C Series

CS300

ENVIRONMENTAL PRODUCT DECLARATION

BOMBARDIER

Fred Cromer,
President,
Bombardier
Commercial
Aircraft

In September 2016, we were proud to be the first aircraft manufacturer to release an Environmental Product Declaration for our CS100 aircraft type.

This year, we are releasing an Environmental Product Declaration for our CS300 aircraft type. With these two EPDs, we are thrilled to be able to provide you with an overview of the entire C Series family's environmental performance.

This declaration is a testament to Bombardier's active support of the industry's climate change goals. As our industry faces global environmental challenges, we are proud to contribute to a more sustainable future for aviation with the C Series aircraft family – the greenest single-aisle aircraft designed for the small single-aisle aircraft segment.

As a key player in the aviation industry, we are leading the way with new solutions aimed at reducing our global environmental footprint. Our product innovation life-cycle process – from the design and manufacture of the aircraft to its end-of-life – was applied throughout the development of the C Series family of aircraft. This will minimize the airliners' impact on the environment.

Sustainability is a key factor guiding our thoughts and business processes, and the C Series family of aircraft is a testament to our commitment to a greener future for aviation.

C Series

Meet the only community-friendly family of aircraft optimized for the small single-aisle aircraft segment

The C Series aircraft is a game-changer from nose to tail. Thanks to a long line of industry-shaping Bombardier aircraft as well as the expertise and experience of the company's highly skilled workforce, the C Series aircraft family is the natural progression of Bombardier's successful commercial aircraft families.

With its unmatched environmental scorecard, including the lowest noise levels of any commercial jet currently in production, the C Series is ideal for urban operations and noise-sensitive airports.

Communicating Environmental Performance – ISO 14025

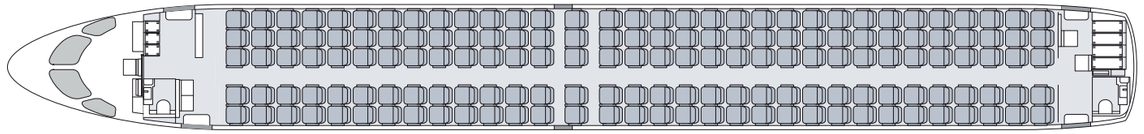
Bombardier communicates the environmental performance of its products through Environmental Product Declarations (EPDs) in accordance with the international EPD® system. The EPD is based on verified life-cycle analysis (LCA) data. It summarizes and communicates comparable information about the environmental impact of a product at each phase of its life cycle in a transparent manner.

The EPD for the CS300 aircraft was developed as per the Product Category Rules (PCR) for Passenger Commercial Aeroplanes (PCR 2015:02 CPC code 49623) as well as with the principles and procedures of ISO 14025:2006.

The external validation of the EPD was carried out by independent verifiers approved by the technical committee of the international EPD® system.

CS300 – FACTS AND FIGURES

Commercial name	CS300
Type of aeroplane	Single-aisle
Type Certificate Data Sheet Number	A-236
Date of certification	July 2016
Certification body	Transport Canada
Propulsion system	Turbofan
Engine trade name	Pratt & Whitney PurePower® PW1500G
Standard accommodation	130 passengers (dual class) 150 passengers (high-density single class)
Maximum passenger capacity	160 passengers
Maximum takeoff weight	67,585 kg (149,000 lb)
Takeoff field length	1,524 m (Base) to 1,890 m (Max) 5,000 ft. (Base) to 6,200 ft. (Max)
Maximum cruising speed	871 km/h (0.82 Mach)
Maximum operating altitude	12,497 m (41,000 ft.)
Maximum range	6,112 km (3,300 NM)
Fuel efficiency	As low as 2 liters/100 km per passenger



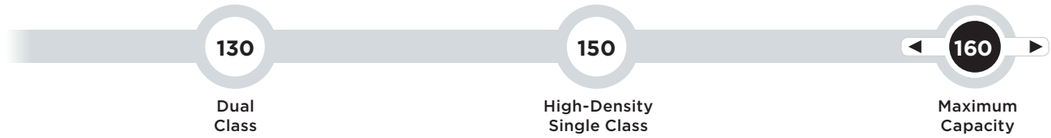
CS300 Configuration

The C Series aircraft family offers a flexible cabin with a capacity that typically ranges from 100 to 160 passengers. The CS300 aircraft can offer a maximum capacity of 160 passengers. For this Environmental Product Declaration, Bombardier selected a 160-seat configuration for the aircraft.

