Noise and climate impacts of emerging commercial supersonic aircraft

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icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Presentation overview

- Introduction and background
- Current supersonic transport aircraft development
- Environmental impacts of emerging SSTs
- What's up next for policy
- Conclusions

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Introduction and background

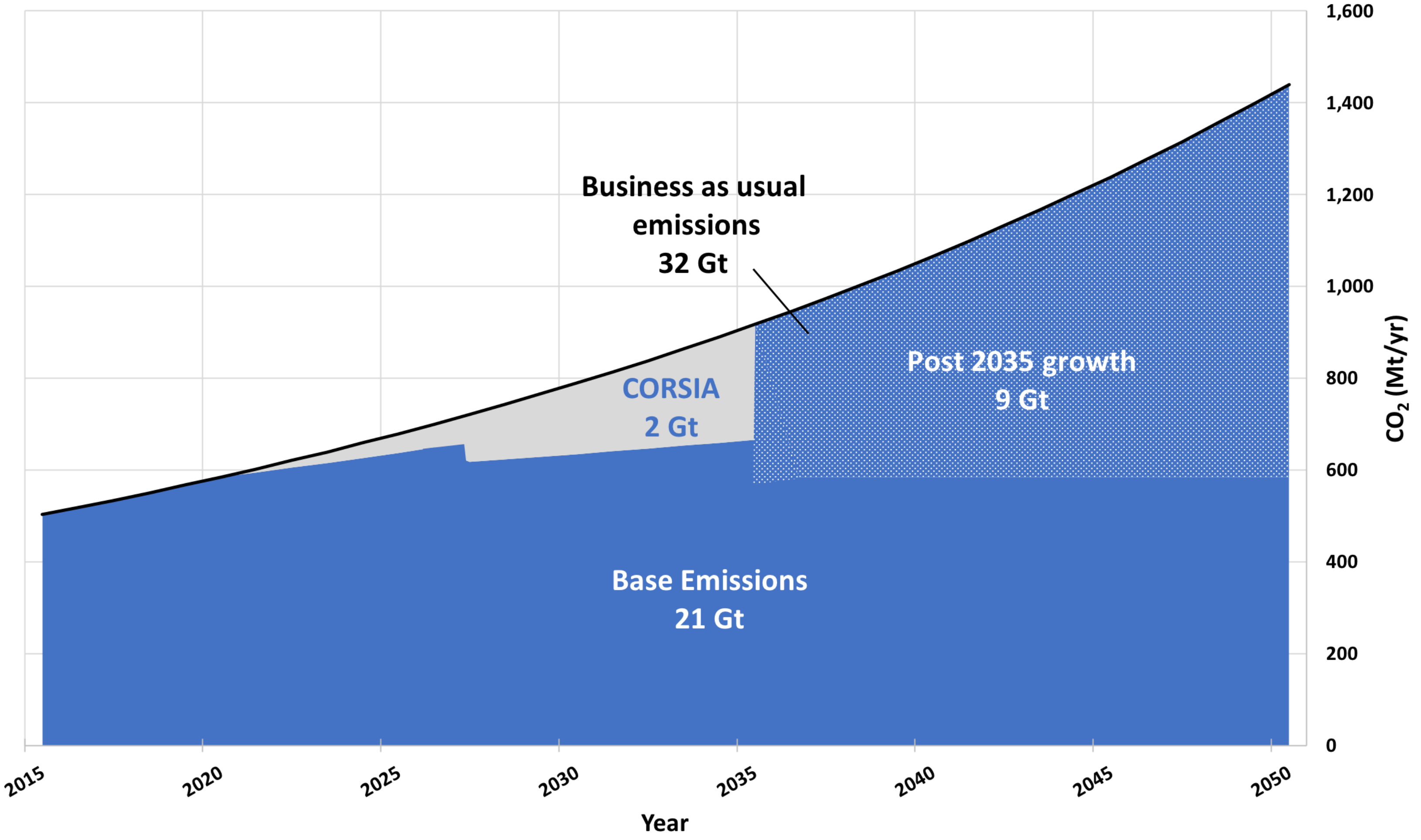
International Council on Clean Transportation

- Goal of the ICCT is to dramatically reduce conventional pollutant and greenhouse gas emissions from all transportation sources in order to improve air quality and human health, and mitigate climate change.
- Promotes best practices and comprehensive solutions to:
  - Improve vehicle emissions and efficiency
  - Increase fuel quality and sustainability of alternative fuels
  - Reduce pollution from the in-use fleet, and
  - Curtail emissions from international goods movement.
- The Council is made up of leading regulators and experts from around the world.

www.theicct.org

Environmental challenges for aviation are significant even under an all subsonic aircraft baseline

Projected CO_2 emissions from international aviation, 2015 to 2050



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Current supersonic transport aircraft development

Three SST startups currently active

Table 1. SST startup companies.

