays

•Tow aircraft to the runway before starting engines

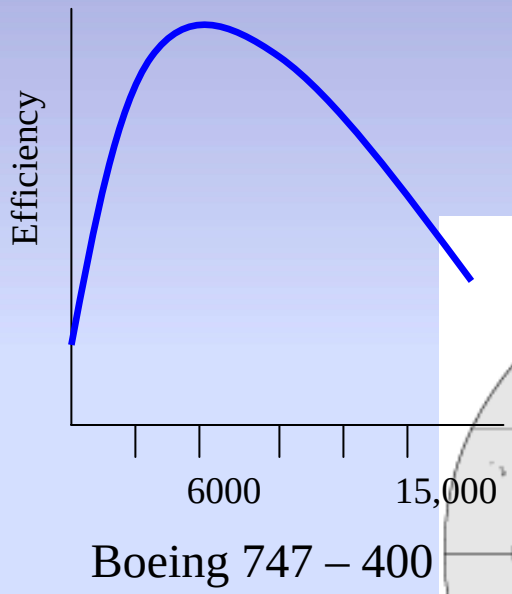
Fuel Conservation

Competition

- Fly less
- Increased Load Factor
- A return to a regulated industry with government restrictions on aircraft size and frequency on each route

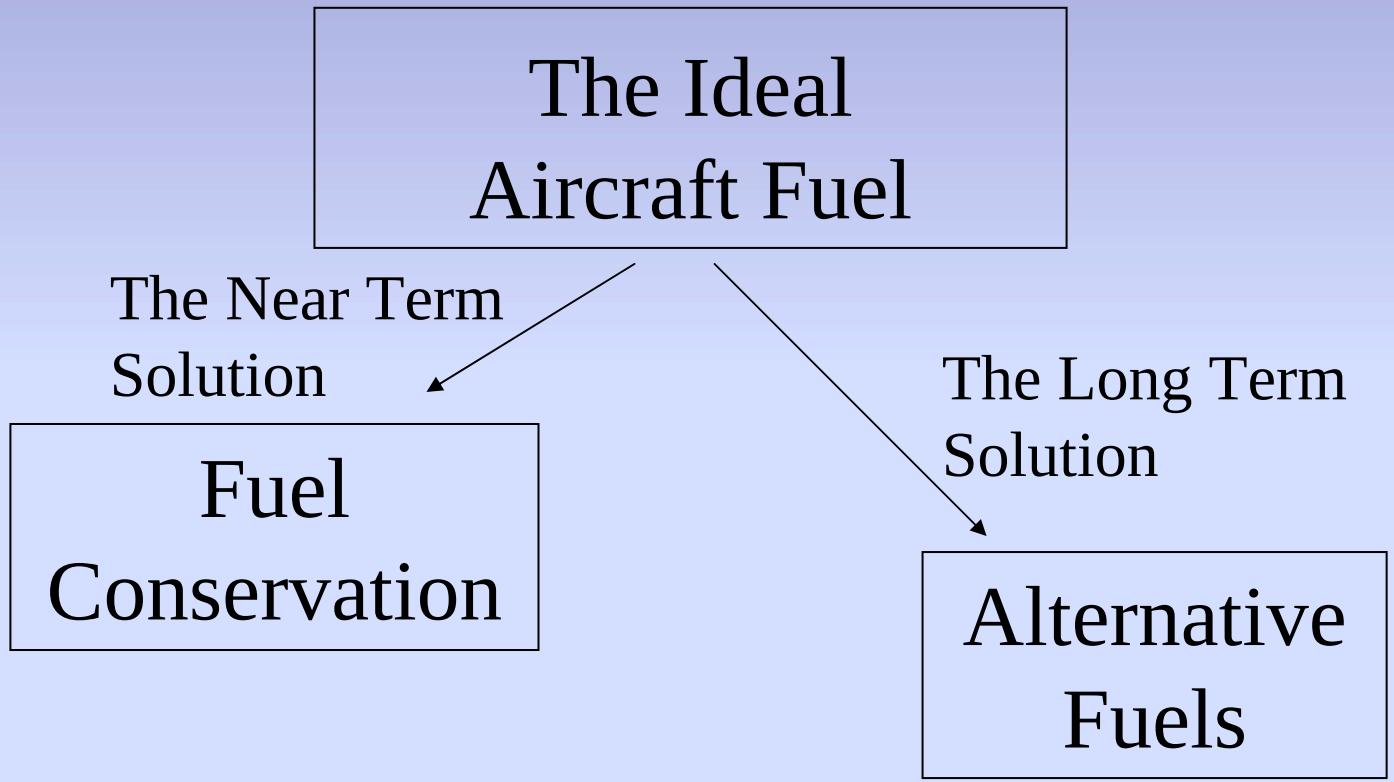
Fuel Conservation

Shorter Sector Lengths



- Aircraft Efficiency versus Sector Lengths
- Hub & Spoke networks

Aviation and Oil Depletion



Alternative Fuels

- Hydrogen
- Natural Gas
- Alcohols
- Biofuels
- Synthetics

Alternative Fuels

Hydrogen

- Provides 2.5 times the energy per Kg than kerosene
- The volume of hydrogen would be 2.5 times that of an equivalent amount of kerosene
- No CO_2 emissions
- Generates 2.6 times more water vapour