SELECTED CS300 AIRCRAFT CABIN CONFIGURATION

Number of lavatories	2
Number of trolleys	5.5
Seat Pitch	0.71 m (28 in.)
Number of seats	160

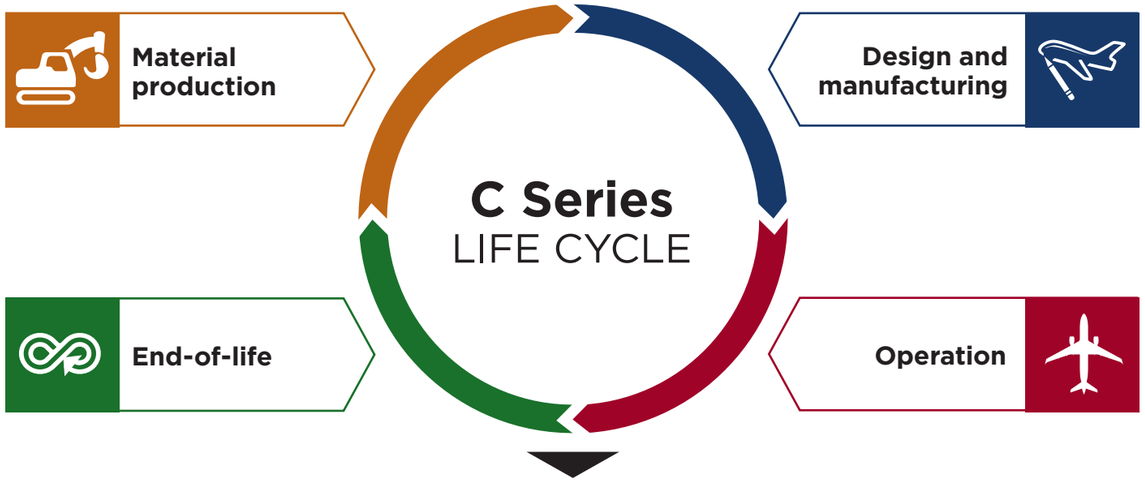
CS300 AIRCRAFT CAPACITY



In each of its interior configurations, the single-aisle C Series aircraft delivers a widebody feel. The cabin was intentionally designed from the inside out to provide space where it matters most, leading to an unrivaled passenger experience.

- Up to 50 per cent larger windows
- More shoulder room
- Best living space and comfort with 19-inch wide seats
- More baggage capacity

Environmental Profile of the CS300 Aircraft



At Bombardier, life cycle thinking is an integrated feature of the design process, highlighting the significance of different design options and the true overall environmental impact these options offer.

Life Cycle Assessment

Resource efficiency, waste generation and overall environmental impacts were estimated throughout all life cycle phases of the CS300 aircraft, following ISO 14044:2006 methodology.

The results represent a functional unit of one passenger being transported on the aircraft over 100 km, based on a standard 926 km mission (500 NM). The aircraft is assumed to have a full load of passengers (100 per cent load factor).

We based the assessment on the following: the aircraft will fly 60,000 times over its entire lifetime (i.e. 90,000 hours) at a maximum of 12,497 m (41,000 ft) of altitude and a typical speed of 829 km/h (M0.78). It will consume 2,693 kg (5,936 lb) of fuel per 500 nautical mile (NM) mission and transport 1,500 kg (3,305 lb) of fuel from the reserves* with 160 passengers on board. The end-of-life phase of the life cycle is modeled according to technology available today.

*Fuel reserves are considered as a dead weight in the aircraft and are not considered as burnt during the flight.

All Bombardier sites are ISO 14001-certified.

