POLICY UPDATE

JANUARY 2017

INTERNATIONAL CIVIL AVIATION ORGANIZATION'S CO_2 STANDARD FOR NEW AIRCRAFT

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

SUMMARY

On 8 February 2016, the International Civil Aviation Organization (ICAO) finalized a proposed performance standard for new aircraft that will mandate improvements in fuel efficiency and reductions in carbon dioxide (CO_2) emissions. The standard, the first ever to impose binding energy efficiency and CO_2 reduction targets for the aviation sector, was hammered out at the tenth meeting of ICAO's Committee for Environmental Protection (CAEP). It will apply to all new commercial and business aircraft delivered after 1 January 2028, with a transition period for modified aircraft starting in 2023. The standards will on average require a 4% reduction in the cruise fuel consumption of new aircraft starting in 2028 compared to 2015 deliveries, with the actual reductions ranging from 0 to 11%, depending on the maximum take off mass (MTOM) of the aircraft.

Separately, technology following standards were set for new aircraft designs with entry into service (EIS) dates after approximately 2024. Given the substantial lead time for the standards, along with anticipated fuel efficiency gains for new aircraft types already in development by manufacturers, the standards will serve primarily to prevent backsliding in emissions. Flexibility measures to address aircraft types and manufacturers with low production volumes will be discussed later in 2016.

POLICY BACKGROUND

ICAO's CO_2 standard, which has been under development since 2010, will be the first enforceable climate measure for international aviation developed since the Kyoto Protocol, which assigned jurisdiction over international aviation greenhouse gas emissions to ICAO in 1997. The standard builds upon the draft CO_2 certification requirement CAEP finalized in 2013 which established an efficiency metric, scaling factor, and flight test procedures to measure and compare the fuel efficiency of new aircraft.[1]

1 See "International Civil Aviation Organization's CO_2 certification requirement for new aircraft" (ICCT Policy Update), August 2013. http://www.theicct.org/sites/default/files/publications/ICCTupdate_ICAO_CO2cert_aug2013a.pdf, and http://www.icao.int/environmental-protection/Documents/CO2%20Metric%20System%20-%20Information%20Sheet.pdf

**This is an update to a prior policy update that was originally published in February 2016. http://www.theicct.org/sites/default/files/publications/ICCT-ICAO_policy-update_feb2016.pdf

ICAO's recommended standard is expected to serve as the basis for domestic regulations for states that manufacture and certify aircraft, including the United States. The U.S. Environmental Protection Agency's (EPA) proposed Endangerment Finding and Advance Notice of Proposed Rulemaking (ANPR) on aviation greenhouse gas emissions, published in July 2015, signaled the agency's intent to adopt the ICAO CO_2 standard provided it is consistent with the goal of requiring additional fuel efficiency improvements from domestic aircraft.

OVERVIEW OF THE PROPOSED STANDARD

Under the standard, an aircraft type's fuel efficiency will be evaluated on ICAO's metric value (MV), a proxy of cruise fuel efficiency that is calculated as function of an aircraft's specific air range (SAR) and Reference Geometric Factor (RGF), which is a close approximation of the pressurized floor area of the aircraft. In order to be certified under the standard and sold internationally, each aircraft/engine combination produced by a manufacturer will need to meet a MV limit, assigned as a function of its maximum takeoff mass (MTOM) and measured at three equally weighted gross weight test points.[2]

The fuel efficiency targets of individual aircraft types are differentiated as follows:

» Aircraft mass: Targets are set as a function of an aircraft's maximum takeoff mass (MTOM), which designates the maximum combined mass of aircraft empty weight, payload, and fuel that an aircraft can operate at. In order to distinguish smaller aircraft—business jets, turboprops, and regional jets—from larger commercial aircraft with more technologies available to improve fuel efficiency, the standard line includes a plateau starting at 60 tonnes MTOM to transition to stricter requirements for larger aircraft.

» Certification status: Reflecting the fact that new aircraft designs typically offer step function improvements in fuel efficiency, the CO_2 standard includes two tiers of regulatory targets: one for new deliveries of already certified aircraft ("in-production aircraft", or InP), and a second set of higher regulatory targets for new designs that will begin to be type certified after 1 January 2020 (commercial jets) and 1 January 2023 (business jets) and enter into service sometime after 2024[3] and 2027, respectively. These "New Type" (NT) targets are estimated to require approximately 30% of the technology potential to improve new aircraft efficiency in 2024, and will be met by new designs being type certified today.

