ICAO ENVIRONMENT

The Independent Expert Integrated Review, IEIR

Dimitri Mavris

Regents Professor,

Georgia Institute of Technology

and Co-Chair IEIR

CAEP Memo 102, Attachment A, (4th July 2016):

- A scientific overview of aviation environmental effects related to the aircraft and engine at source;
- For each technology, assess the possibility of noise reduction and fuel efficiency improvement, with specific focus on the interdependencies and trade-offs between fuel efficiency and noise;
- An assessment of the technological possibilities for NO_x and non-volatile Particulate Matter (nvPM) emissions control with specific focus on the interdependencies and trade-offs between fuel efficiency and/or noise.

The Independent Expert Integrated Review (IEIR) Panel

- Co-chairs:

  Nick Cumpsty (UK) and Dimitri Mavris (USA)
- 15 Independent Experts drawn from 7 nationalities:

  Fernando Martini Catalano (Brazil)
  David Zingg (Canada)
  Chris Eyers (EC)
  Marius Goutines (France)
  Alain Joselzon (France
  Juan Alonso (ICSA)
  Iurii Khaletskii (RF)
  Tomas Gronstedt (Sweden)
  Frank Ogilvie (UK)
  Malcolm Ralph (UK)
  Jim Hileman (USA)
  Jayant Sabnis (USA)
  Rich Wahls (USA)

Technology Reference Aircraft

Four types of aircraft considered each with notional reference aircraft selected

Aircraft Class	Number of Seats	Notional Aircraft
Business Jet (BJ)	< 20	Gulfstream G650ER
Regional Jet (RJ)	20 – 100	Embraer E190-E2
Single Aisle (SA)	101 – 210	Airbus A320neo
Twin Aisle (TA)	211 – 300	Airbus A350-900

BJ

RJ

SA

TA

Process to Assess the Technology Goals for each Technology Reference Aircraft

STEP I:
2017 Reference TRA

→

STEP II:
2017 TRA optimized

→

STEP III:
2027 & 2037
Setting Metrics,
Interdependencies & Goals

Technologies:
Fixed at **2017** TRA levels

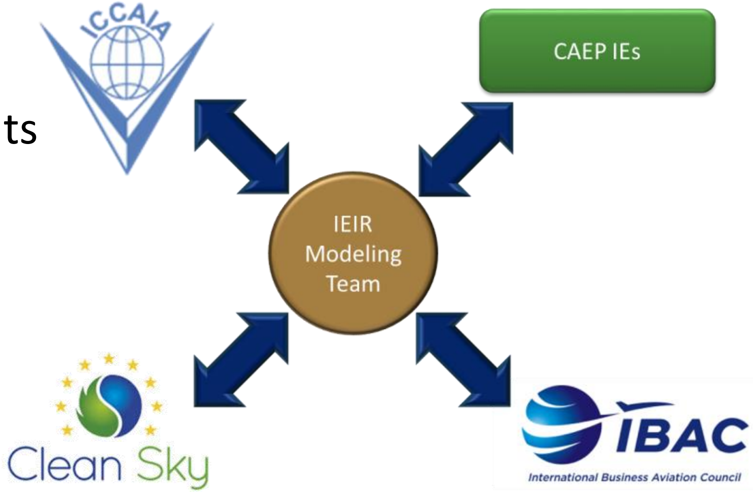
Design Parameters:
Vary over parameter ranges

Technologies:
Vary at three confidence levels (High, Nominal, Low)

Design Parameters:
Vary over parameter ranges

Implementing Future Technologies

- To protect proprietary data, **technology improvements** were received from ICCAIA for each timeframe (2027 and 2037) in following high-level areas
  - Aerodynamics: drag
  - Noise: airframe & engine noise sources
  - Structures: fuselage, wing and empennage weights
  - Propulsion: cycle, efficiencies, nacelle drag & weight, component weights
- Technology improvements given were applied to 2017 TRA at three confidence levels:
  - Low
  - Nominal
  - High
- Extensive interactions with industry and IEs