Company	Aerion	Spike	Boom
Aircraft type	Business jet	Business jet	Airliner
Aircraft name	AS2	S-512 Quiet Supersonic Jet	—
Target entry into service	2025	2023	2023
Target speed	Mach 1.4	Mach 1.6	Mach 2.2
Target maximum range	7,780 km	11,500 km	8,300 km
Low-boom technology?	No	"Quiet supersonic flight technology"[1]	No
Corporate customers	Flexjet	—	Virgin Group Japan Airlines CTrip

[1] Spike Aerospace (2017b).

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Environmental impacts of emerging SSTs

Aircraft level analysis methodology

Table 2. Airframe parameters used for modeling.

Parameter	Value	Source
Maximum takeoff mass (kg)	77,000	www.flightglobal.com/news/articles/dubai-boom-to-make-a-big-noise-at-show-about-shorte-442767
Design range (km)	8,300	https://boomsupersonic.com/airliner
Maximum passengers	55	https://boomsupersonic.com/airliner
Design speed (Mach number)	2.2	https://boomsupersonic.com/airliner
Length (ft)	170	https://boomsupersonic.com/airliner
Wingspan (ft)	60	https://boomsupersonic.com/airliner
Reference geometric factor[a] (m^2)	80	Estimated
Balanced field length (ft)	10,000	https://boomsupersonic.com/airliner
Cruise altitude (ft)[b]	60,000	https://techcrunch.com/2017/01/12/boom-shows-off-its-xb-1-supersonic-demonstration-passenger-airliner
Engine	Medium-bypass-ratio turbofan, no afterburner	https://blog.boomsupersonic.com/why-we-dont-need-an-afterburner-a4e05943b101

[a] Reference geometric factor, which approximates an aircraft's pressurized floor area, is used to calculate the CO_2 standard metric value. The metric value is used to demonstrate compliance with ICAO's CO_2 standard (see below).
[b] We reduced the cruise altitude slightly in our analysis to meet a lower average altitude more consistent with a cruise-climb to 60,000 ft.

Commercial SSTs will struggle to meet existing subsonic aircraft standards, especially with derivative engines

