Fuel Conservation
A manufacturer's perspective

Alain Joselzon

Head of Engineering Environmental Strategy

Airbus for ICCAIA

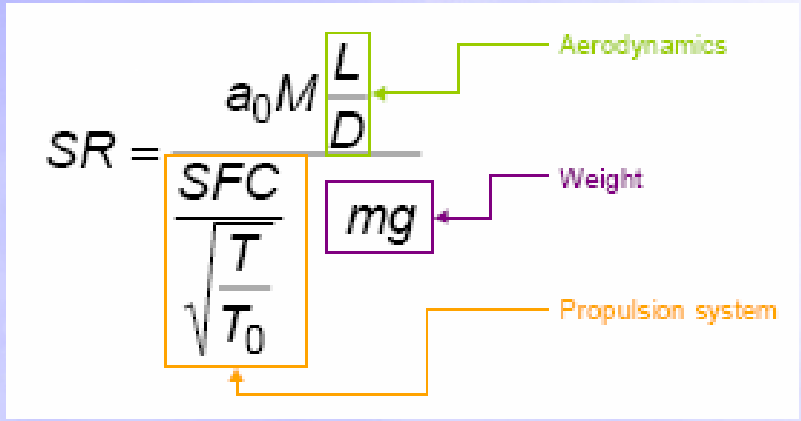
Contents

- Flight equation and Environmental protection
- The manufacturers' challenge
  - Technology
  - Efficiency
  - Research
  - Trade-offs
- What about the future?

The flight equation

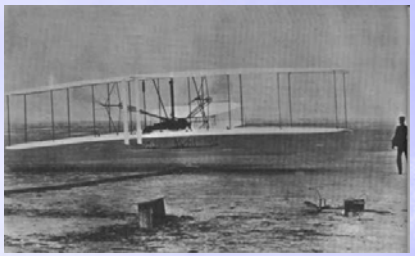
- Air transport's mission is to carry safely the highest commercial payload (passenger and/or freight) over an optimised route between two cities, with the minimum environmental impact.

SR : Specific Range
L : Lift
D : Drag
M : Mach Number
SFC : Specific fuel Consumption
T : Static Air Temperature



The manufacturers' challenge

- Safety is paramount
- Manufacturers design, sell, manufacture and support aircraft (airframe/engine/ systems combinations) that can accomplish the mission
  - Technological breakthroughs