» Aircraft type: Separate start dates are set for the NT requirements commercial aircraft and business jets, defined as aircraft with a maximum seating capacity of less than 19. Binding requirements for all new InP aircraft begin in 2028 regardless of aircraft type and size.

2 For an overview of ICAO's certification requirement, see http://www.theicct.org/sites/default/files/publications/ICCTupdate_ICAO_CO2cert_aug2013a.pdf

3 The NT requirements will take effect when a manufacturer applies for type certification process for a new production. Since the type certification process typically requires four or more years to complete, this translates into targets for new designs with an entry-into-service date of approximately 2024+.

STANDARD REQUIREMENTS

The stringency of the standard will be set as a single continuous line, with a plateau starting at 60 tonnes MTOM to distinguish regional and business jets from smaller single aisle aircraft. These stringency lines, along with data on recent aircraft deliveries, can be used to estimate the required reductions compared to 2015 year deliveries. Table 1 summarizes the percentage MV reductions required from different aircraft categories, along with the start date of the standard. Table 2 summarizes the same percentage metric value reductions required from different aircraft types under the New Type provisions.

Table 1. Estimated metric value reduction required for new in-production aircraft by aircraft category

Aircraft category[1]	MTOM (tonnes)	Metric Value (kg/km)			% reduction	
		2015 worst	2015 average	2028 Target[2]	Worst aircraft	Average aircraft
Very large aircraft	>350	2.95	2.93	2.62	11%	10%
Twin aisle	120 – 350	1.88	1.70	1.75	7%	0%
Single aisle	60 – 120	0.94	0.91	0.86	9%	6%
Regional jets	13.5 – 60	0.71	0.69	0.68	3%	0%
Business jets	<60[3]	0.64	0.56	0.61	6%	0%
Freighters	n/a	2.13	2.06	1.92	10%	7%
Average		1.59	1.49	1.46	8%	4%

[1] Example aircraft include VLA: A380; Twin Aisle: B-777; Single Aisle: A320; Regional Jet: Embraer E-190; Business Jet: Gulfstream G550; Freighter B777-F
[2] Assumes the same MTOMs in the 2015 sales mix. Actual required reductions will vary if the sales mix changes over time.
[3] Also with less than 19 certified seats.

Table 2. Estimated metric value reduction required for new types

Aircraft type[1]	Start date	MTOM (tonnes)	Metric Value (kg/km)		% reduction
			New design aircraft[1]	Required MV	
Very large aircraft	**2020**	>350	2.75	2.51	10%
Twin aisle	**2020**	120 – 350	1.51	1.68	0%
Single aisle	**2020**	60 – 120	0.76	0.82	0%
Regional jets	**2020**	13.5 – 60	0.55	0.66	0%
Business jets	**2023**	<60, <19 seats	0.46	0.58	0%

[1] Defined as new types certified between 2011 and 2019. Example range include the 747-8 (2011 EIS, through the 777X (expected 2020 EIS).

As shown in Table 1, on average the standard will require a 4% MV reduction for new aircraft relative to 2015 deliveries in 2028, with the actual required reduction ranging for no improvement (twin aisle aircraft and business jets) to 10% (very large aircraft). Since the standard will be applied as a pass/fail requirement for individual products, its impact on the least efficient models in 2015 is also important; as shown in Table 1 the standard will require 7 to 11% reductions from the least efficient, widely sold aircraft in 2015.

Regarding the NT requirements, as summarized in Table 2 the required MVs for new types are above (worse) that of new aircraft types with entry into service dates between 2010 and 2020 for all aircraft types except very large aircraft (VLA), which have not yet been certified with the most recent, state of the art engines. For that reason, the standards are best understood as anti-backsliding provisions, noting that they may require additional improvements if applied to all new aircraft in the future.