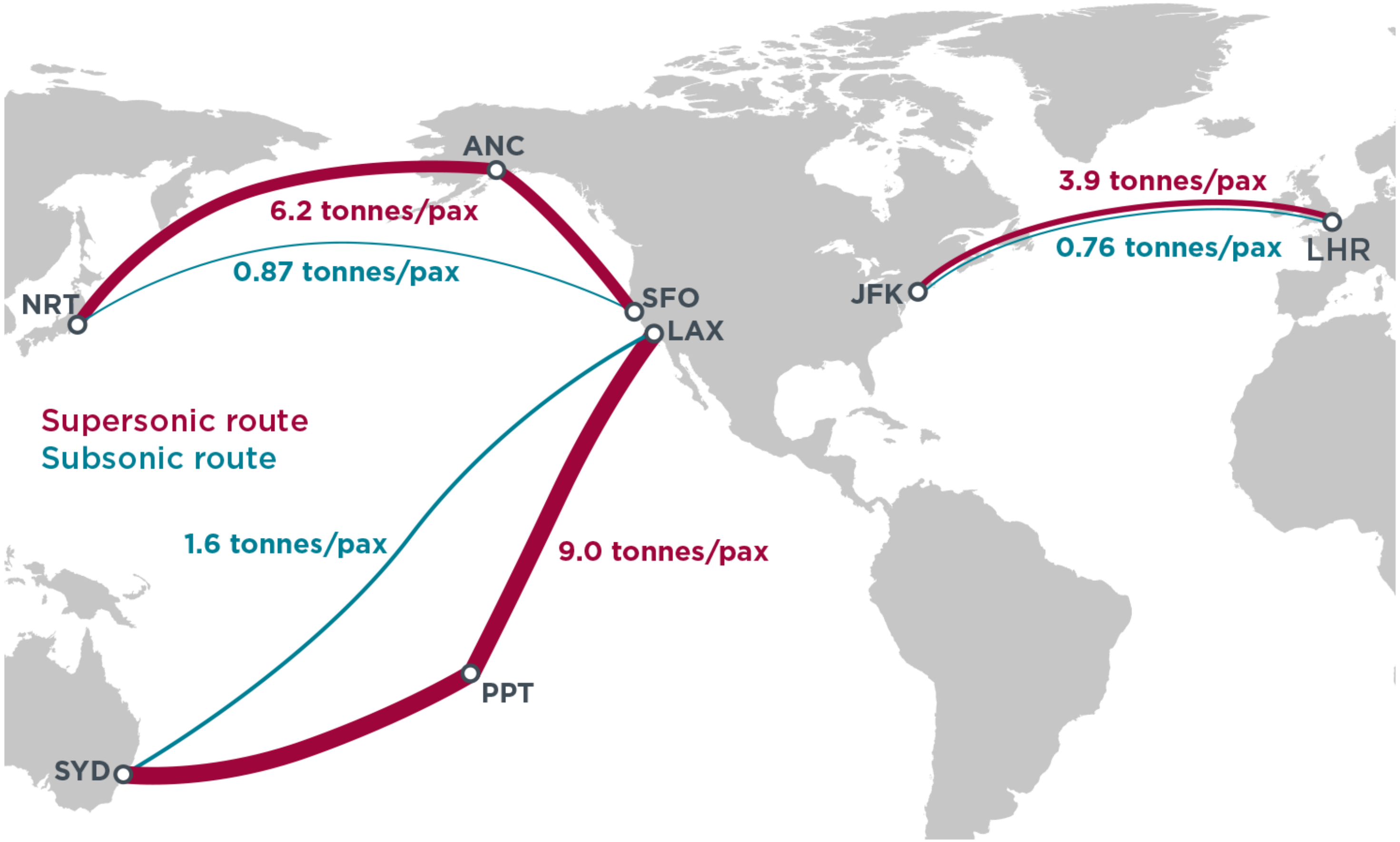
Table 4. Modeled NO_x and CO_2 performance of SST aircraft by configuration.

Pollutant	Standard[a]	Year	Parameter	Configuration		
				Best	Most likely	Worst
NO_x	CAEP/8	2014	Overall pressure ratio	15	15	13.8
			SST (g/kN)	18	40	—[b]
			Standard (g/kN)	29	29	—[b]
			Exceedance	−37%	+38%	—[b]
CO_2	CAEP/10	2020	Maximum takeoff mass (kg)	77,000		
			SST (kg/km)	1.21	1.33	1.72
			Standard (kg/km)	0.80		
			Exceedance	+52%	+67%	+115%

[a] ICAO's environmental standards are referenced to the meeting at which they were agreed. ICAO's current CAEP/8 (NO_x) and CAEP/10 (CO_2) standards were finalized in 2010 and 2016, respectively.
[b] NO_x emission estimates were unavailable for this configuration.

Emerging commercial SSTs could be 5 to 7 times as carbon intensive as comparable subsonic aircraft

Round trip carbon dioxide emissions per passenger by route and aircraft type



Daily movements by market for an unconstrained SST network in 2035

Figure 2. Daily commercial supersonic flights by market

Daily movements by country and airport, 2035

Table 2. Commercial supersonic transport movements by departure country in 2035

Rank	Country	Movements/day	Share of Movements	Cumulative share of Movements
1	United States	1317	27%	27%
2	United Kingdom	351	7%	34%
3	United Arab Emirates	322	7%	40%
4	China	237	5%	45%
5	Russia	215	4%	49%
6	Japan	183	4%	53%
7	India	183	4%	57%
8	Germany	158	3%	60%
9	Singapore	140	3%	63%
10	France	132	3%	65%
11	Thailand	121	2%	68%
12	Canada	119	2%	70%
13	Australia	118	2%	73%
14	Qatar	92	2%	74%
15	South Korea	86	2%	76%
16	Turkey	85	2%	78%
17	Netherlands	74	1%	79%
18	Malaysia	66	1%	81%
19	Indonesia	62	1%	82%
20	Switzerland	50	1%	83%
	Other	844	17%	100%
	Total	**4,954**	**100%**	