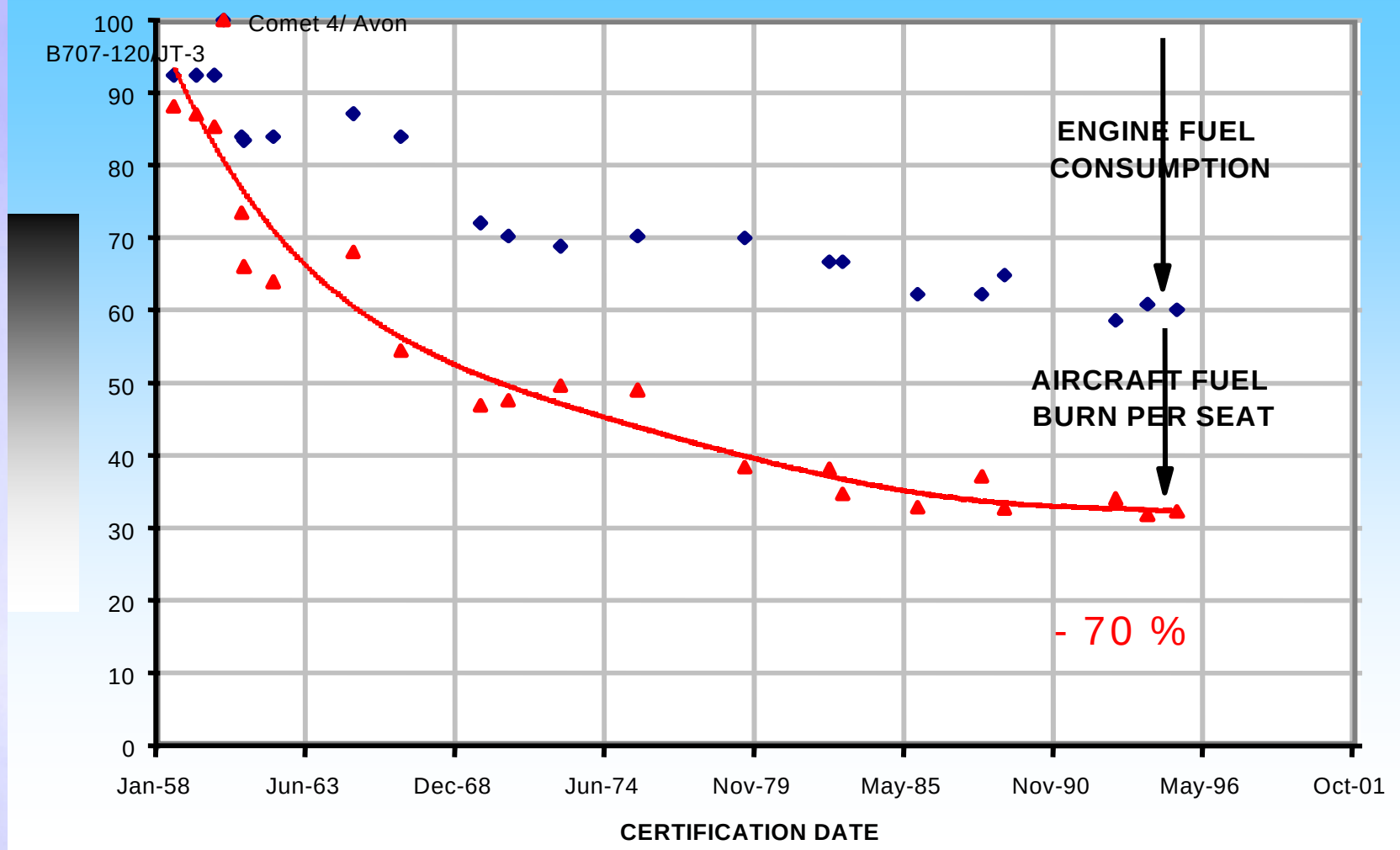



The manufacturers' challenge

- Reliability

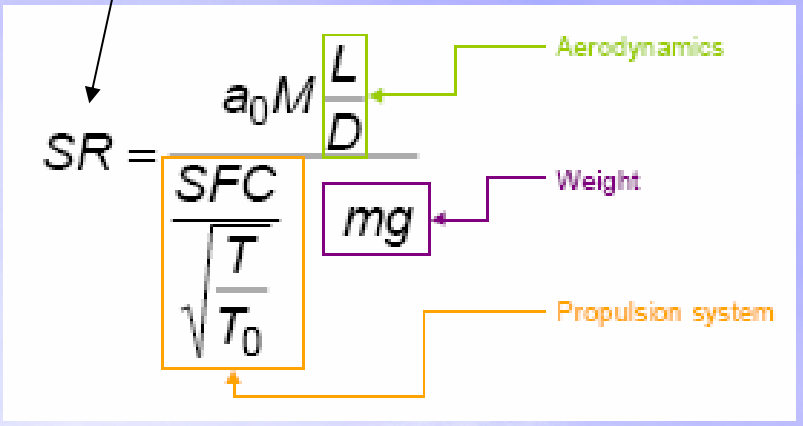
- Efficiency

The manufacturers' challenge : efficiency



The manufacturers' challenge

Specific Range



Aerodynamics :

- aircraft design
- engine integration
- increased laminar flow
- high lift devices
- new configurations

Weight :

- reduce MWE (Manufacturer's Weight Empty)
- advanced alloys
- progressive implementation of composite materials
- fly-by-wire

Propulsion system :