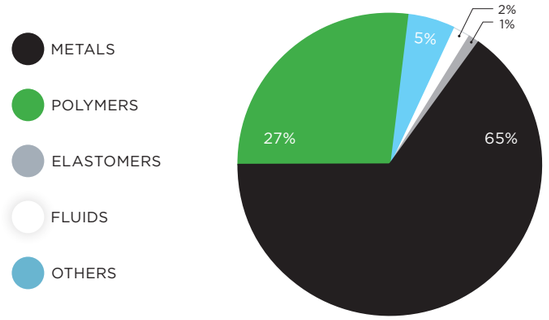
The C Series aircraft final assembly line in Mirabel and the Belfast (Northern Ireland) site, where the C Series aircraft wing is manufactured, are both **LEED* certified.**

* LEED: Leadership in Energy and Environmental Design

Material production

The extensive use of advanced structural materials (advanced aluminium and composite), combined with the specific design point contributed to significant weight savings (up to 5,400 kg [12,000 lb] lighter versus re-engined aircraft in its class). The following figure shows the typical material composition of a CS300 aircraft.

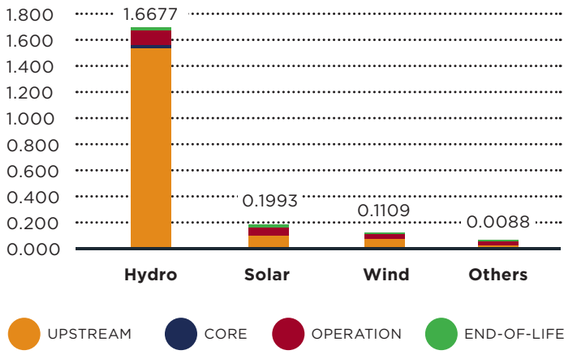
CS300 MATERIAL COMPOSITION



Design and manufacturing

Eighty per cent of the environmental impact of an aircraft is determined at the design stage. This fact influenced our decisions from the beginning of the program. In addition, C Series aircraft are assembled at Bombardier's Mirabel facility (Québec, Canada) where most of the energy comes from hydropower, a renewable energy resource.

RENEWABLE ENERGY (MJ)



Operation

Over the last 40 years, the average fuel efficiency of commercial aircraft improved by 70 per cent. However, while this is an impressive achievement for the industry, the environmental footprint of aircraft must continue to be reduced. As fuel burn directly relates to CO_2 emissions, it is essential to target minimal fuel consumption per passenger.

Bombardier has designed the only single-aisle aircraft family optimized for the small single-aisle aircraft segment using best-in-class technologies. The C Series aircraft have unmatched fuel efficiency, as low as 2 liters per 100 km per passenger. The tables here provide examples on how fuel consumption varies in accordance with the number of passengers on board the aircraft as well as the flight length.

AS LOW AS 2 LITERS / 100 KM PER PASSENGER
(Equivalent to 118 MPG or 50 km/L)

EFFECT OF NUMBER OF PASSENGERS ON FUEL BURN

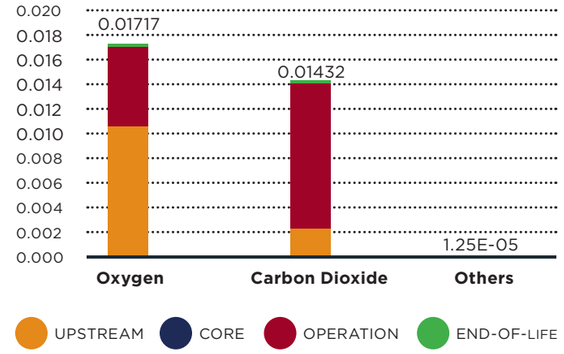
Mission (NM)	Number of Passengers	Fuel Burn (L/100 km per passenger)
2,000	130	2.25
2,000	150	2.02
2,000	**160**	**1.93**

