ACT GLOBAL

ICAO: UNITING AVIATION ON CLIMATE CHANGE

ICAO Colloquium on Aviation and Climate Change

Pushing the technology envelope: Aircraft manufacturers' views

Philippe FONTA
ICCAIA

Supporting a **greener future** for flight
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ICAO Headquarters, Montréal, Canada, 11- 14 May 2010

THE QUIET ARRIVAL

Reducing airport noise is the name of the game today. That's why we made the A300 the quietest transport flying.

The A300, first wide-body jet designed for short to medium haul routes, was created from the outset to comply with strict environmental criteria.

How quiet is the A300?

The area in which noise exceeds the 90 EPNdB nuisance level is only 4.4 square miles for the A300, most of that within airport limits. Compare that with the quietest wide-body airplane with its 7.6 square miles or the best narrow-body airplanes which, even when modified with expensive hush kits, affect 13.5 square miles. Older four-engine jets have a nuisance area of 58 square miles.

It's no surprise, therefore, that the US Federal Aviation Agency has certified the A300 as the world's quietest jet airliner. It's quieter even than most turbo-props now in service. That's why the A300 makes possible a new approach to the question of airport curfews to the benefit of both airlines and the public.

As quiet as the A300 is we can't emphasize too loudly the other superior features of the A300. Its huge underfloor cargo capability which brings added revenue. Its unequalled fuel efficiency. And its design features which are optimized to produce profits on short to medium length trips.

More reasons why the A300 is the right plane at the right time.

Airbus A300

The right plane at the right time.

FROM AIRBUS INDUSTRIE

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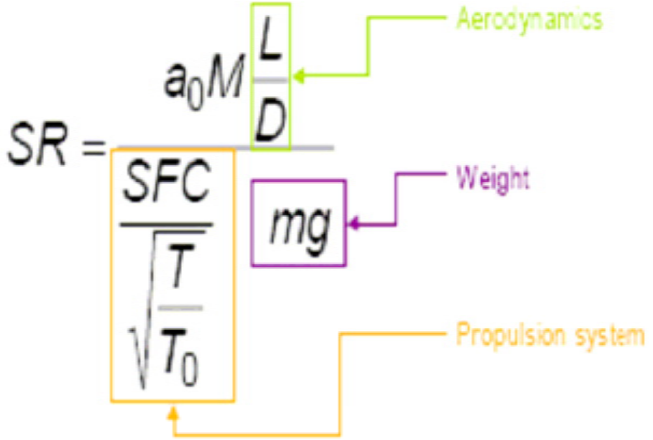
A continuous improvement process

- Each new airplane type bring substantial environmental benefits
- Major step changes that shape the world differently

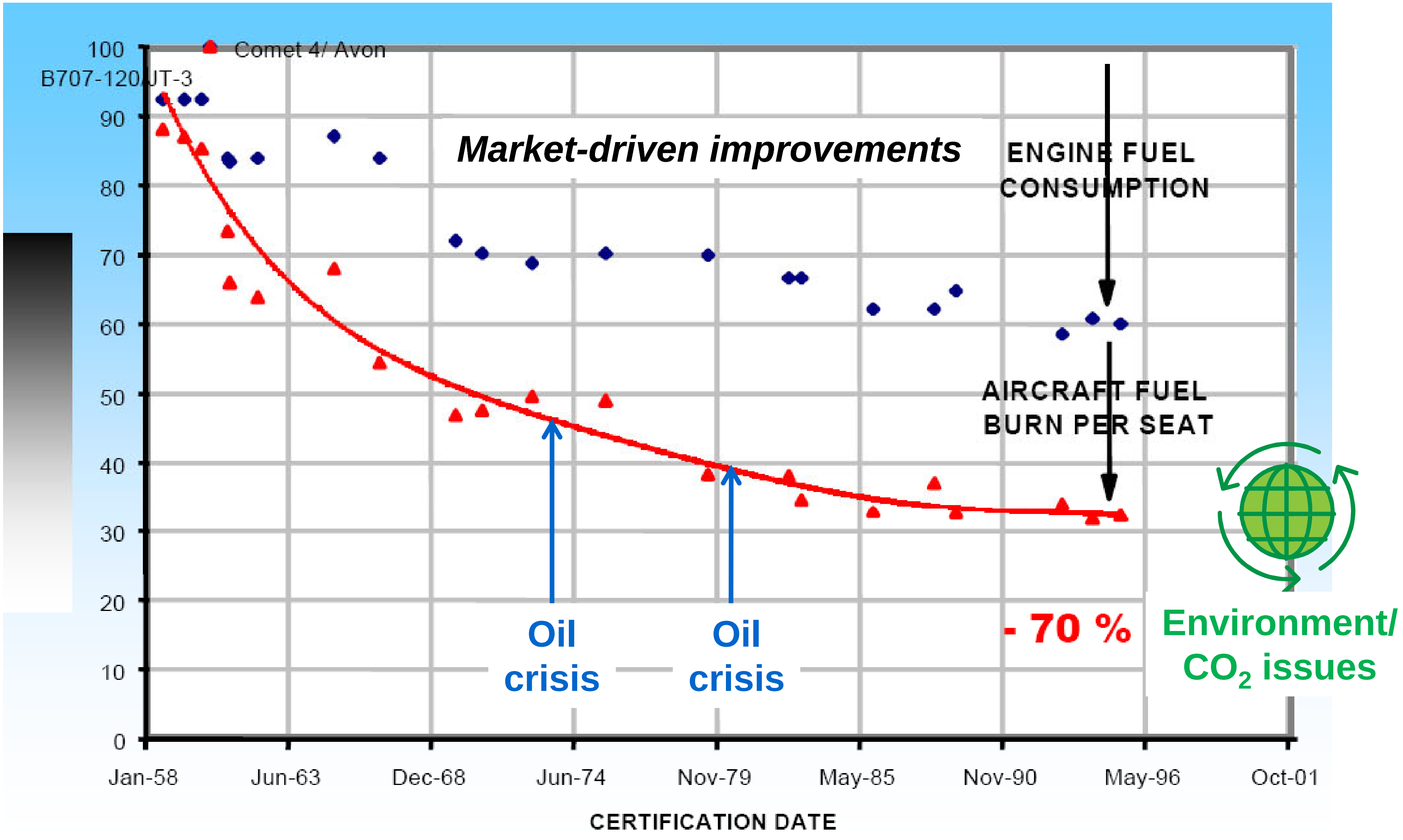
Understanding: the basics

- **Air transport's mission is to carry safely the highest commercial value (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**



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


Comet 4/ Avon
B707-120/JT-3
Market-driven improvements
ENGINE FUEL CONSUMPTION
AIRCRAFT FUEL BURN PER SEAT
Oil crisis
Oil crisis
- 70 %
Environment/ CO_2 issues
100
90
80
70
60
50
40
30
20
10
0
Jan-58
Jun-63
Dec-68
Jun-74
Nov-79
May-85
Nov-90
May-96
Oct-01
CERTIFICATION DATE