Alternative Fuels

Hydrogen

- Hydrogen is expensive to produce and difficult to store
- Requires cryogenic storage on the aircraft
- There is currently no infrastructure
- It will not be practical until it is available worldwide

Alternative Fuels

Dornier 328 Jet

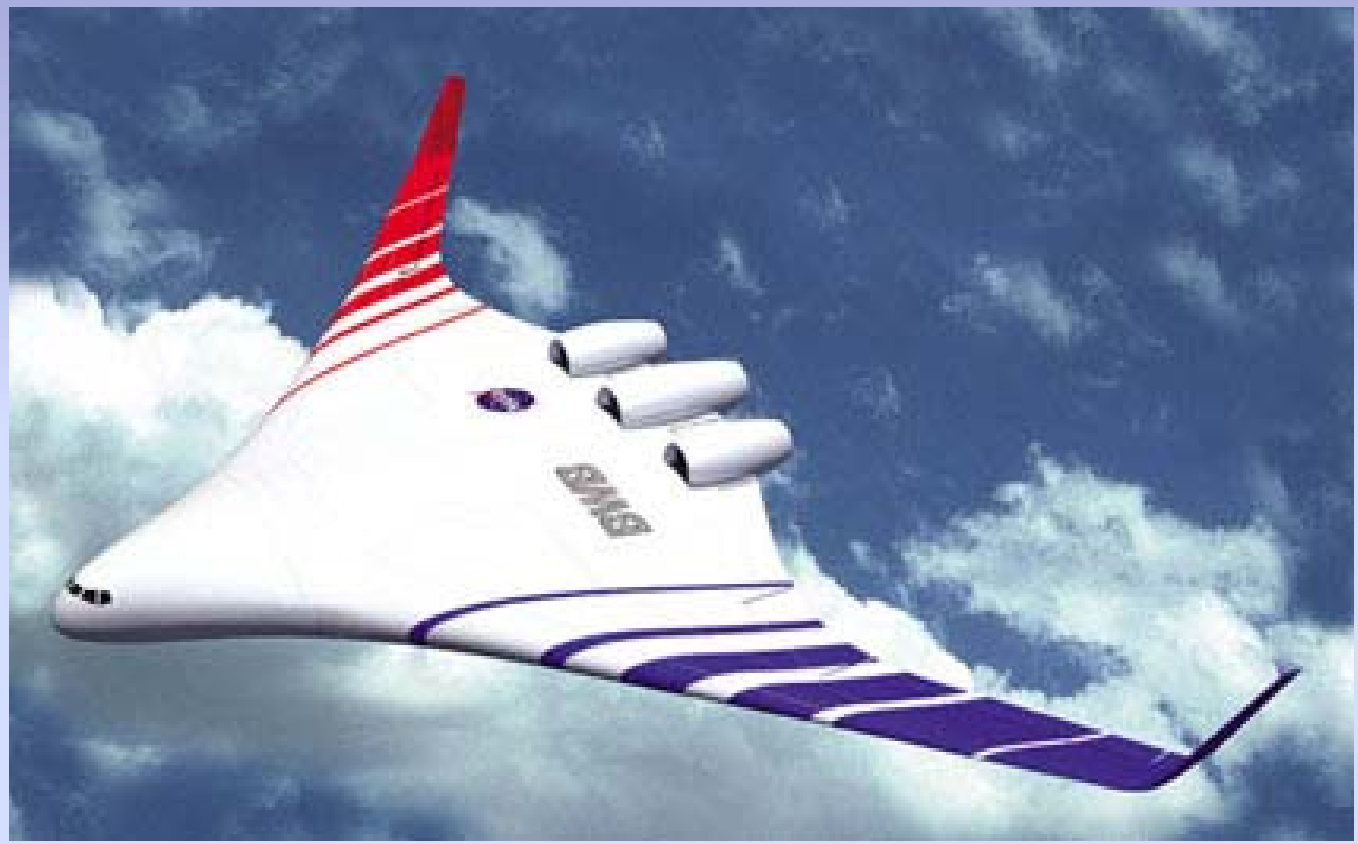
Configured to use hydrogen

Alternative Fuels

Hydrogen

Airbus A300 with Cryogenic Storage

NASA Blended Wing Airliner



30% improvement in fuel consumption

Alternative Fuels

Alcohols

- Less energy by volume (50-75%)
- Very corrosive
- Increased Volatile Organic Compounds which destroy the ozone layer
- Carbon neutral (sort of)