EFFECT OF FLIGHT MISSION LENGTH ON FUEL BURN

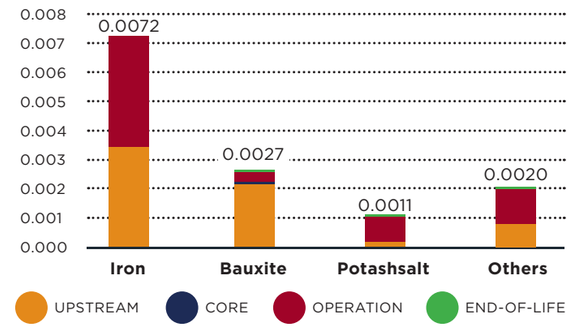
Mission (NM)	Number of Passengers	Fuel Burn (L/100 km per passenger)
500	**160**	**2.23**
1,000	160	2.0
1,500	160	1.94
2,000	160	1.93

The operation phase appears to be the major consumer of material resources and non-renewable energy resources (kerosene production process). The upstream phase, which includes raw material extraction and components production, is when more renewable material resources are consumed.

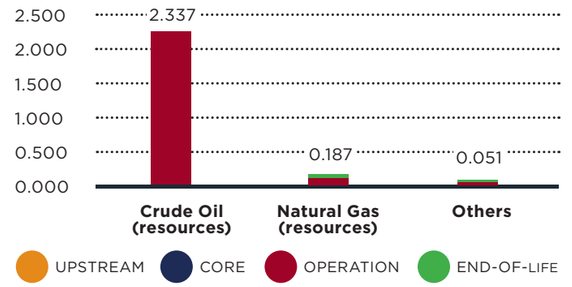
RENEWABLE MATERIAL RESOURCES CONSUMPTION (KG)



NON-RENEWABLE MATERIAL RESOURCES CONSUMPTION (KG)



NON-RENEWABLE ENERGY RESOURCES CONSUMPTION (KG)



Environmental Impact in Detail

GaBi database v.6 was used to generate the results. Results are shown using the April 2013 version of the CML2001 impact methodology (https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors). All specific data collected through 2012-2016 remains unchanged for 2017 and is valid for a global market. The table shows that most the upstream phase, which includes raw material extraction and components production, is the more important contributor to eutrophication potential impact at 56%. On the other hand, the operation phase is the more important contributor to acidification potential impact (94%), global warming potential impact (90%) and photochemical ozone creation potential impact (72%). CO_2 emissions responsible for the global warming environmental impact, come from the operation phase, which is expected to take place over the next 20 to 30 years for these aircraft. The C Series aircraft, with its unmatched fuel efficiency compared to other aircraft in its class, contributes to a significant reduction in CO_2 emissions (up to 120,000 tonnes per aircraft, the equivalent of taking more than 32,000 mid-sized cars off the road for a year.).

	Upstream[1]	Core[2]	Operation[3]	End-of-Life	Total
Acidification (kg SO_2-eq)	3.67E-04	8.35E-07	5.88E-03	3.28E-08	6.25E-03
Eutrophication (kg Phosphate-eq)	1.73E-03	3.76E-07	1.36E-03	9.98E-08	3.10E-03
Global warming (kg CO_2-eq)	7.72E-01	1.27E-03	6.63E+00	7.63E-05	7.40E+00
Photochemical ozone creation potential (kg Ethene-eq)	4.31E-04	1.76E-07	1.14E-03	2.33E-08	1.57E-03
Water consumption (kg)[4]	1.85E+03	1.04E+01	1.87E+02	1.98E-02	2.05E+03

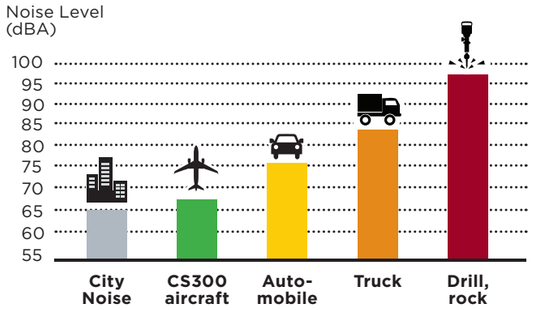
Note: These results are only valid for this range and this configuration. No linear assumption can be made to extrapolate environmental impact for another distance, another configuration or another aircraft type.