R&T - creating partnerships that matter

Objectives for 2020

50% reduction in CO_2

ACARE

Vision 2020

Aircraft manufacturers

CLEANSKY
Joint Technology Initiative
for Aeronautics & Air Transport
www.cleansky.eu

Engine manufacturers

SESAR consortium

Air and Traffic Mgmt

50% reduction in perceived noise

Noise reduction at source
Operational procedures

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80% NOx reduction

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National and Industry Collaboration for Environmental Excellence

FAA CLEEN program
-32 dB Noise Chapter 4
-60% NOX re: CAEP 6
-33% Fuel burn
And enabling introduction of alternative fuels

NASA Environmentally Responsible Aviation Program
-42 dB Noise Chapter 4
-70% NOX re: CAEP 6
-50% Fuel burn

NextGen ATM Transformation
Provide environmental protection that allows sustained aviation growth

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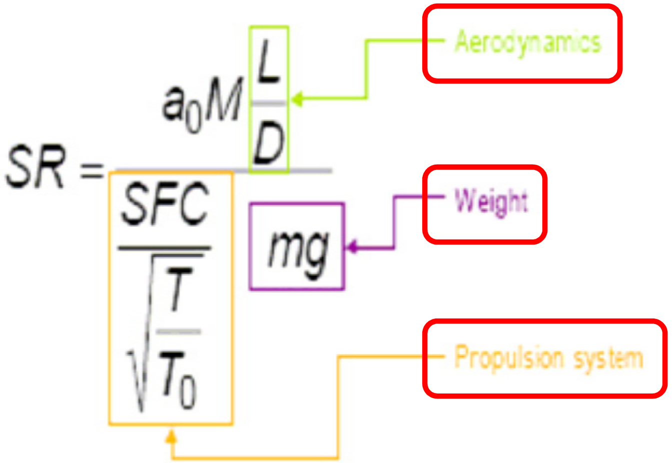


$$SR = \frac{a_0 M \frac{L}{D}}{\frac{SFC}{\sqrt{\frac{T}{T_0}}} mg}$$

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

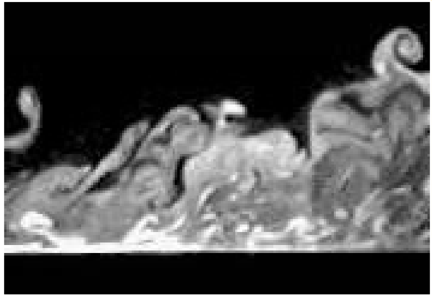
Propulsion system :
- engine technology
- fuel used
- associated systems and bleeds

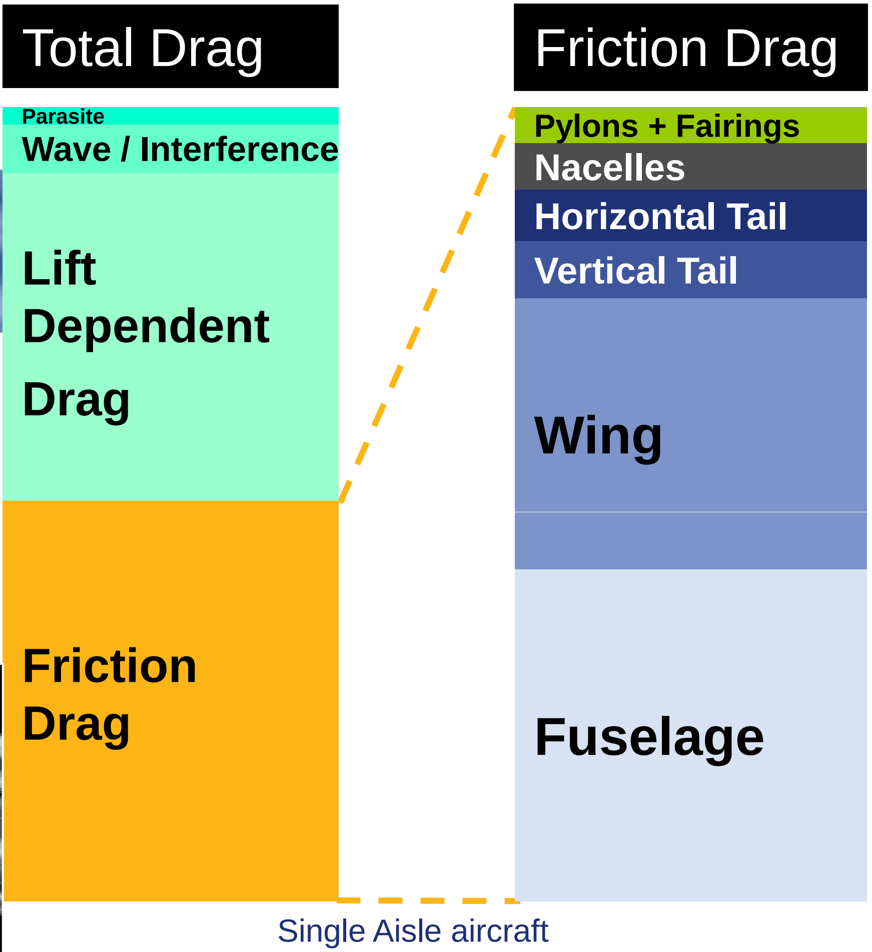
Weight:
- advanced alloys
- progressive implementation of composite materials
- fly-by-wire
- manufacturing techniques

Aerodynamics

- Improved aerodynamics
  - Less drag, so less thrust to fly the aircraft
  - Less thrust per unit of weight leads to 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

Aerodynamics





Total Drag

Parasite

Wave / Interference

Lift Dependent Drag

Friction Drag

Friction Drag

Pylons + Fairings

Nacelles

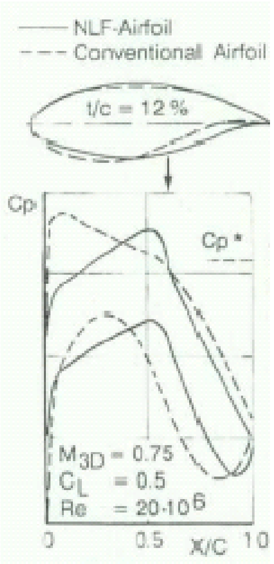
Horizontal Tail

Vertical Tail

Wing

Fuselage

Single Aisle aircraft



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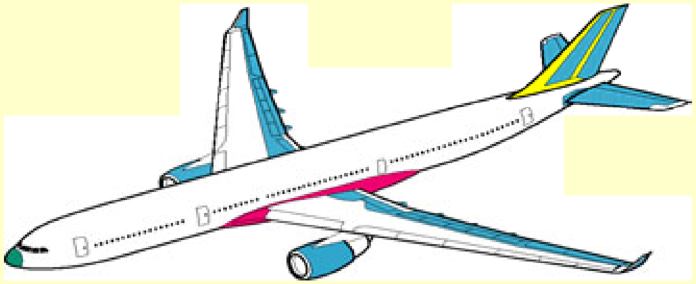
Wing offers *(besides fuselage)*
highest potential for friction drag reduction