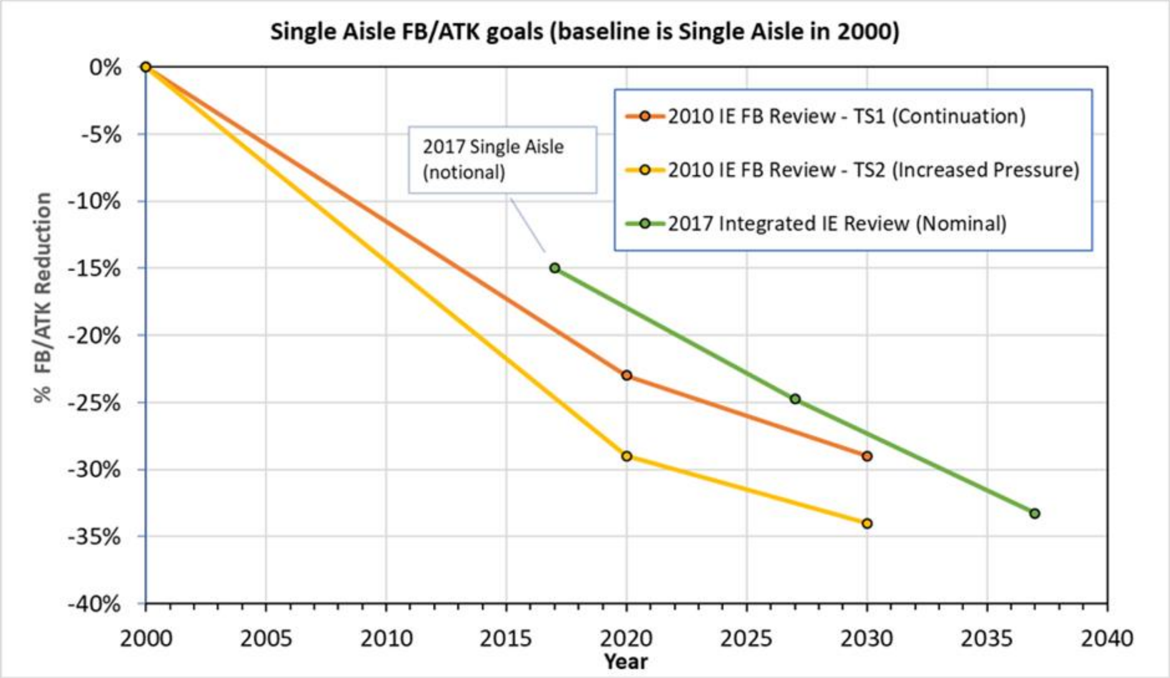


Single-Aisle TRA and Optimization

- Notional Airbus A320neo – Technology Reference Aircraft model
  - Assumed design payload 165 pax (15 Business & 150 Economy)
  - Design range of 3,500 nm
  - Two geared fan engines
- Optimized Vehicles
  - Varying design parameters to minimize fuel burn, noise, and NOx separately
  - Technology benefits held at three fixed levels agreed with ICCAIA , plus 7% increase in L/D
  - Subject to mission, wing span, and ground clearance constraints
- All vehicles are resized for all combination of design parameters and technology benefits.
- No NO_x combustion technology improvements in modeling

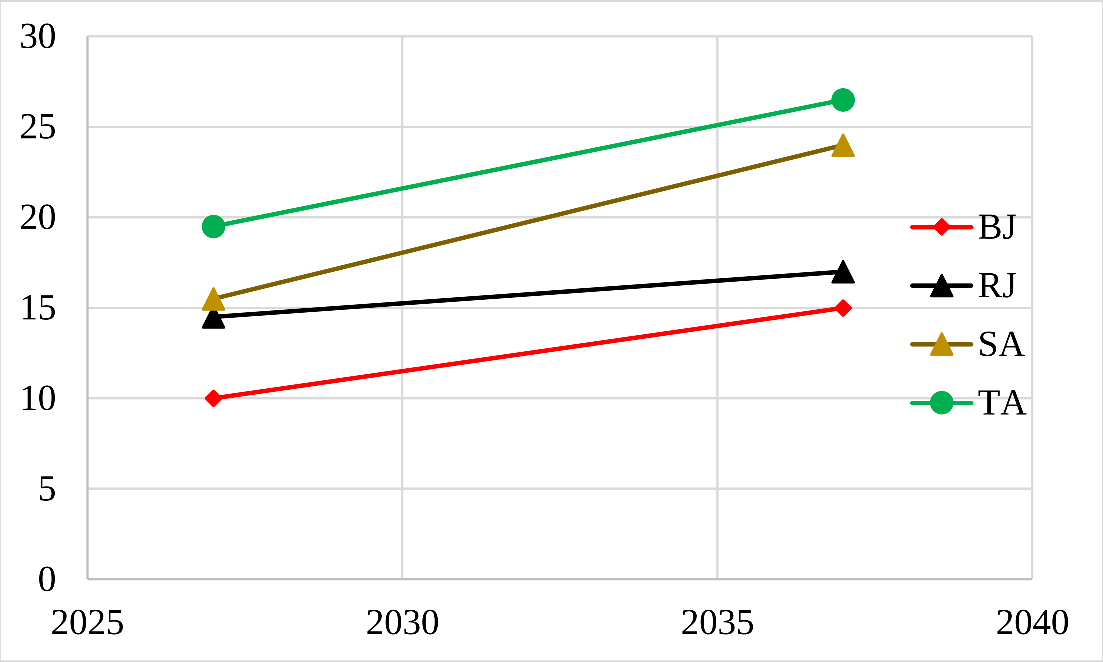
- Current goals compared with earlier IE goals expressed as annual change in Fuel -Burn per available tonne kilometer Metric (FB/ATK) relative to the respective baselines for each review measured at the R1 point in the payload-range diagram