- engine technology
- fuel used
- associated systems and bleeds

The manufacturers' challenge : propulsion

- Reduce propulsion system SFC and weight
  - Increased T4°
  - Increased component efficiencies
  - Optimized / New propulsion systems configurations and concepts

$$SR = \frac{a_0 M \frac{L}{D}}{\frac{SFC}{\sqrt{\frac{T}{T_0}}}\, mg}$$

Aerodynamics

Weight

Propulsion system

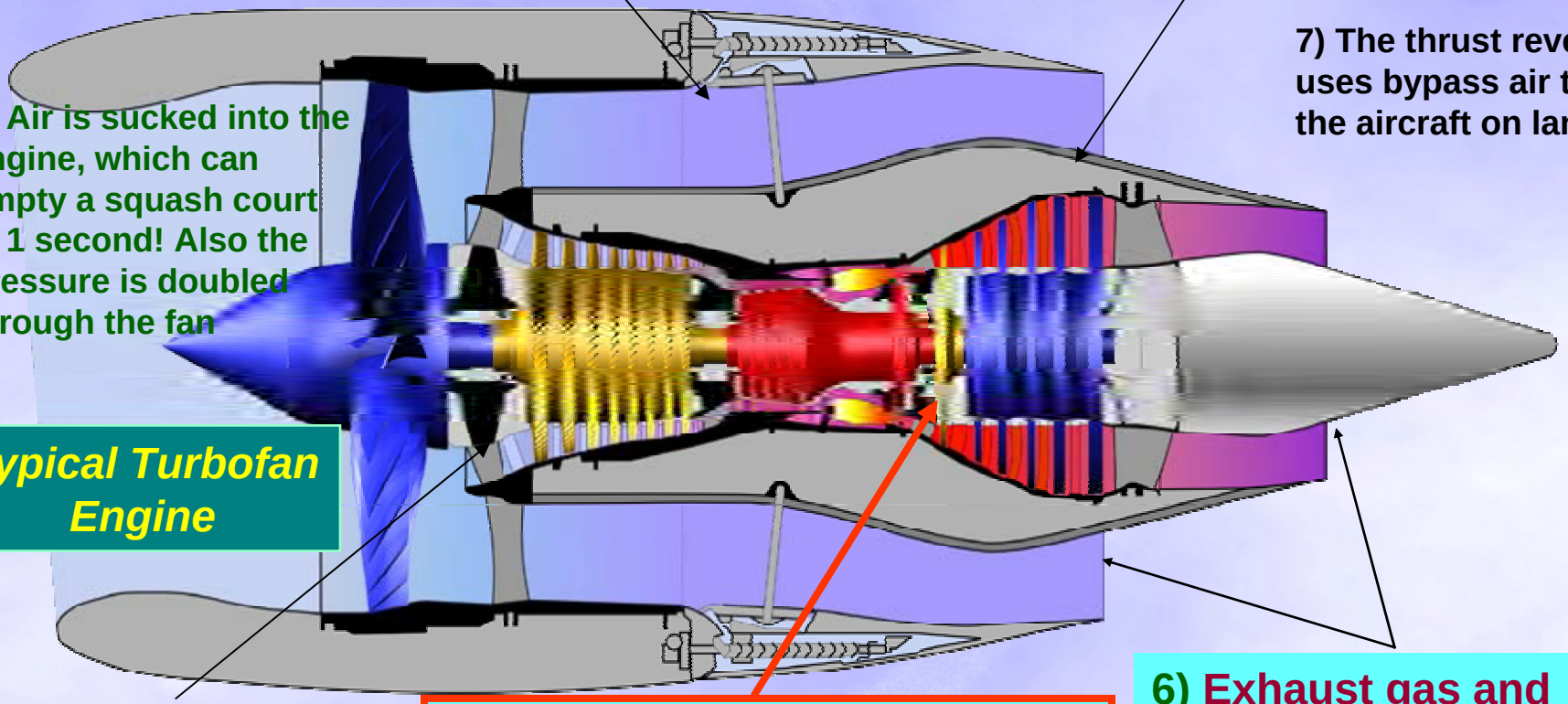
Aviation Emissions Source

3) 85% of the air bypasses the core and exits the engine

5) The hot gas expands through the turbine which takes energy out to drive the fan and compressor