Structural Weight Reductions: a considerable progress story

Composite + Advanced Materials

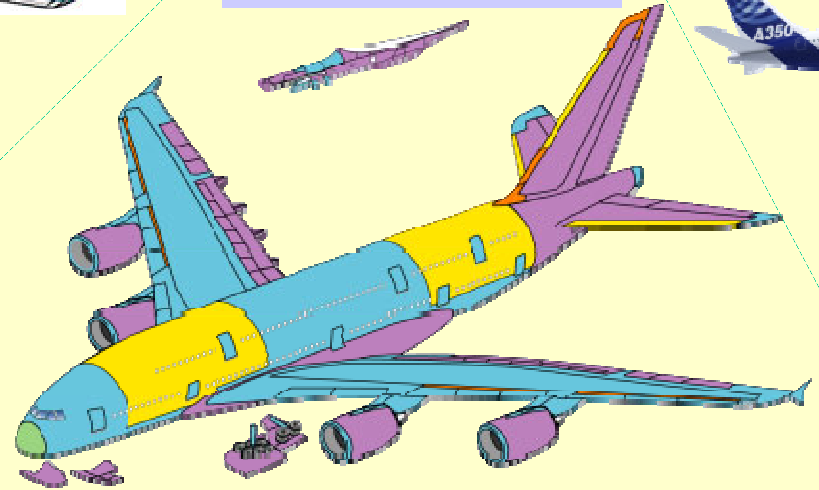
*1990 (10-12% *)*



« Materials Baseline »

** Percentage of composites in structural weight*

2005 (20-25%)*



🟧 GFRP (Glass)
🟩 QFRP (Quartz)
🟪 CFRP (Carbon)
🟦 Metal
🟨 Glare

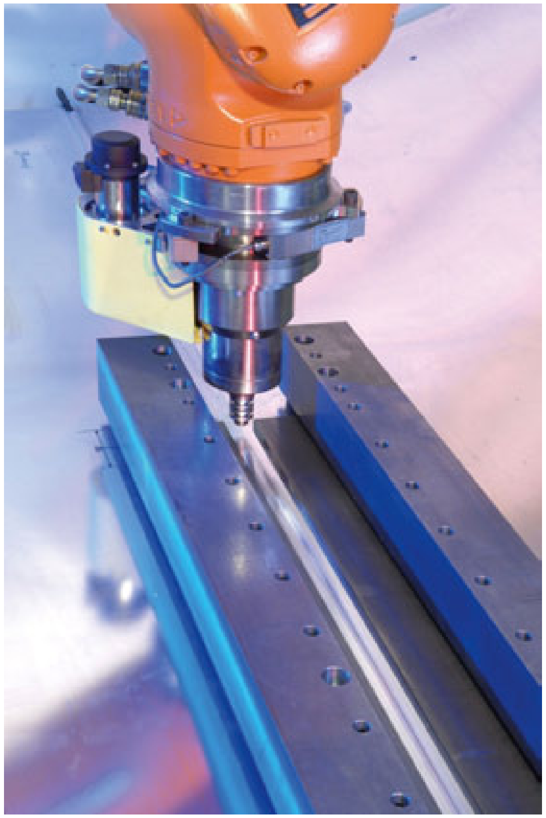
est. structural weight saving ~ 8%

2010-2015 (50+%)*

Composite wing and fuselage

est. structural weight saving ~ 15%

Weight reduction



- 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)
- Eco-design (for lower life-cycle environmental foot-print)

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Steve CSONKA
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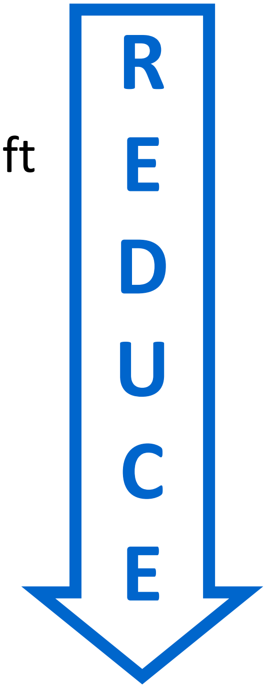
Our task … Technology Investment to provide clean, quiet, affordable, reliable, efficient power

- **Fuel consumption**
- **Emissions** – LTO & Aloft
- **Noise**
- Ownership cost
- Maintenance cost
- Disruptions
- Installation impact



… a continuous improvement process

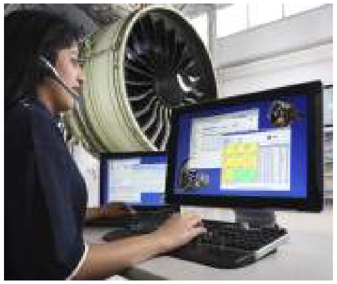
Investment for in-service / in-production

- Multiple **engine upgrade programs** in last decade delivering up to 2% fuel burn*
  - CFM56-TI, CFM56-E
  - Tech CF6, CF34-3B Upgr., GE90-115B Mat'y
  - V2500 SelectOne
  - PW4000 Advantage70
  - Trent 700 EP
- Additional progress on certified / fielded engines difficult due constraints of physics

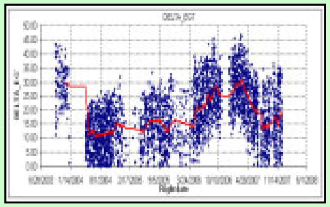
*via efficiency and retention improvements

Investment for in-service / in-production

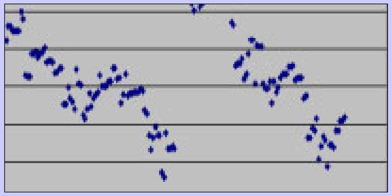
- Using data/analysis to **find inefficiencies**
  - Data-driven operational consulting
  - Prognostics/Diagnostics monitoring
  - Performance-focused workscoping



Operation & Customer CTQs



Diagnostics



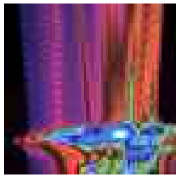
Module Health

Workscope

Investment for in-service / in-production

- Keeping engines **operating at peak** efficiencies
  - Engine wash
  - Improving overhaul & restoration processes

Engine Washing

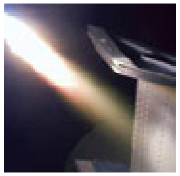


Inspection

Cleaning

Joining

Specialized Welding



Coating

Metal Addition

Investment in technology for carbon relief from jet-fuel … tomorrow!