Table 3. Commercial supersonic transport movements by airport in 2035

Rank	Airport	Movements/ day	Share of Movements	Cumulative share of movements
1	Dubai International (DXB)	322	7%	7%
2	London Heathrow (LHR)	314	6%	13%
3	Los Angeles (LAX)	181	4%	16%
4	Singapore Changi (SIN)	140	3%	19%
5	San Francisco (SFO)	140	3%	22%
6	New York (JFK)	126	3%	25%
7	Frankfurt (FRA)	125	3%	27%
8	Bangkok International (BKK)	113	2%	29%
9	Paris Charles de Gaulle (CDG)	97	2%	31%
10	Hamad International (DOH)	92	2%	33%
11	Indira Gandhi International (DEL)	91	2%	35%
12	Hong Kong (HKG)	89	2%	37%
13	Istanbul Atatürk (IST)	85	2%	39%
14	Tokyo Narita (NRT)	84	2%	40%
15	Seoul Incheon (ICN)	84	2%	42%
16	Amsterdam Schiphol (AMS)	74	1%	44%
17	Beijing Capital (PEK)	73	1%	45%
18	Kuala Lumpur (KUL)	66	1%	46%
19	Sydney (SYD)	63	1%	48%
20	Shanghai Pudong (PVG)	62	1%	49%
21	Mumbai (BOM)	62	1%	50%
22	Tokyo Haneda (HND)	58	1%	51%
23	Chicago O'Hare (ORD)	56	1%	52%
24	Newark International (EWR)	52	1%	53%
25	Toronto Pearson (YYZ)	50	1%	55%
Other[1]		2255	45%	100%
	Total	**4,954**		

[1]: Other includes "transit" airports, defined as 75% or more of available seats being from refueling stops.