- Current IEIR technology assessments reveal that the prior goals were more optimistic than the 2010 review

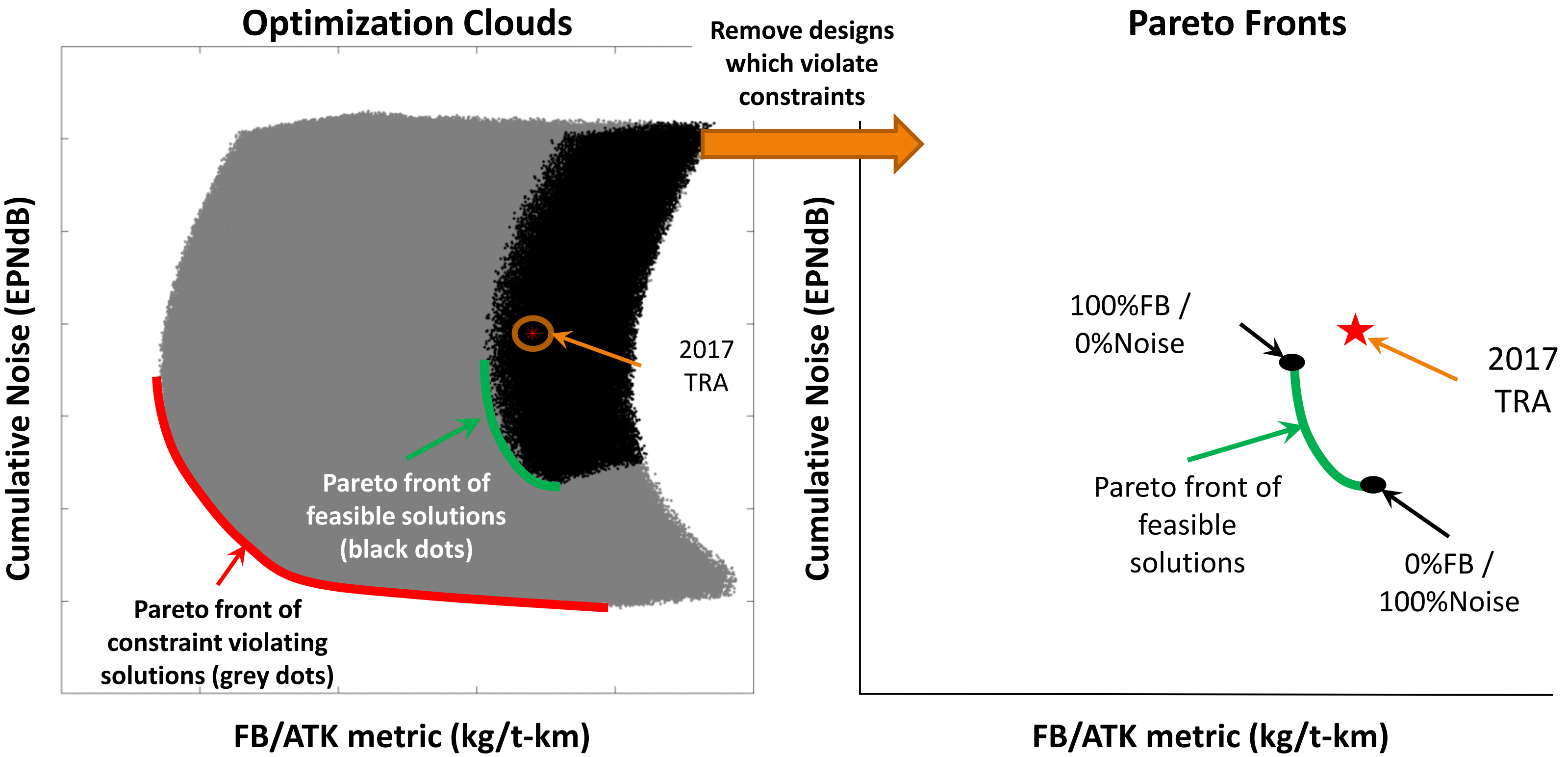


Proposed Noise Goals

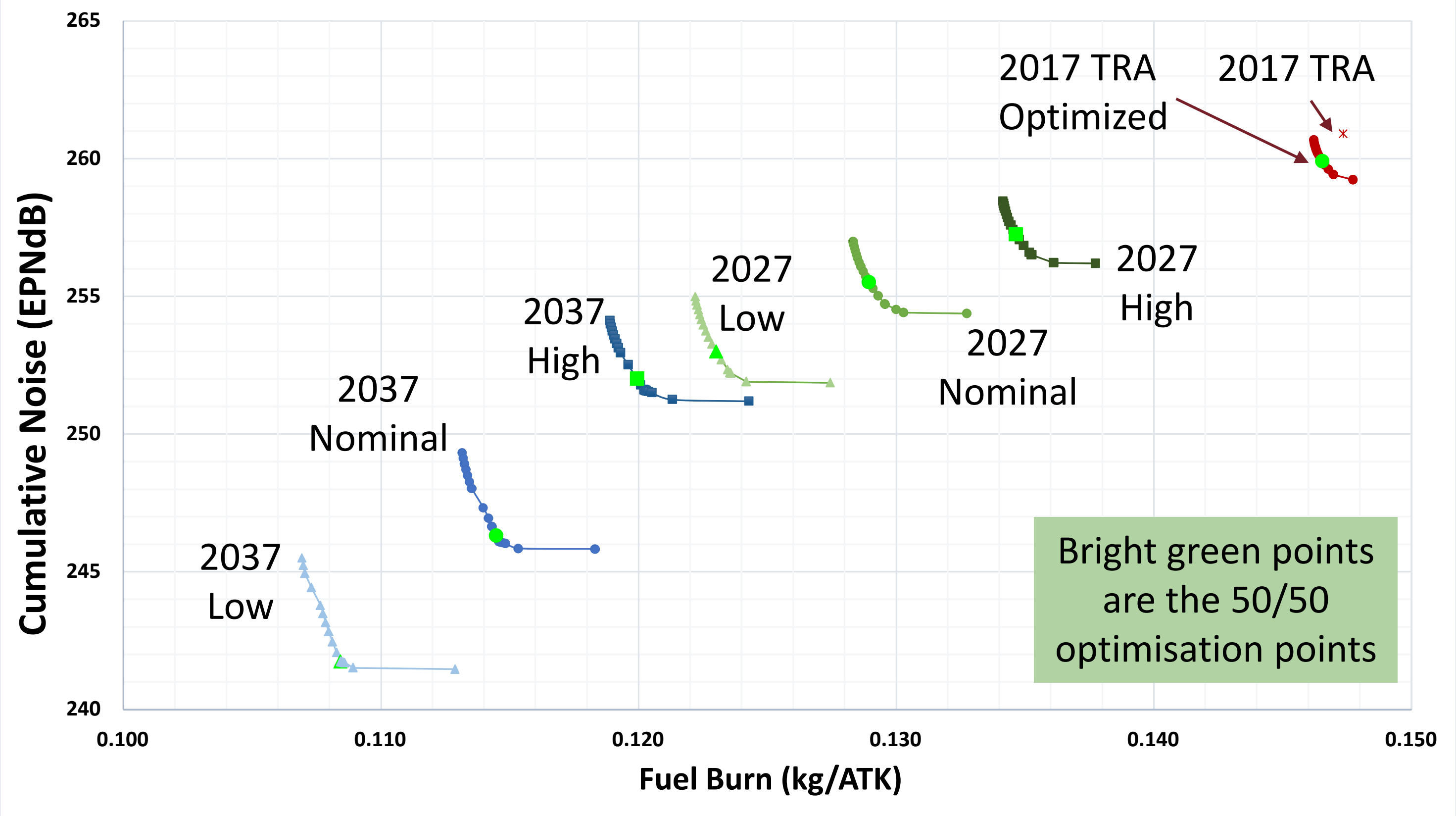
- Noise Goals Expressed as Cumulative EPNdB below Chapter 14 Noise Limit
- In comparison to the prior review, the percent improvement in noise margin is less in the long term due to the expectations of the technologies to bear in the future