ANALYSIS

As a pass/fail requirement, the effect of the standard will depend upon the improvements required from individual aircraft models. Table 3 compares estimated Metric Values of key aircraft types from fifteen aircraft manufacturers relative to the agreed standard.[4] Positive values denote an exceedance where an aircraft type has a higher (worse) metric value than required under the standard and would require additional improvements in order to be delivered in 2028, while negative values indicate that the aircraft would pass the standard with a margin. Aircraft that are anticipated to be in-production in 2023 when the transitional standard takes effect are indicated with an X in the rightmost column.[5]

Table 3. Estimated standard exceedance by manufacturer and aircraft type*

Manufacturer	Aircraft type	Exceedance	2023 production?
Airbus	A319	3% to 8%	
	A320	-1% to 4%	
	A321	1% to 6%	
	A330-200	-1% to 3%	
	A330-300	-2% to 3%	
	A350-800	-15% to -11%	X
	A350-900	-14% to -10%	X
	A350-1000	-13% to -8%	X
	A380-800	2% to 7%	X
	A319neo	-11% to -6%	X
	A320neo	-13% to -9%	X
	A321neo	-7% to -3%	X
	A330-800neo	-16% to -11%	X
	A330-900neo	-15% to -11%	X

4 Aircraft metric values were estimated using Piano-5, an aircraft performance and emissions model widely used for environmental analysis, including within CAEP. See Kharina & Rutherford, 2015 for a detailed overview of how metric values are estimated using Piano.

5 Predicted production status are based upon an analysis of the year of last delivery, assuming that aircraft without firm orders for delivery after 2019 in the Ascend database will be out of production in 2023.

Manufacturer	Aircraft type	Exceedance	2023 production?
Antonov	An-148-100A	-3% to 1%	
	An-158	-3% to 2%	
Boeing	B737-600	-1% to 6%	
Boeing	B737-700ERW	5% to 9%	
	B737-700W	5% to 10%	
	B737-700NG	4% to 12%	
	B737-800W	2% to 6%	X
	B737-800NG	7% to 12%	
	B737-900NG	5% to 10%	
	B737-900ERW	5% to 10%	X
	B767-300ER	10% to 15%	
	B767-400ER	7% to 12%	
	B777-200ER	1% to 6%	
	B777-200LR	4% to 9%	
	B777-300	2% to 6%	
	B777-300ER	1% to 6%	X
	B787-8	-14% to -10%	X
	B787-9	-17% to -12%	X
	B787-10	-17% to -13%	X
	B747-8 I	6% to 11%	
	B737 MAX-8	-10% to -5%	X
	B737 MAX-9	-7% to -2%	X
	B777-8X	-13% to -9%	X
	B777-9X	-16% to -12%	X
Bombardier	CS100	-20% to -16%	X
	CS300	-15% to -11%	X
	CRJ 1000	-1% to 5%	
	CRJ 701 ER/LR	0% to 5%	
	CRJ 900 ER/LR	-5% to -1%	
	Global 5000	-4% to 4%	
	Global Express 6000	-7% to 1%	X
	Global 7000	-20% to -16%	X
	Global 8000	-18% to -14%	X
Cessna	Citation X	-15% to -11%	X
	CitationJet CJ3	-9% to -3%	X

Manufacturer	Aircraft type	Exceedance	2023 production?
Comac	C919	-13% to -9%	X
Dassault	Dassault Falcon 2000	-18% to -12%	
Embraer	170	-2% to 6%	
	175	-2% to 6%	
	190	0% to 9%	
	195	-1% to 7%	
	E175-E2	-19% to -15%	X
	E190-E2	-16% to -12%	X
	E195-E2	-18% to -14%	X
Gulfstream	Gulfstream 550	-17% to -10%	X
	Gulfstream 650	-21% to -14%	X
Ilyushin	IL-96-300	23% to 35%	
Pilatus	Pilatus PC-24 SVJ	-11% to -5%	
Irkut	MC-21-200	-11% to -6%	X
Mitsubishi	MC-21-300	-10% to -5%	X
	MRJ-90	-22% to -18%	X
Sukhoi	Superjet 100-95B	-10% to -2%	
	Superjet 100-95LR	-7% to 1%	
	Sukhoi SBJ	-7% to 1%	
Tupolev	Tu-204	10% to 20%	

*This table has been updated from the original publication in February 2016 to update some of the numbers

Since manufacturer production lines change over time, another way to understand the impact of the standard is to consider how the MV improvements required relate to the projected performance of future deliveries. Figure 1 presents the year-by-year average margin to the standard for project deliveries of new commercial aircraft greater than 60 tons globally, based upon a database purchased from Ascend Online Fleets.[6] Positive values represent fuel efficiency worse than required under the standard, while negative values indicate fuel efficiency performance better than that required under the standard. Error bars on the graph represent the 10^{th} and 90^{th} percentile aircraft delivered in a given year, weighted by MTOM.

