RTX

COLLINS AEROSPACE

PRATT & WHITNEY

RAYTHEON

RTX
2023 Environmental, Social,
and Governance Report:
Sustainable Technology & Innovation

Sustainable technology and innovation

2023 marked two years since RTX, along with the commercial aviation industry, set an ambitious goal to achieve net-zero carbon emissions for commercial aviation by 2050. The goal aligns global civil aviation with the Paris Agreement to pursue efforts to limit global temperature increase to 1.5°C above pre-industrial levels.[1]

WHY IT MATTERS

As one of the world's largest aerospace and defense companies, we not only have a responsibility to reduce the impact of our own products, but we also have an opportunity to lead the way to help reduce the sector's impact.

Hear Graham Webb, chief sustainability officer at Pratt & Whitney, discuss the aviation industry's emissions goals and what it will take to reach them.

Read more about our efforts to advance our 2050 aspiration on Page 5.

[1] In October 2022, the International Civil Aviation Organization (ICAO) member states adopted a collective long-term goal of net-zero carbon emissions by 2050 for international aviation.

OUR APPROACH

Together with our engineers and scientists, we are pursuing multi-year efforts with industry partners, suppliers, customers and others across our value chain to develop and deliver advanced aircraft systems and propulsion technologies, as well as improvements in aircraft operations and infrastructure. Our path forward is demonstrated in our roadmap on Page 3.

Leading our efforts is our chief technology officer (CTO), who works closely with the vice presidents of engineering, chief sustainability officers and advanced technology teams at our business units, as well as the RTX Technology Research Center and other corporate research and development teams. Our Sustainable Technology & Innovation ESG working group drives sustainable technology projects across the organization, develops and implements an environmental sustainability technology roadmap and supports climate-related disclosures.

RTX Ventures, our venture capital group, invests in startups to further accelerate the development of new technologies. In 2023, we announced an agreement with EnCharge AI, a company creating scalable hardware and software solutions that make AI more accessible and efficient, to develop advanced AI chips that are expected to deliver 15x higher performance than market leaders with a 10x reduction in energy and cost.

Advancing aviation emissions reduction efforts

We recognize that a basket of measures is needed to achieve net-zero carbon emissions in commercial aviation. We're exploring diverse innovations for aircraft engines and aircraft systems to enable next generation aircraft to be more energy efficient and transition to greener fuels, thus reducing emissions from its source.

- Exploring engine technologies that will continue to enable **reduced fuel consumption**, including advanced small-core technologies, next-generation ceramic matrix composite materials and demonstrating the compatibility of sustainable aviation fuel (SAF) with advanced combustors.
- Developing advanced cycles for both SAF and hydrogen-powered engines.
- Continuing to innovate and mature **new aircraft systems**. These solutions span technology threads, including hybrid-electric propulsion systems, hydrogen-compatible aircraft components and system design, thermal management, eco-friendly fire suppression systems, adaptive environmental control systems and advanced, lightweight materials.

We're also exploring a comprehensive portfolio of innovations for aircraft operations to further reduce emissions. This includes optimizing aircraft trajectories and operations at the airport, reducing the distance and time flown, and delay on the ground by better coordinating the movement of the fleet.

- Developing **aircraft avionics**, including airborne navigation systems, enhanced visions systems, weather radar and onboard sensors, to achieve safe and more efficient aircraft operations, including harnessing information for flight path planning and optimization.
- Fielding and upgrading state-of-the-art **communication, navigation and surveillance systems (CNS)** including datalink solutions, satellite-based precision navigation infrastructure and air traffic radar systems essential for efficient airspace operations.
- Working on **air traffic automation and flight operations control systems** to allow for flight trajectories to follow near-optimal routes at near-optimal altitudes and speeds during all phases of flight, which reduces delays, fuel consumption and emissions.
- Modernizing and providing **weather** information services, weather sensors and integrated weather processing systems.