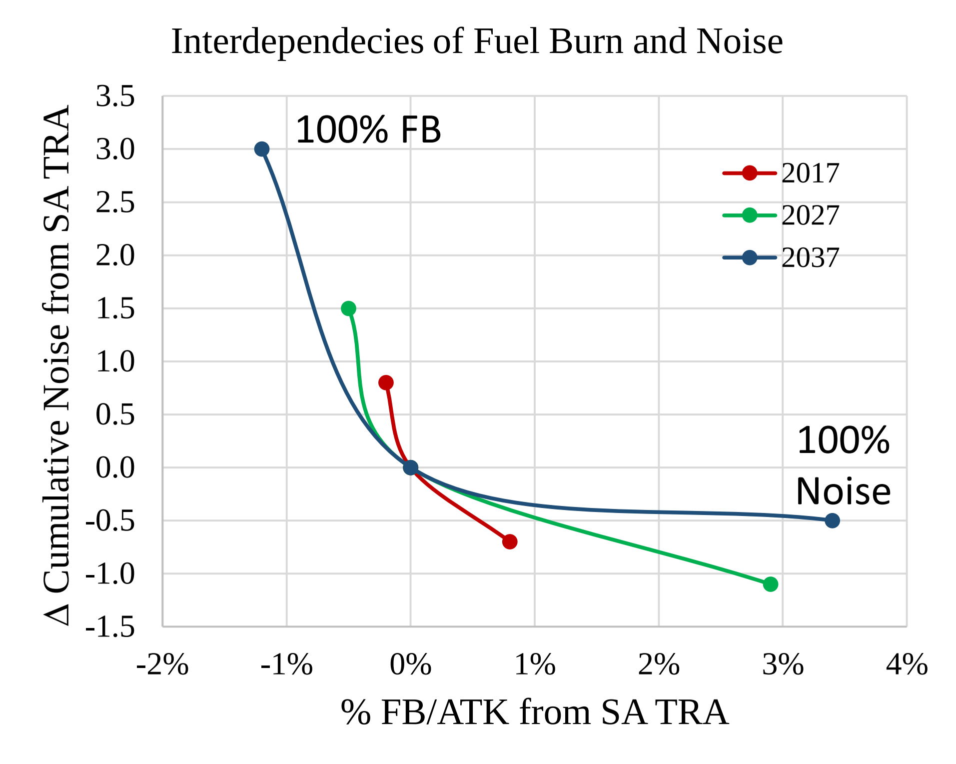
Visualizing and Interdependencies using Pareto Frontiers



Single Aisle Noise vs Fuel Burn Interdependencies



Single Aisle Interdependencies relative to the 50% Fuel-burn/50% noise optimization point



Year	Optimization weighting	Δ FB/ATK	Δ EPNdB
2017	100% FB	-0.2%	0.8
	50/50	0.0%	0.0
	100% Noise	0.8%	-0.7
2027	100% FB	-0.5%	1.5
	50/50	0.0%	0.0
	100% Noise	2.9%	-1.1
2037	100% FB	-1.2%	3.0
	50/50	0.0%	0.0
	100% Noise	3.4%	-0.5

Model Optimization for Nominal Confidence. Performed at R_1 of 2017 TRA. Change in FB/ATK reported at the design range.

Concluding Remarks

- IEIR process led to an accepted set of mid- and long-terms goals for fuel burn (CO_2), noise, and while accounting for NO_X interdependencies
- Consideration was provided on:
  - Aviation's environmental, climate, and health impacts
  - Advanced configurations
  - Alternative approaches
- IEs recognized that the current goals were less aggressive than prior reviews predominantly because the baseline vehicles were more current
- IEs concur with ICCAIA's view that further environmental improvements can be achieved through the infusion of new advanced configurations

ICAO

THANK YOU