6 http://www.ascendworldwide.com/what-we-do/ascend-data/aircraft-airline-data/ascend-online-fleets.html

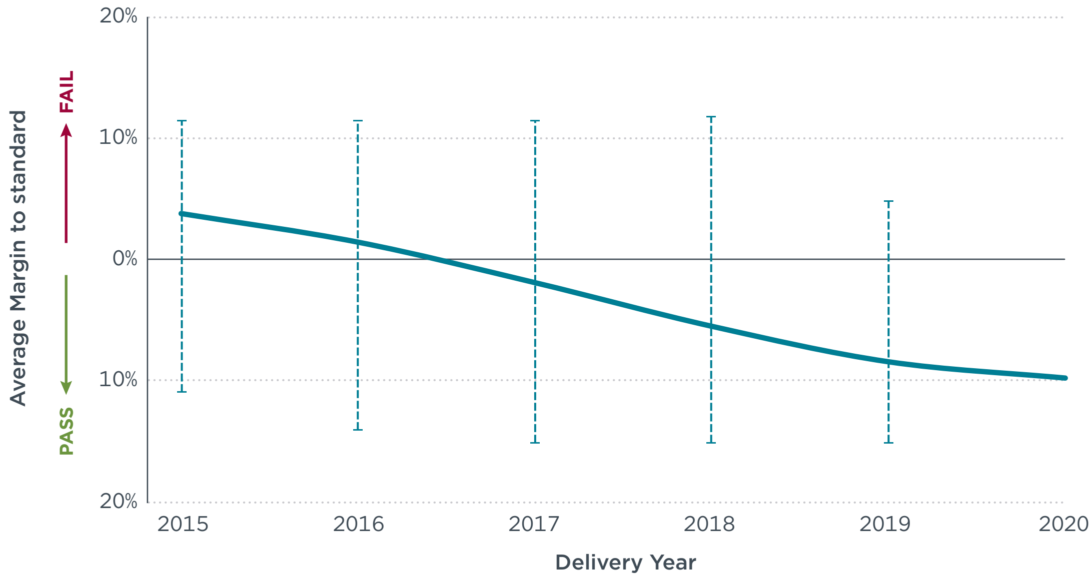

Figure 1. Projected average commercial aircraft MV by delivery year, 2015 to 2020, aircraft greater than 60 tonnes MTOM.

As the graphic shows, the average newly delivered single and twin aisle commercial aircraft is expected to comply with the standard starting in 2017, more than a decade before the binding requirement on InP aircraft requirement takes effect. Less efficient models, represented by the 90^{th} percentile efficient aircraft (upper error bar), would fail the standard through 2019, while the most efficient (10^{th} percentile) 2016 models currently pass the standard with a 15% margin. Beginning in 2020, eight years before the standard takes effect, the average new aircraft delivered is expected to comply with the standard by approximately 10%. This projected pre-compliance with the standard is due to the introduction of many new aircraft designs over the next five years (e.g. A320neo, 737 MAX, the 777X, the A330neo, Embraer E-Jet E-2) that pass the standard with a substantial margin.

ENFORCEMENT

Like other safety and environmental requirements, the CO_2 standard will be implemented as a new requirement under each National Aviation Authority's (NAA) aircraft type certification system. The standard will be enforced via a production cutoff for new in-production aircraft starting in 2028 where non-compliant models will not be certified for sale in the jurisdiction area of the certification body (e.g. EASA in Europe and FAA in the USA). In the event that a future aircraft design is less efficient than current new types and therefore fails the standard, it would not be allowed to be type certified and sold internationally.

The standards also include an applicability trigger for modified in-production aircraft after 1 January 2023 through 2028, when non-compliant aircraft could not be sold. Starting in 2023 derivative aircraft with significant degradations in fuel efficiency would need to be certified to the standard, as would aircraft with substantial changes such as new engines or wings. Since the former is extremely rare, and the latter aircraft would be expected to pass the standard in any event, these provisions are not anticipated to impose further requirements on manufacturers.

NEXT STEPS

Following CAEP's recommendation, the standard must be ratified by the ICAO Council (consists of 36 member states) in June 2016 and then endorsed by ICAO Assembly in October. The standard would then need to be implemented by individual contracting states (or countries) under domestic legislation. The countries that has certifying bodies (e.g. FAA in the US and EASA in Europe) may adopt this standard or impose tighter restrictions on CO_2 emissions from aircraft if the standard is deemed to be insufficient.

REFERENCES

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