7) The thrust reverser uses bypass air to slow the aircraft on landing

1) Air is sucked into the engine, which can empty a squash court in 1 second! Also the pressure is doubled through the fan



Typical Turbofan Engine

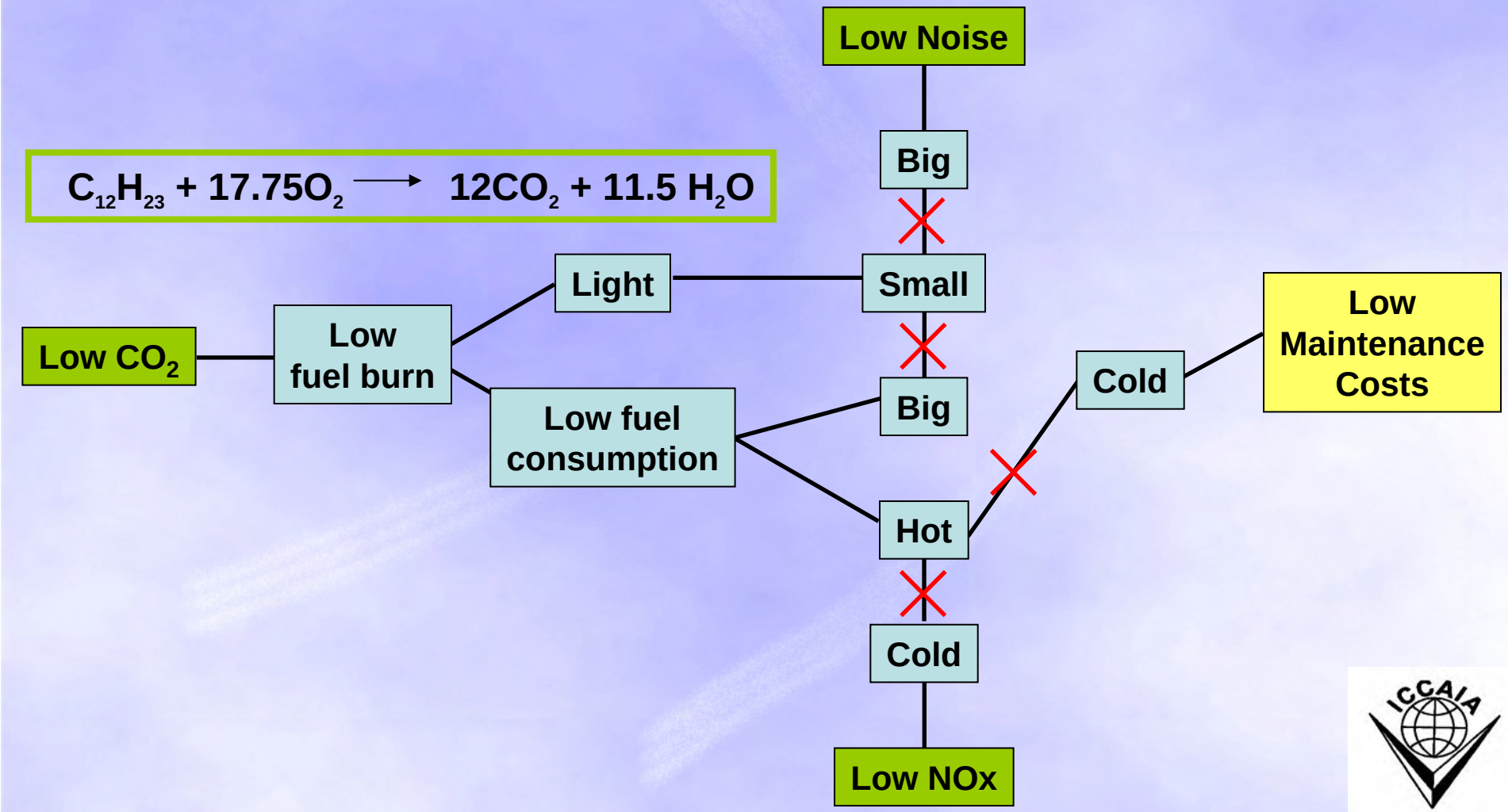
2) 15% of the air enters the core and is compressed to 40 times atmospheric pressure