- Alternative fuels development and proving
- Component, rig and engine ground tests to support airline flight tests
- Finalizing testing of BSPK; Supporting ASTM approval of up to 50/50 blends within ~12 months
- Extensive ongoing research into other biological sources of jet fuel

Investment for new product development

- **New engine/APU programs**, designed to target 15+% reductions in fuel burn versus the aircraft they replace

  B&GA: G250, G650, Legacy 450/500

  Regional: ARJ, MRJ

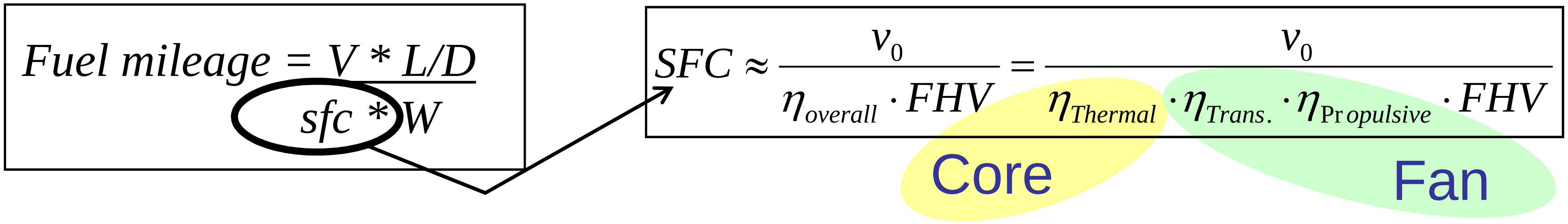
  Transcon: C919, C-Series, Superjet

  Long Range: 787, 747-8I, A350

Enabling Technologies:

- Materials
- Coatings
- Aerodynamics
- Combustion
- Cooling
- Sensors
- Modeling
- Integration
- Producibility processes

Investment for future improvements



$$Fuel\ mileage = \frac{V * L/D}{sfc * W}$$

$$SFC \approx \frac{v_0}{\eta_{overall} \cdot FHV} = \frac{v_0}{\eta_{Thermal} \cdot \eta_{Trans.} \cdot \eta_{Propulsive} \cdot FHV}$$

- **Our Efficiency Tools (delivering ~1%/yr):**
  - Thermal Efficiency: Higher OPR, Better Aero
  - Transmissive Efficiency: Components & Architecture
  - Propulsive Efficiency: Lower FPR => Grow Fan
  - Weight Reduction: Composites, Advanced Alloys
  - Advanced Integration: Control impact of size

Investment for the next generation

- Driving to Thermal Efficiency with **OPR and cycle refinements**:
  - Recuperative/Regenerative Intercooled engine cycle
  - Wave rotor engine
  - Pulse detonation
  - Adaptive cycles features

Must "Balance" Design:

- Higher temperatures vs. severity/cost
- Higher complexity vs. weight/drag/cost
- Unique approaches vs. reliability

Investment for the next generation

- Driving to Propulsive Efficiency with **architectures**
  - Advanced Turbofan
  - Advanced Geared Turbofan
  - Open Rotor
  - Hybrids, Distributed Thrust, …

  . . . Each with their own multi-generation product development plans

… and the path to 2050 -vs- s.o.a.

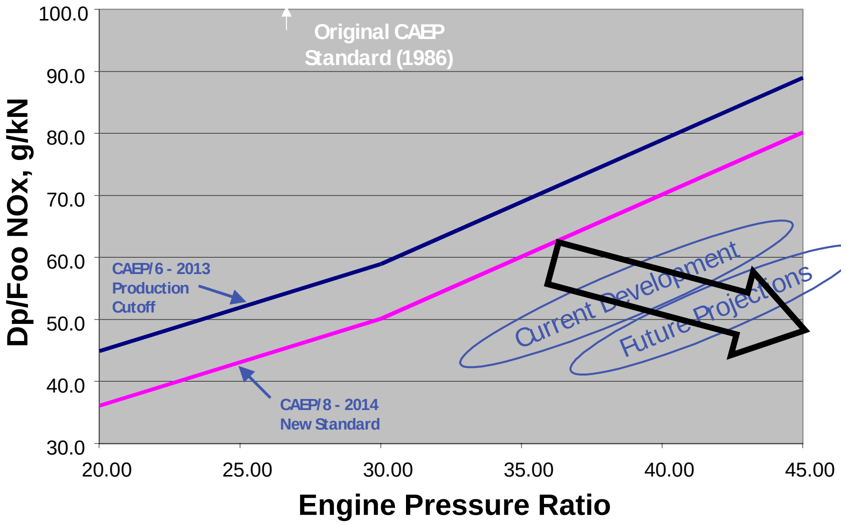
- Brayton entitlement 3 decades to go

… and in no particular order, or TRL

- Adaptive features + ~ 10%
- Integrated power + ~ 10%
- Hybrid propulsion + tbd%
- Beyond Brayton Cycle + ~20%
- “Zero-carbon” energy sources

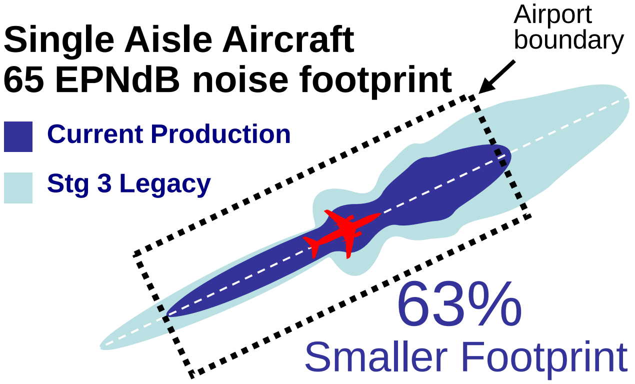
Emissions

- Staying ahead of advancing stringency
  - Advanced RQL systems
    - PW TALON X
    - RR Phase 5
    - HON SABER
  - Lean-burn, low-emissions combustion systems
    - GE TAPS
    - RR Lean Burn

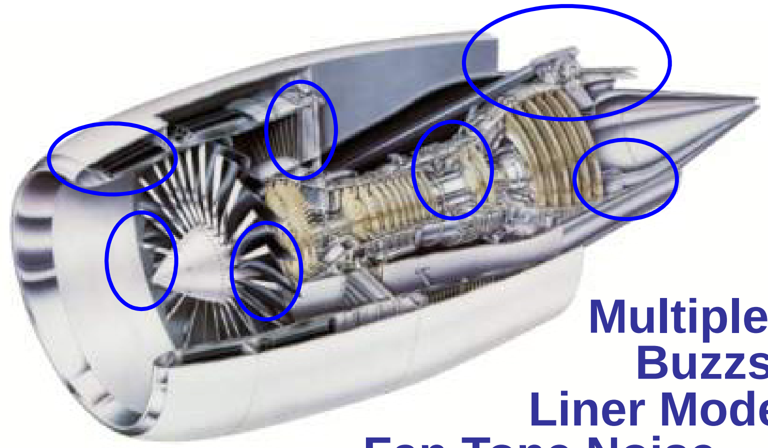


Noise

Single Aisle Aircraft
65 EPNdB noise footprint



- Continuing to make progress
- Pursuing Source reductions
  - Advanced acoustics elements and architecture solutions:



Jet Noise Fluidics

Core Noise

Combustor Noise

Fan Broadband Noise

Slowing the Fan – GTF

Open rotor mitigation

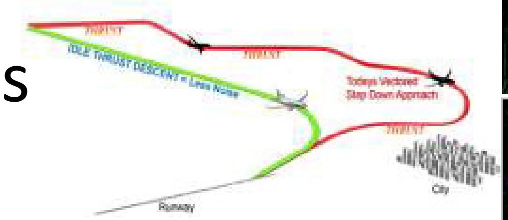
Multiple Pure Tone / Buzzsaw

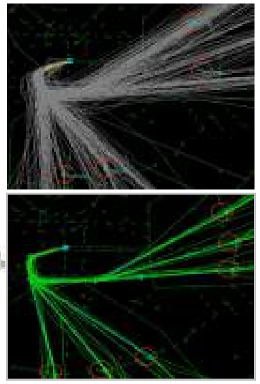
Liner Modeling

Fan Tone Noise

Shock-Cell Noise

- Operational improvements





Summary

- Propulsion: a continuous improvement process
  - Via in-service upgrades and airline assistance
  - Via pending new product introductions
  - Via next-generation concepts
- Industry making significant investments (& progress)
  - Fuel, Emissions, and Noise
  - Quicker carbon relief can come from bio-fuels
- Appreciative of government investments in research programs
- Many opportunities for further dramatic reductions in fuel burn via integrated development with airframers

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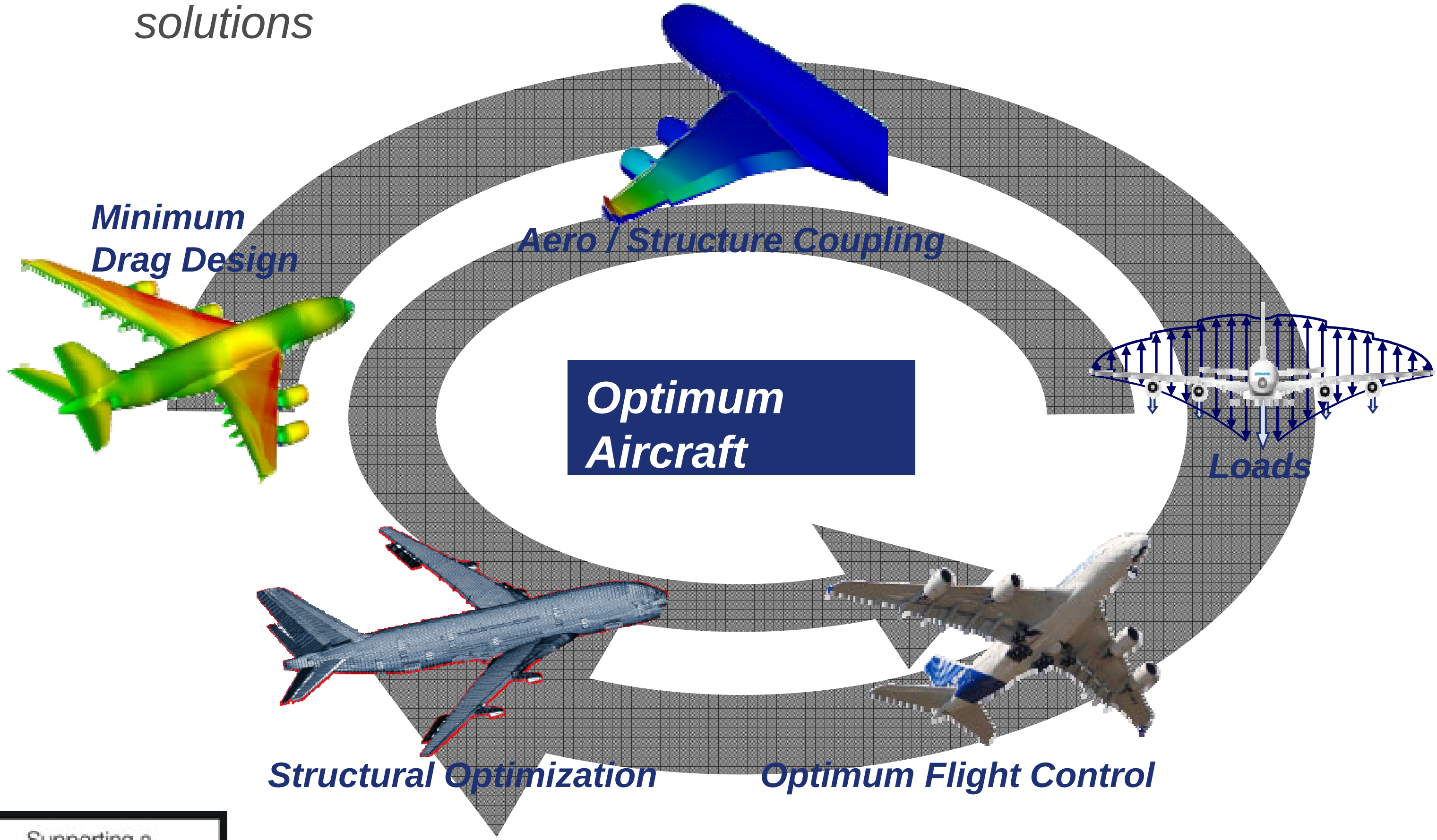
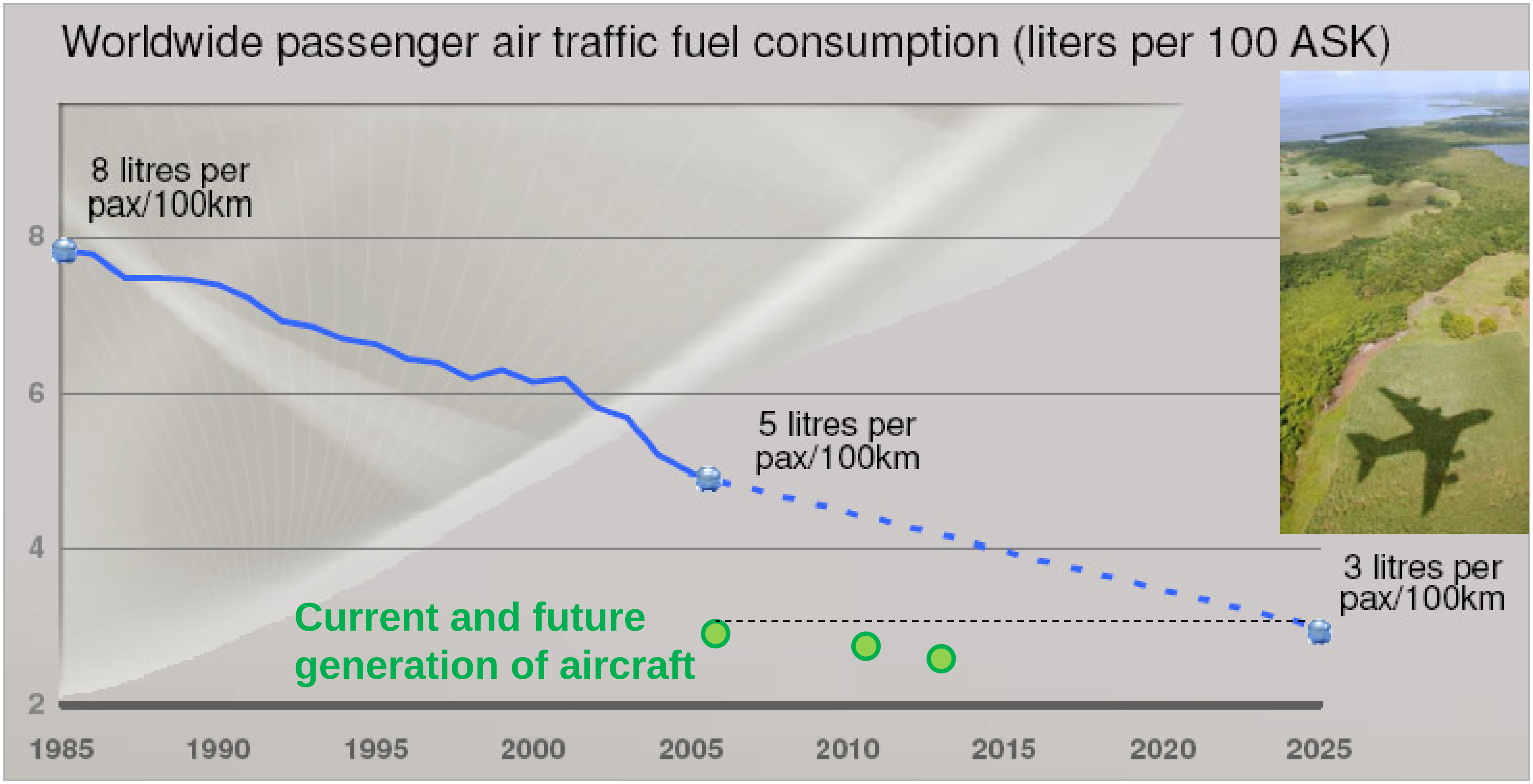
Rethinking Design Methodologies