LTO noise impacts of emerging commercial supersonics

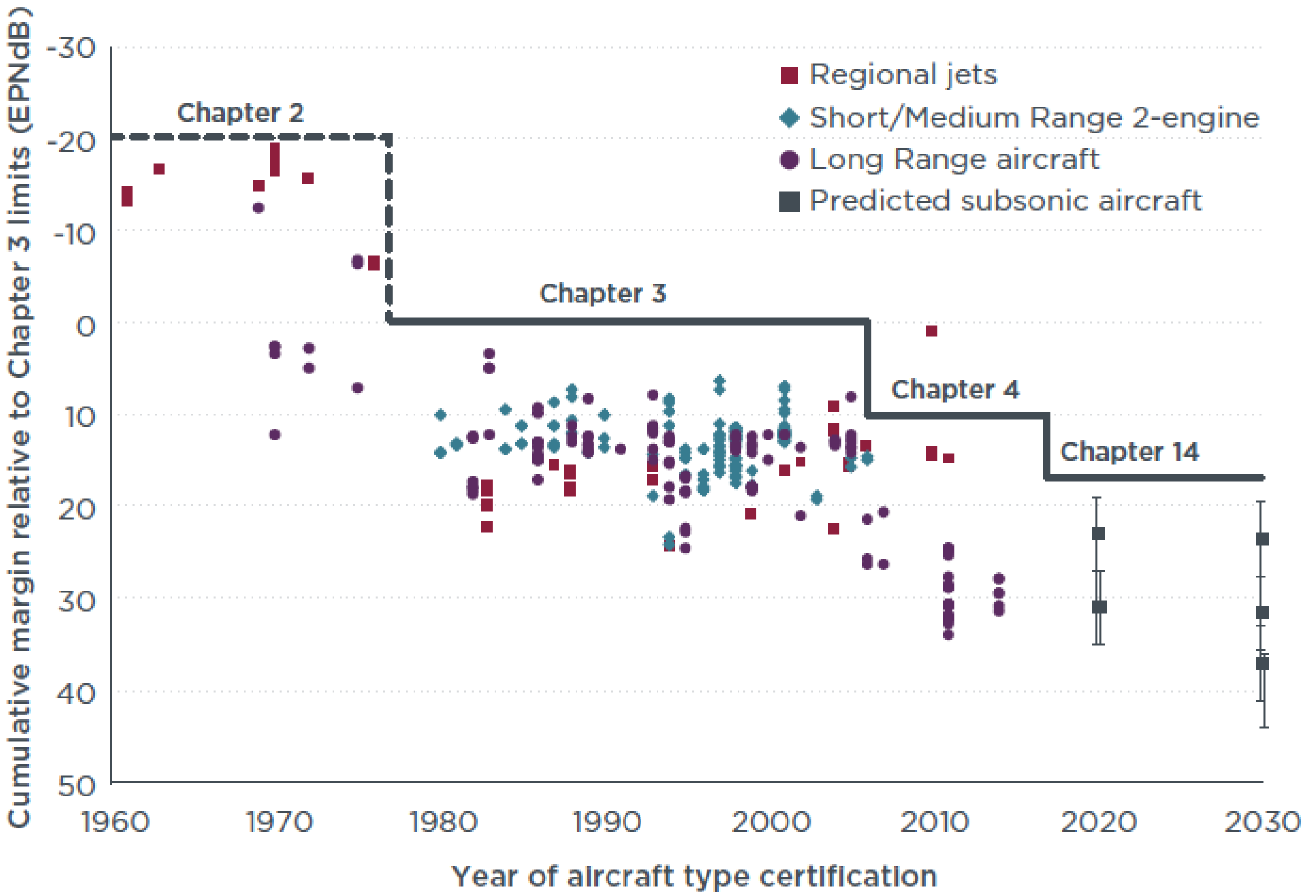


Figure 1. Subsonic aircraft noise performance vs. year of type certification (adapted from EASA, EEA, and EUROCONTROL, 2016)

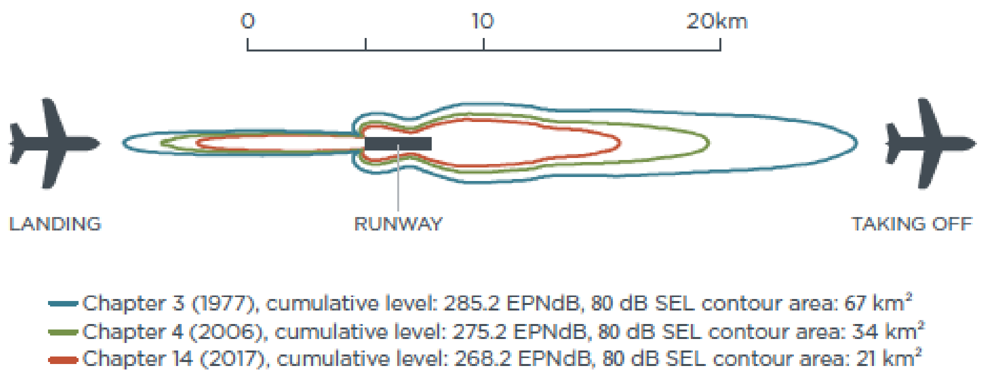


Figure 3. 80 dB Sound exposure level contours for 75-tonne aircraft just meeting the various ICAO chapter limits (adapted from EASA, EEA, and EUROCONTROL, 2016).