[1] Raw material extraction and component production
[2] Final assembly
[3] Use and maintenance
[4] 2.43 kg of water are also emitted during the operation phase as part of the combustion

Lowest noise and emissions in its class

The noise signature of the C Series aircraft is comparable to smaller aircraft such as turboprop aircraft, and is significantly less than its similar-sized competitors. With the lowest noise and emissions levels of any commercial aircraft in its class, the C Series aircraft is ideal for urban operations and noise-sensitive airports. To give a real feel on how quiet the CS300 is, the graph below compares the CS300 aircraft noise level to other urban sounds:

NOISE LEVELS OF COMMON URBAN SOURCES



Community noise certification numbers

The noise of the aircraft varies according to the engine thrust and aircraft weight. Three examples are shown below:

NOISE (EPNdB[1])	Configuration A	Configuration B	Configuration C
Approach	92.4	92.4	92.4
Lateral	86.9	86.7	87.8
Flyover	79.4	80.2	81.3
Total	258.7	259.3	261.5
Margin to Stage 4	17.2	17	16.1

Configuration	A	B	C
MTOW	130,000 lb.	134,500 lb.	149,000 lb.
MLW	129,500 lb.	129,500 lb.	129,500 lb.
Engine	PW1521G (21K lbf.)	PW1521G (21K lbf.)	PW1524G (23.3 K lbf.)

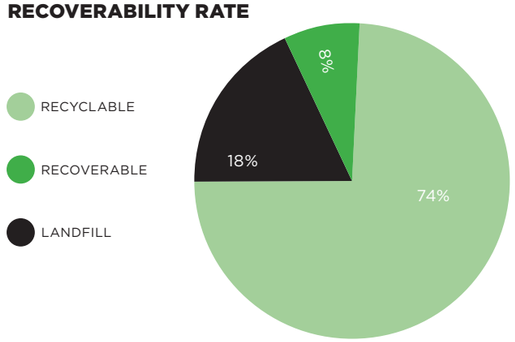
[1] Community noise certification is regulated by the International Civil Aviation Organization (ICAO) and expressed in Effective Perceived Noise in Decibels (EPNdB).

End-of-life

Using materials featuring high recyclability rates maximizes the overall recoverability of the CS300 aircraft. Material recycling and energy recovery aggregate to an 82 per cent recoverability rate.

Bombardier is involved in research projects to improve the recoverability rate of its aircraft to 100 per cent by 2025.

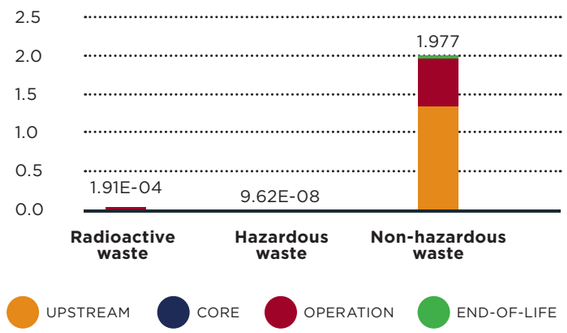
CS300 RECYCLABILITY AND RECOVERABILITY RATE



Bombardier puts a strong focus on minimizing the use of hazardous materials and related toxic emissions.

99.99 per cent of waste quantity generated over the life cycle of the aircraft is non-hazardous as shown in the graph below:

WASTE GENERATION (KG)



Glossary of terms

Life cycle assessment

Life cycle assessment (LCA) is the process used to measure a product's environmental impact at any point for any activity or use over its whole lifetime from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling.

Acidification potential

The aggregate measure of the acidifying potential of some substances, calculated through the conversion factor of sulphur oxides and nitrogen and ammonia into acidification equivalents (SO_2).

Global warming potential

Global warming potential is the aggregate measure of the warming potential of greenhouse gases emitted over all phases of the life cycle. It is expressed in CO_2 equivalents.

Eutrophication potential

The aggregate measure of the inland water eutrophication potential of some substances, calculated through the conversion factor of phosphorous and nitrogen compounds (waste water discharges and air emissions of NO_x and NH_3) into phosphorous equivalents.

Photochemical ozone creation potential

The aggregate measure of the ground level ozone creation potential of some substances, calculated through the conversion factor of ethylene equivalents that contribute to the formation of photochemical oxidants.