4) In the combustion chamber fuel is mixed with air and burnt at temperature ≈ 1900 °K with peak ≈ 2600 °K

6) Exhaust gas and bypass air mix through hot and cold nozzles to produce thrust

The manufacturers' challenge: tradeoffs

$C_{12}H_{23} + 17.75O_2 \longrightarrow 12CO_2 + 11.5\ H_2O$

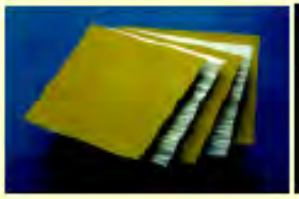


The manufacturers' challenge : weight

➢ Lighter materials

- Composites

- Advanced light Alloys (Ti, Al-Li, Mg), New Hybrid Alloys



- Innovative, smart materials

$$SR = \frac{a_0 M \frac{L}{D}}{\frac{SFC}{\sqrt{\frac{T}{T_0}}}\, mg}$$

Aerodynamics

Weight

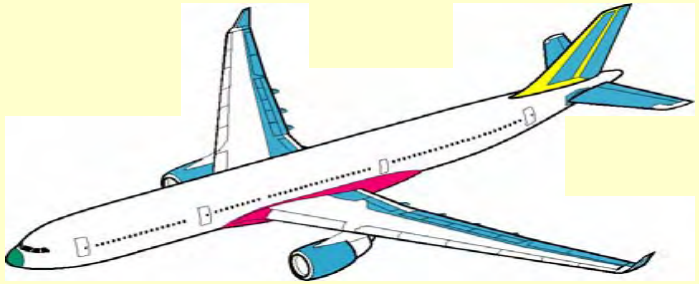
Propulsion system

Progressive introduction of advanced materials as the technology gets mature

Structural Weight Reductions

Composite + Advanced Materials

1990 (10-12% *)



« Materials Baseline »

**** Percentage of composites in structural weight***

2005 (20-25%*)

GFRP (Glass)
QFRP (Quartz)
CFRP (Carbon)
Metal
Glare

est. structural weight saving ~ 8%

2010-2015 (50-60%*)

Composite wing and fuselage

est. structural weight saving ~ 15%

The manufacturers' challenge : weight

- New manufacturing techniques
  - Welding
    - Electron Beam Welding
    - Laser Beam Welding
    - Stir Friction Welding
- Systems weight reductions
  - More electrical systems: Fly-by-wire (mechanical cables and pulleys replaced by electrical wires)
  - Lighter cables, new and optimized systems

$$SR = \frac{a_0 M \frac{L}{D}}{\frac{SFC}{\sqrt{\frac{T}{T_0}}}\, mg}$$

Aerodynamics

Weight

Propulsion system

The manufacturers' challenge : aerodynamics

- Improved aerodynamics
  - Less drag ⇨ less thrust to fly the aircraft
  - Less thrust per unit of weight ⇨ better efficiency and lower fuel burn
- Laminar airflow
  - Improve natural flow through structural optimization and improved integration (slats, flaps…)
  - Research on how to keep the airflow laminar