- Full Integration of Wide Range of Aircraft Design Disciplines

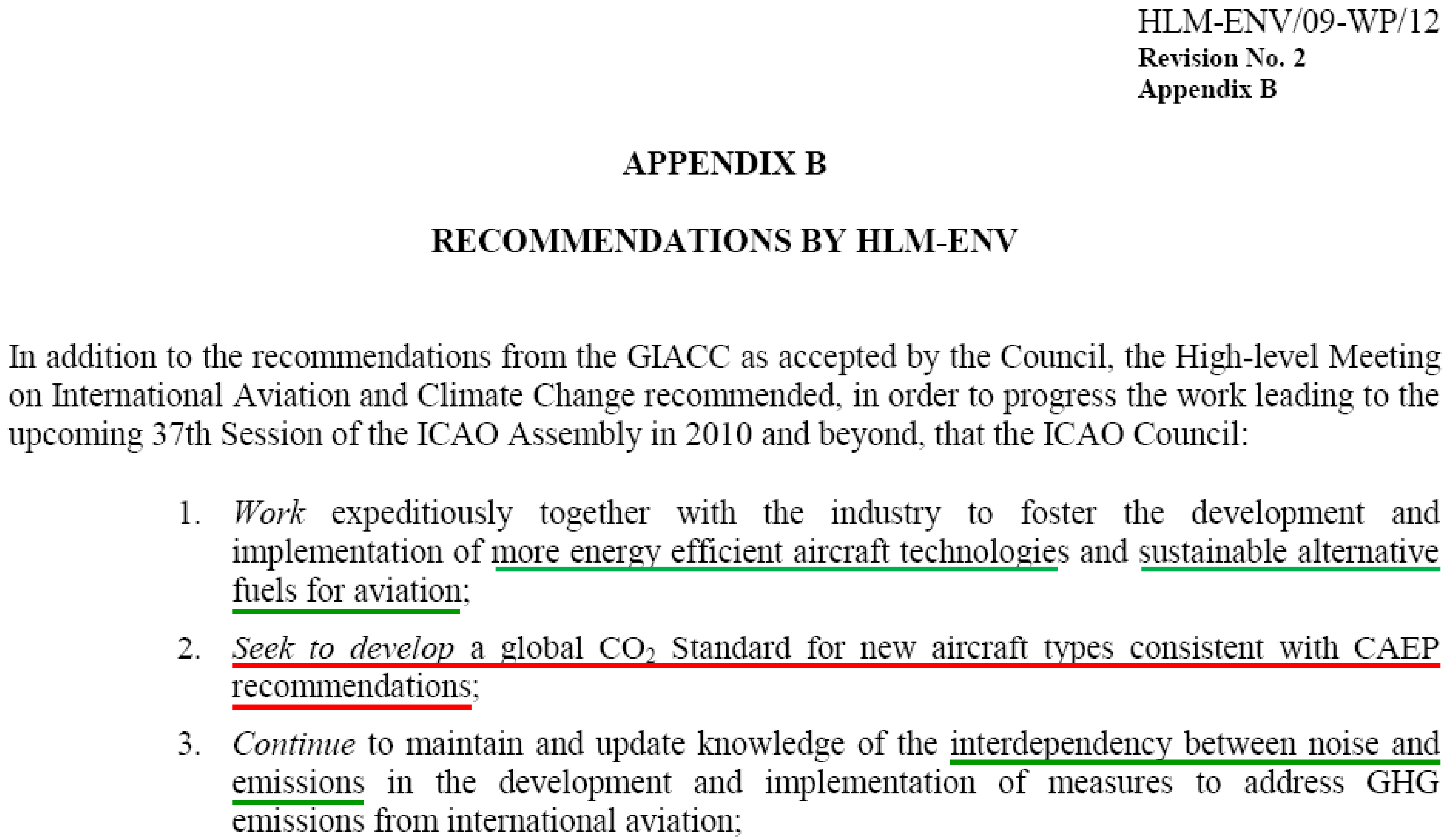
Multi-Disciplinary Design enables exploration of new design solutions



Optimum Overall Aircraft Performance through Multi-Disciplinary Design



Fleet modernisation is one key element



HLM-ENV/09-WP/12
Revision No. 2
Appendix B

APPENDIX B

RECOMMENDATIONS BY HLM-ENV

In addition to the recommendations from the GIACC as accepted by the Council, the High-level Meeting on International Aviation and Climate Change recommended, in order to progress the work leading to the upcoming 37th Session of the ICAO Assembly in 2010 and beyond, that the ICAO Council:

1. *Work* expeditiously together with the industry to foster the development and implementation of more energy efficient aircraft technologies and sustainable alternative fuels for aviation;
2. *Seek to develop* a global CO_2 Standard for new aircraft types consistent with CAEP recommendations;
3. *Continue* to maintain and update knowledge of the interdependency between noise and emissions in the development and implementation of measures to address GHG emissions from international aviation;

New configurations

And for the future?