Global sonic boom incidence, 2035

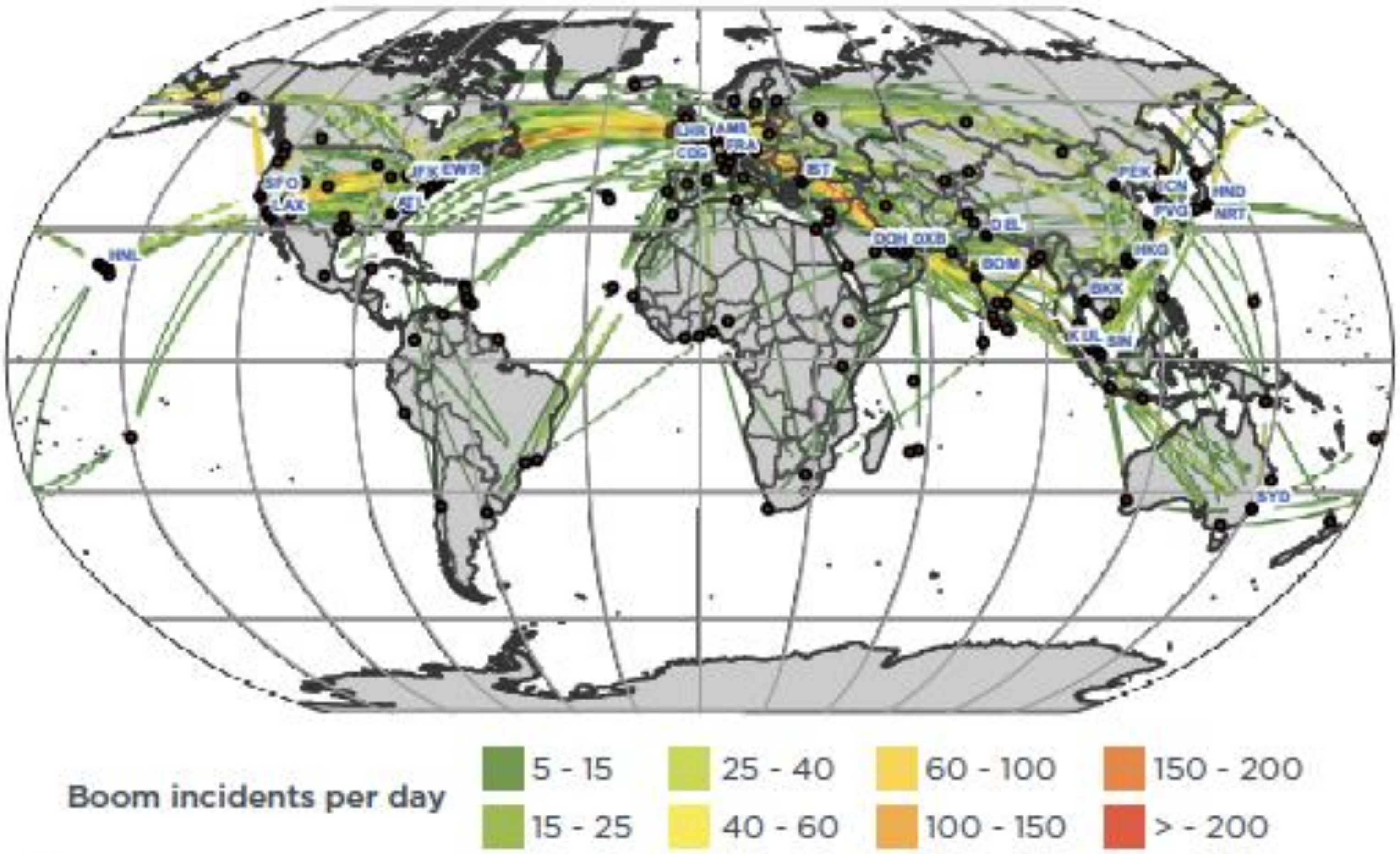


Figure 4: Global sonic boom incidence

https://www.theicct.org/publications/noise-climate-impacts-unconstrained-supersonics