The manufacturers' challenge: configurations

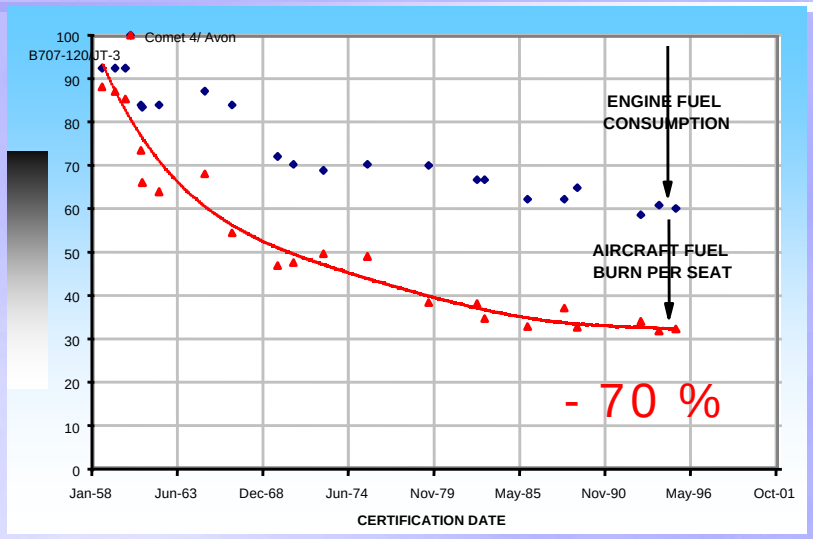
The manufacturers' challenge: configurations

Some of them will remain…

… paper aircraft…

… and others simply dreams.