Alternative Fuels

Biodiesel

- Unsuitable for jet engines due to
  - Very high flash point,
  - Low volatility,
  - Need for high pressure,
  - Thickens and crystallizes at the temperature found at jet aircraft operating altitudes
- Currently approved as a kerosene extender up to 10%
- Possibly up to 20% with enhanced filtration technology

Alternative Fuels

Synthetics (Synfuel)

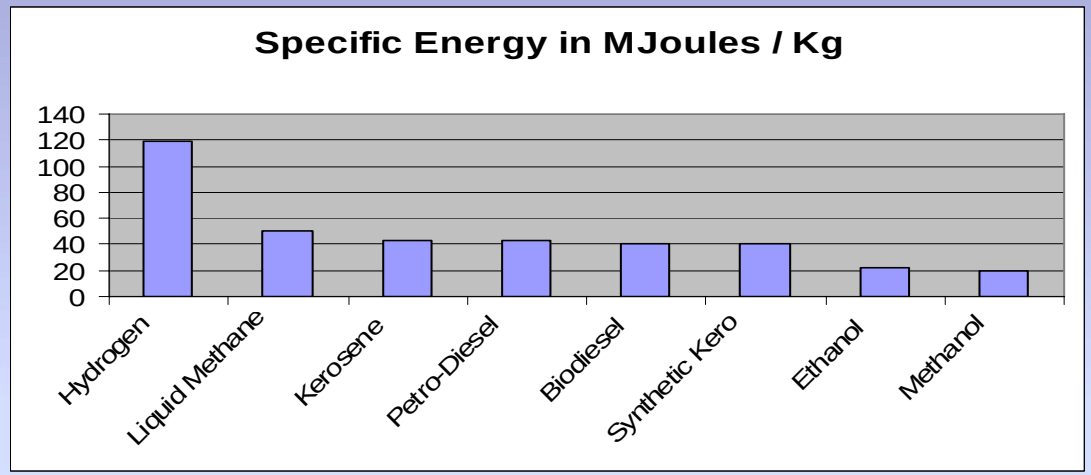
- Produced from coal, natural gas or biomass
- Fischer-Tropsch method
- Coal is converted to gas then to liquid
- Cleaner than petroleum kerosene with lower sulphur
- Sulphur acts as a lubricant and would need to be replaced by additives

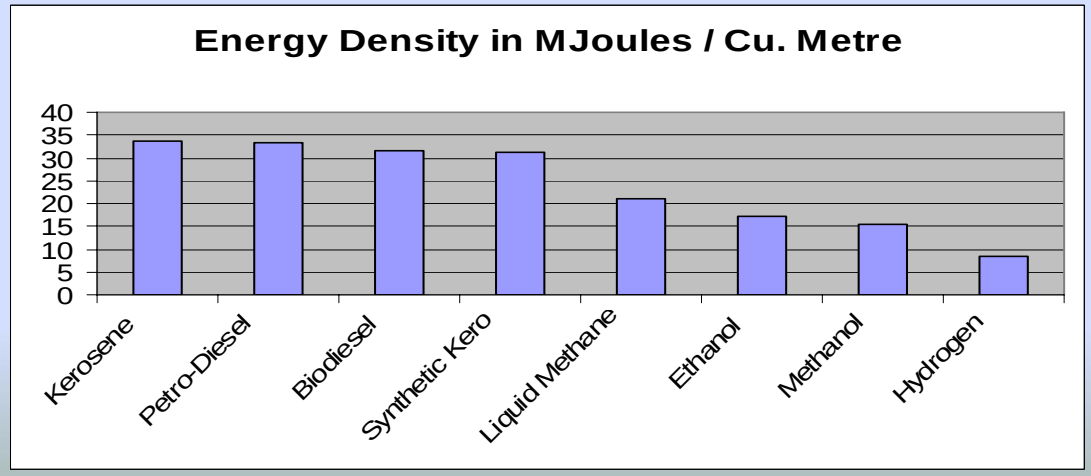
Alternative Fuels

Synthetics (Synfuel)

- Produced by Sasol of South Africa since 1999
- Current regulations permit a maximum of 50% synthetic fuel mixed with petroleum derived kerosene
- Already used on flights departing Johannesburg
- Aero Engine manufacturers expect to have a fully synthetic fuel approved in 2006

Alternative Fuels





Historically engines have been designed around fuel. It's time to design the fuel around the engine's needs. Synthetic fuels can help us do that.

Fred Biddle, Fuels Technology Manager, Pratt & Whitney

Conclusions

- Fuel efficiency and fuel conservation strategies will continue to dominate airline fuel policy
- Kerosene will continue to be used in aircraft with a gradual shift to synthetic fuel driven by availability and price
- Hydrogen powered aircraft offer little benefit until there is a world wide supply
- Global Warming emissions will continue to be a serious problem

Thank You