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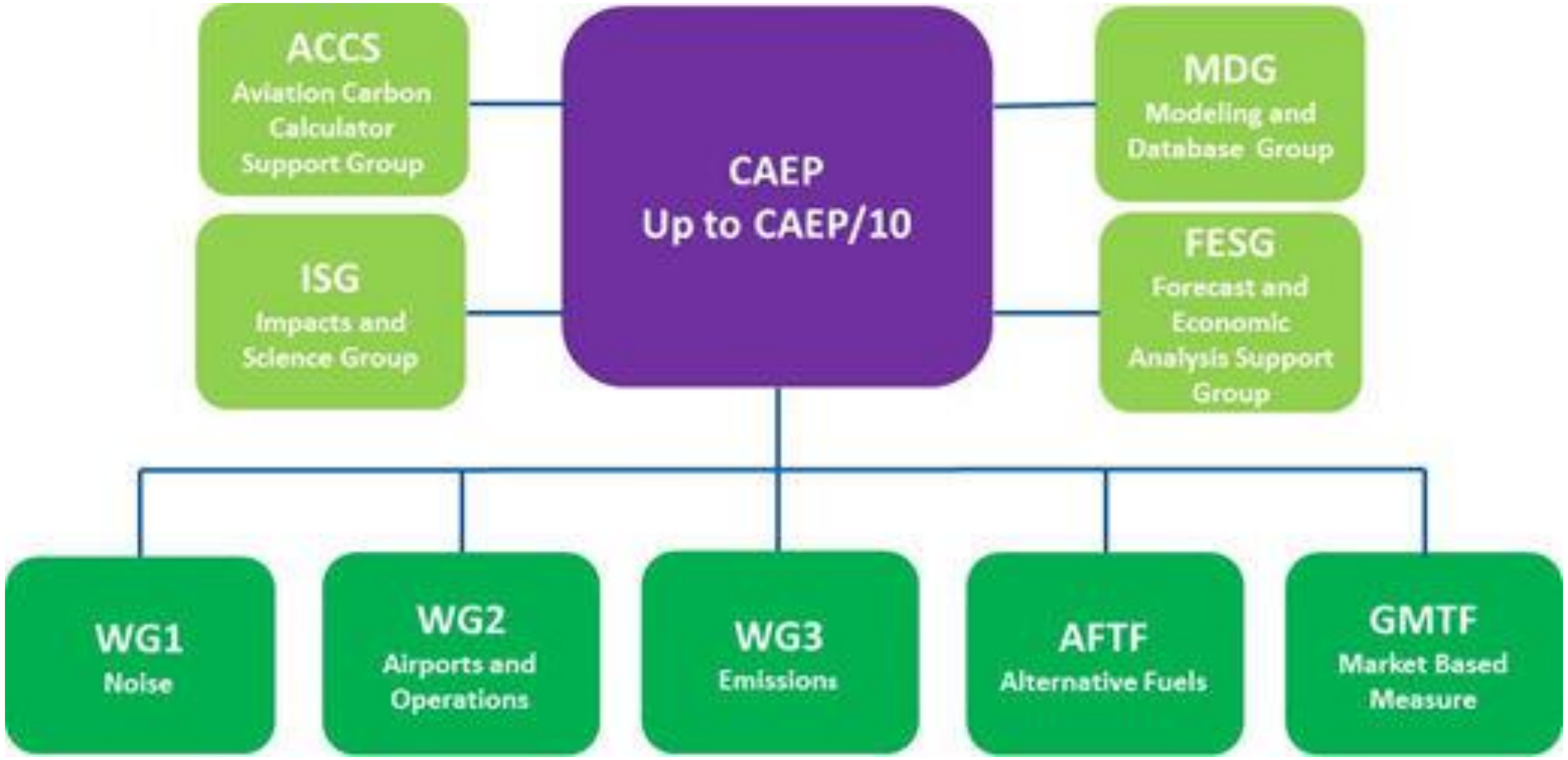
What’s up next for policy

SST provisions under the 2018 FAA Reauthorization Act

- Directs FAA to show leadership on technology development and standard setting
- Indicates both long-term regulatory direction and near-term certification approach for FAA
  - Long-term
    - **Propose a LTO noise standard for supersonic aircraft by 31 March 2020**
    - Propose a rule to streamline domestic SST flight testing
    - Review on a biannual basis starting in 2020 whether the overland flight ban can be lifted.
  - Near-term
    - Would require FAA to initiate rulemakings to certify designs that apply before the above LTO standard is finalized.
    - Apply traditional criteria used for ICAO environmental standard setting to determine stringency: technological feasibility, environmental benefit, economic reasonableness, etc.

Further details at https://www.theicct.org/blog/staff/death-taxes-and-supersonic-aircraft

CAEP/11 outcomes



- No agreement to establish LTO noise stringency by 2022
- Impact assessment of SST noise, AQ, and climate impacts
- Study how existing subsonic test procedures can be modified for application to supersonics.

https://www.icao.int/environmental-protection/Documents/CAEP/Images/OrganigramStructure.jpg

Next up…

Environmental implications of emerging supersonic aircraft

Conclusions

Conclusions

- Environmental constraints on aviation growth are significant even without SSTs
- Commercial SSTs will need to make special efforts to meet subsonic aircraft standards, particularly at ”Concorde-like” speeds with derivative engines
- Potential SST market will be predominately international, heavily European, and overland
- Road to commercialization likely includes
  - Short-term: certification to subsonic standards
  - Mid-term: technology forcing standards to control sonic boom; addressing non-CO_2 climate impacts

Thank you!

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