The manufacturers' challenge: continuous improvement



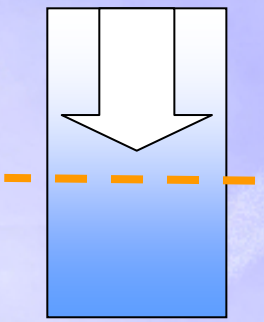
-70% in CO_2 emissions

in 40 years

Target 2020

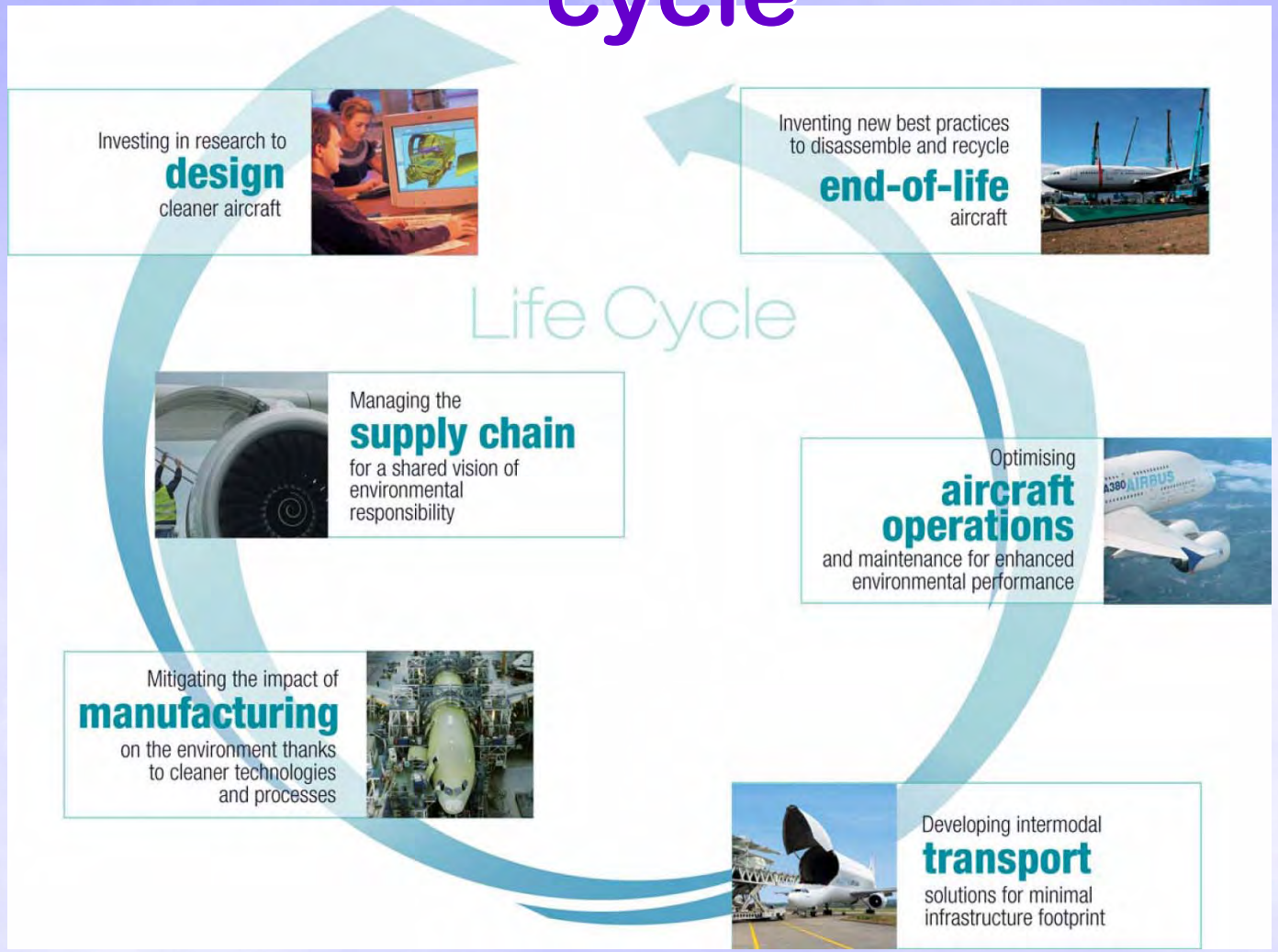
-50%

Fuel burn and CO2



Fuel: current aircraft are more efficient than average cars

The manufacturers' challenge: aircraft life cycle



What about the future?

- Keep committed to continuously improving the aircraft efficiency
  - Lower fuel burn ⇨ less CO_2 emitted
  - Technology alone can bring more than 1% improvement per year
  - Define optimum operational use of aircraft
- Need strong and powerful research programmes, supported by governments

What about the future?

- Research is key for our sector
  - Technology alone cannot solve the problem but is definitely part of the solution
    - Manufacturers together with research organizations are dedicated to intensive research aimed at developing new technologies
  - Scientific research can help to understand the remaining uncertainties (NOx, Contrails, cirrus…)
    - Manufacturers are also deeply involved in scientific research
  - Research will allow the sector to evaluate potential improvements in various fields, including that of alternative fuels.

What about the future?

- Alternative fuels
  - XTL or Anything To Liquid (GTL, CTL, BTL)
    - Manage the CO_2 emitted during the fuel transformation process
    - No modification of existing aircraft and/or engine design
  - Biofuels (additive to conventional fuels)
    - Chemical compatibility, Lower efficiency and affordability
  - Hydrogen (long-term horizon)
    - Not a fuel: need energy to produce it, new infrastructure for storage and supply
    - Bigger volume, new aircraft configuration
  - Fuel cells
    - Potential opportunities to replace auxiliary power units

What about the future?

- Keep a strong collaborative effort with key stakeholders
  - *Airlines* to optimise operations and maintenance (clean aircraft, performance monitoring, flight planning…)
  - *Airports* to implement innovative solutions (late engine run, reduce taxi time, innovative taxiing techniques, efficient power supply on ground…)
  - *Air traffic management* to improve operating procedures (more direct routes, better low-speed procedures, improved separation, CDA…)
  - *Regulators* to have a long-term vision together, define internationally applicable standards (ICAO to play a leading role).
  - *Governments* to keep a robust research activity

As for the future,
you do not have to foretell it,
but to enable it.

Antoine de Saint Exupery

Thank You