Some will remain
paper aircraft…

… and others simply dreams.

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A global problem that needs a global solution

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Each stakeholder has a part to play in meeting the challenge

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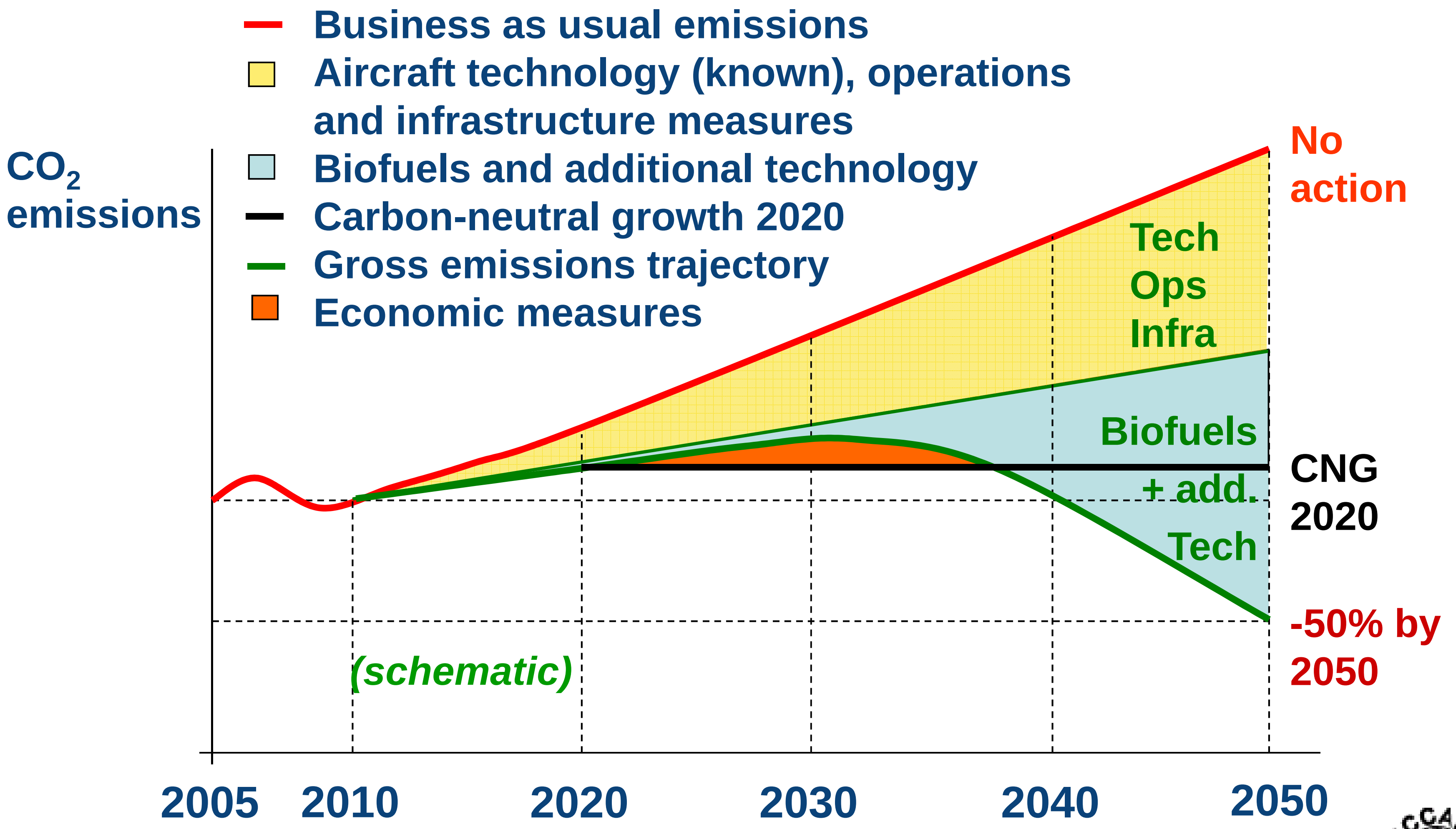
United industry’s common position

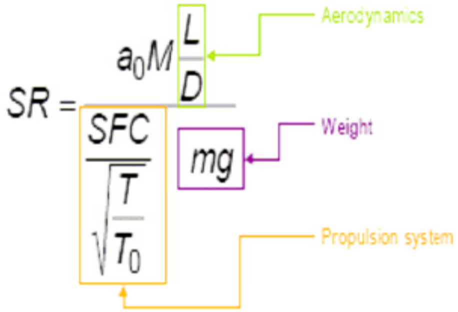
- A global sectoral approach for a global issue
- ICAO plays a leading role in managing the emissions from aviation
- Industry’s commitments
  - 1.5% improvement per year in average in terms of fuel efficiency
  - Carbon-neutral growth from 2020
  - Absolute reduction of net CO_2 emissions by 50% in 2050, compared to 2005 levels.

Industry emissions reduction roadmap



The political dimension

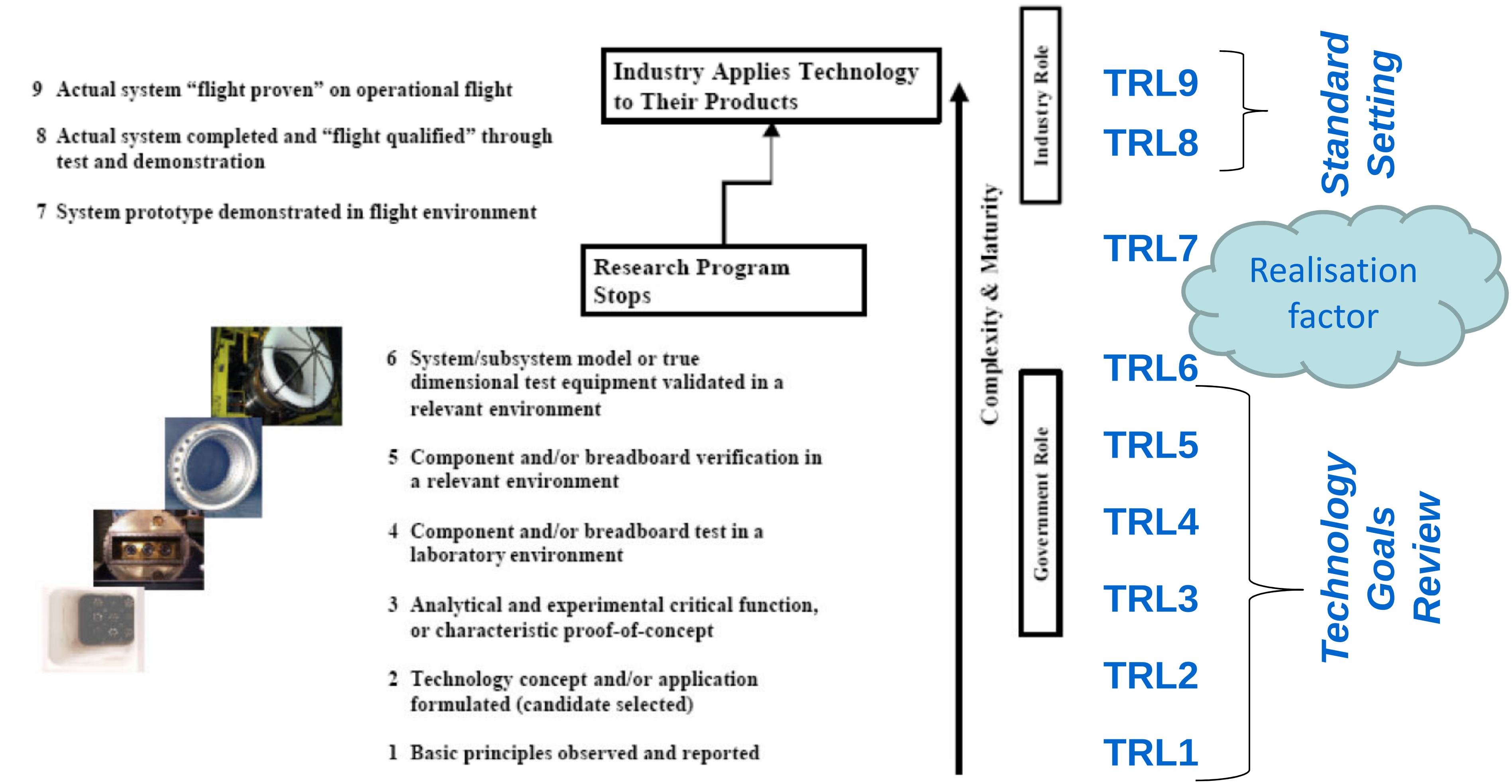
- Flight physics is and will remain unchanged