Recyclability and recoverability

The recyclability and the recoverability rate of a new aircraft vehicle are expressed as a percentage of the mass of the aircraft vehicle that can potentially be recycled (recyclability rate), or recovered, or both (recoverability rate).

Seat Pitch

Distance from any point on one seat to the exact same point on the seat in front.

Eco-Design

At Bombardier, integrating the core value of environmental sustainability into our product development function is fundamental to our process when designing our state-of-the-art aircraft.

Applying a complete life cycle perspective to aircraft design is central to our product responsibility strategy. Maximizing energy and resource efficiency, eliminating hazardous substances and related toxic emissions, as well as enhancing the overall product recoverability rate, are the result of a high quality working process applied to product design and cascaded to our supply chain. The Bombardier Eco-Design and Environmental Affairs team, together with its network, acts as a catalyst by providing the essential tools, expertise and central coordination in projects worldwide.

PCR review was conducted by the technical committee of the international EPD® system:

The Technical Committee of the International EPD® System
email: info@environdec.com

Independent verification of the declaration and data, in accordance to ISO 14025:2006

☐ Internal ☑ External

Third party verifier: **RITA SCHENCK**
Executive Director
Institute for Environmental Research and Education
email: **rita@iere.org**

Approved by: The International EPD® System

Environmental Product Declarations within the same product category, but from different programs may not be comparable.

This EPD is valid until **2020-08-11**.

Registration No. **S-P-00922**

UN CPC 49623

Publication date: **2017-10-03**

Revision date: **2017-11-20**

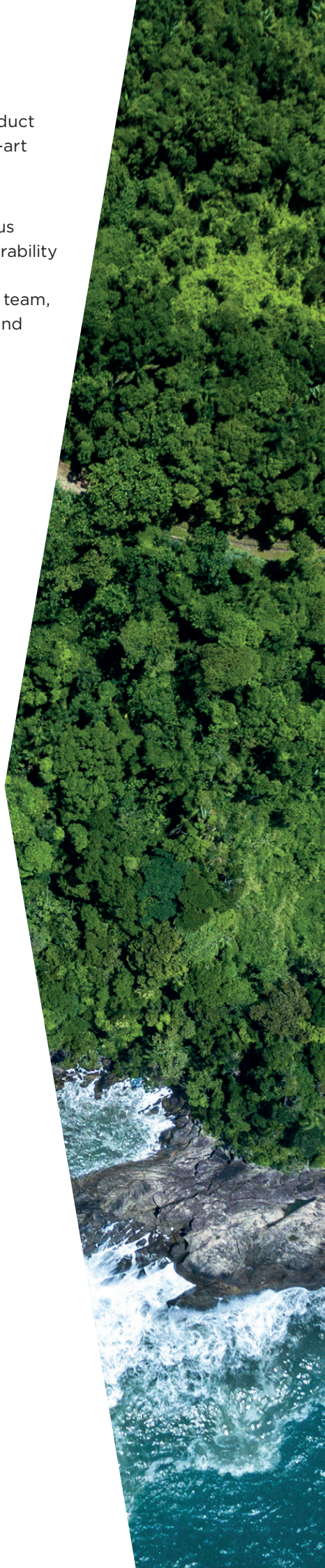
EPD®

More information on the international EPD® system is available at **www.environdec.com**

For more information on Eco-Design and Environmental Product Declarations at Bombardier:
http://www.bombardier.com/en/sustainability.html

For more information on Bombardier Commercial Aircraft's unique portfolio and on the C Series aircraft:
http://cseries.com/environment

Bombardier Commercial Aircraft
13100, Boulevard Henri-Fabre, Mirabel, QC, J7N 3C6 Canada
E-mail address: **bca.marketing@aero.bombardier.com**



PurePower® PW1500G, PW1519G, PW1521G, PW1524G and PW1525G Engines are trademarks of United Technologies Corp. – Pratt & Whitney or its subsidiaries.

Bombardier, C Series and *CS300* are trademarks of Bombardier Inc. or its subsidiaries.