INDUSTRY COLLABORATION

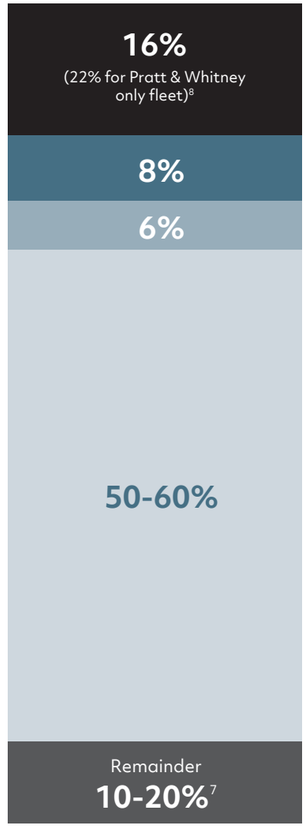
Reaching the sector's ambitious 2050 goals will be challenging, and we will only be successful with cross-sector industry actions and support from policymakers. We work with stakeholders to overcome challenges and achieve industry alignment on technologies, effective measurement processes, interoperability, infrastructure and regulatory policies. This includes collaboration with airframers, energy companies, customers, research institutions, standards development organizations, industry associations and government agencies. In 2023, together, we continued to take important steps toward progress. For a list of who we work with, click here.

Roadmap to 2050: Our civil aviation environmental sustainability technology roadmap

Our Roadmap to 2050 outlines our strategy to accelerate our emissions reduction progress. Significant reductions in our sector's emissions rely on long-term technology investment in products, as well as infrastructure that can be scaled to support the operation of future products. It also requires cross-sector industry actions and support from policymakers. See Page 4 for how we work with partners to make progress toward the sector's goals.

We continue to focus on improving engine efficiency, fielding 100% SAF-compatible systems and hybrid-electric propulsion systems in the near- to mid-term and supporting hydrogen-powered propulsion systems in the long term. In 2023, we shifted from our previous milestone-based emissions reduction targets to expected product-lifetime emissions intensity metrics for measuring improved engine efficiency.[1] This shift enables us to represent improvements from the introduction of more efficient engines and the expected increased use of SAF over time. Intensity-based metrics are also consistent with the aviation industry's emissions reporting practices for Scope 3 Category 11 emissions reporting and are supported by the International Aerospace Environmental Group (IAEG).

		2035	2050
ENGINES AND AIRCRAFT SYSTEMS	**Continuous engine efficiency improvements and technology advancements**	Develop advanced propulsion technologies for next-generation aircraft and deliver Pratt & Whitney GTF engines to customers to support a **45%** reduction in lifetime carbon emissions for each engine.[1]	Develop advanced propulsion technologies for next-generation aircraft and deliver new engines to customers with a **68%** reduction in lifetime carbon emissions for each engine.[1]
	Aircraft system improvements	Optimize the design of aircraft components and equipment to minimize weight and maximize energy efficiency, reducing fuel burn by **3%** per flight.[2]	Optimize the design of aircraft components and equipment to minimize weight and maximize energy efficiency, reducing fuel burn by **8%** per flight.[2]
AIRLINE, AIRPORT AND AIR TRAFFIC OPERATIONS	**Aircraft trajectory and ground operations improvements**	Develop next-generation technologies for air traffic and ground optimization, leading to **5%** fuel burn reductions on average per flight.[3]	Develop next-generation technologies for air traffic and ground optimization, leading to **8%** fuel burn reductions on average per flight.[3]
Driven by RTX / *Supported by RTX*			
VALUE CHAIN PARTNERS	**SAF, and other alternative aviation fuels (AAFs), airframer efficiency improvements and operations improvements from other industry stakeholders[4]**	Support airframer and aircraft operator initiatives to increase fleet-wide efficiency and collaborate with energy industry value chain partners to achieve SAF/AAF availability targets aligned with global deployment goals.	



Aggregate projected in-year emissions reductions from the 2050 civil fleet with RTX aviation products, relative to an inventory baseline with 2015 technology levels.[5,6]