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

- Society’s expectations and political context do change
  - A lot of pressure
- Industry and policy makers must cooperate in anticipating the society’s needs and work on ambitious research programmes

Technology Readiness Level



9 Actual system "flight proven" on operational flight

8 Actual system completed and "flight qualified" through test and demonstration

7 System prototype demonstrated in flight environment

6 System/subsystem model or true dimensional test equipment validated in a relevant environment

5 Component and/or breadboard verification in a relevant environment

4 Component and/or breadboard test in a laboratory environment

3 Analytical and experimental critical function, or characteristic proof-of-concept

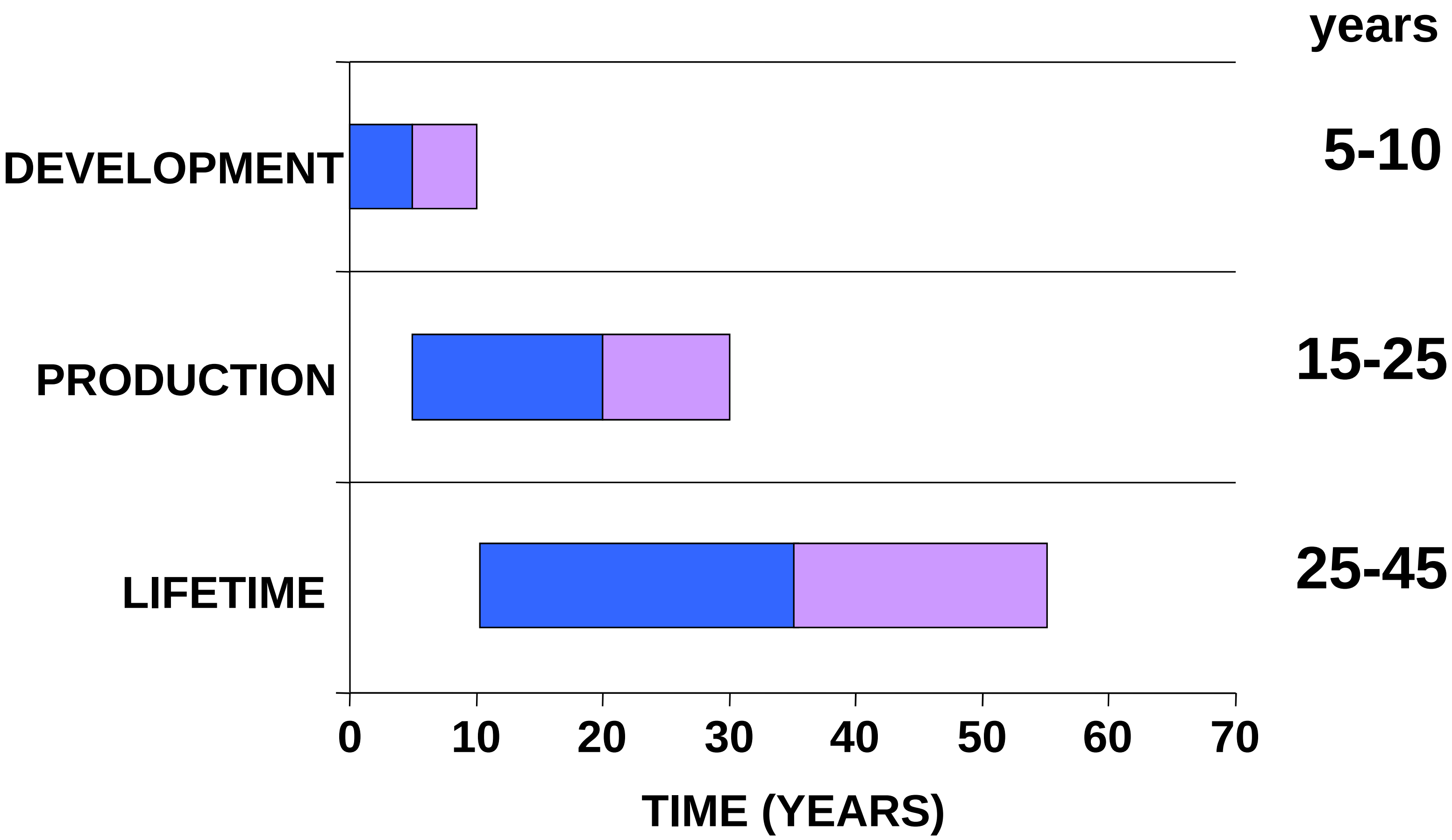
2 Technology concept and/or application formulated (candidate selected)

1 Basic principles observed and reported

Industry Applies Technology to Their Products

Research Program Stops

A long life-cycle industry



We need a clear, fair and stable regulatory framework

Conclusion

- Safety, performance and efficiency (including environmental efficiency) are and remain high on the industry's agenda
  - Technical parameters are unchanged
  - Low carbon alternative fuels are one new additional option
  - R&T is key
- The society's expectations and political context are fast evolving, under extreme pressure.
  - Need to reconcile short-term pressure-driven expectations and technological breakthroughs for a long life-cycle industry
  - Stable and fair regulatory framework to support R&D investments
- Partnerships are essential
  - Optimise resources
  - Build and maintain trust among stakeholders