[1] Lifetime emissions from commercial engines expected to be sold in 2035 and 2050 measured in terms of CO_2 per available seat kilometer relative to engines sold in 2015 using GHG Protocol for Corporate Accounting methods. This metric incorporates the IEA's SDS ETP 2020 forecasted SAF uptake.
[2] Improvements for flights in that year assuming entry in service of next-generation aircraft, relative to aircraft and air traffic operations with 2015 technology levels.
[3] Improvements for flights in that year, relative to air traffic operations with 2015 technology levels.
[4] Airframers and other value chain partners enhance aircraft design to reduce drag and weight and improve overall vehicle fuel economy. This also includes technologies for air traffic optimization and infrastructure improvements from other value chain partners.
[5] Values represent RTX's forecasted estimates for civil fleet net CO_2 emissions, relative to a 2015 technology baseline using GHG Protocol for Project Accounting methods for our fleet of engines and systems. We adopted a 2015 technology baseline consistent with ATAG Waypoint 2050, which is a vision of net-zero aviation widely adopted by the industry. Several new, significantly fuel-efficient aircraft types, including Airbus A320neo and Boeing 737 MAX, were introduced after 2015 and have been, and continue to be, adopted by airlines to replace older aircraft and to grow their fleet to serve traffic demand.
[6] This forecasting method adds direct emissions from aircraft engines to indirect emissions from non-engine related equipment mass, aerodynamic drag and secondary power extraction. The range of 50-60% in the value chain partner section is added to reflect uncertainties in SAF uptake and emission reduction factors. As detailed guidelines for fully analyzing emissions for the aviation industry do not yet exist, the methodology used in the future may evolve with industry standards.
[7] Potential solutions for reducing the remainder include enhancing the advancements noted above to further reduce emissions or employing market-based mechanisms such as the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
[8] 16% with respect to 2050 civil fleet with RTX aviation products, relative to an inventory baseline with 2015 technology levels; 22% with respect to 2050 civil fleet powered by Pratt & Whitney engines, which is a subset of the 2050 civil fleet with RTX aviation products.

OUR PROGRESS

In 2023, we made progress on our civil aviation environmental sustainability technology roadmap, leveraging the advantages of our scale, the complementary expertise of our three business units and our industry partnerships.

Continuous engine efficiency improvements and technology advancements

ENGINE EFFICIENCY

- Received more than 1,000 GTF engine orders in 2023. With 16% to 20% better fuel efficiency over the previous generation of engines, GTF engines have helped airlines save more than 1.4 billion gallons of fuel and over 14 million metric tons of CO_2 emissions since entering service in 2016. GTF engines are also compatible with current 100% SAF fuels.
- Selected by Boeing as a collaborator on the X-66 flight demonstrator, part of NASA's Sustainable Flight Demonstrator project. RTX will support Boeing with GTF engines and Collins' nacelles and engine accessories to support flight testing of the demonstrator aircraft in 2028.

HYBRID-ELECTRIC

- Completed the first engine run and electrical system integration test of our Scalable Turboelectric Powertrain Technology (STEP-Tech) demonstrator and a rated power test of our hybrid-electric flight demonstrator's 1 megawatt (MW) electric motor. Compared to Collins' most advanced electric motor generators fielded today, the 1 MW motor will deliver four times the power and twice the voltage, with half the heat loss and half the weight.
- Inaugurated our new $50 million advanced electric power systems lab in Rockford, Illinois that can perform full system-level electric power testing.

Aircraft system improvements

- Leading a consortium to develop new thermoplastics technology for the liquid hydrogen tanks necessary to power hydrogen propulsion architectures in future, more sustainable aircraft.
- Selected by Lilium N.V. to design, develop and build Lilium Jet's inceptors – the sidestick system used by the pilot to control the aircraft.
- Received an award for approximately $4.5 million for two proposals under the Horizon Europe Clean Aviation Program. In the Hydrogen-Electric Zero Emission Propulsion System project, RTX will develop a heat exchanger system for the flying fuel cell propulsion system. In the Advanced Wing Maturation and Integration project, RTX will develop a multifunction, leading-edge thermoplastic structure with integrated ice protection to support a laminar wing concept.
- Selected to participate in phase one of the Model-Based System Analysis and Engineering Framework Development and Assessment Program to develop advanced techniques for use in multidisciplinary design optimization, including comprehensive and narrow model sharing that boasts twice the voltage, with half the heat loss and half the weight.

Aircraft trajectory and ground operations improvements

- Received a $2.5 million award from the U.S. Department of Energy to predict contrails, which occur when aircraft exhaust water vapor mixes with cold humid air at high altitudes and are considered a powerful aviation-unique climate impact with low predictability.
- Selected to participate in nine projects under the E.U.'s SESAR 3 Joint Undertaking in the domain of Trajectory Based Operations (TBO). RTX will partner in the Network TBO and Air Traffic Control TBO projects, which seek to advance green operations for commercial air transport operations and lay the foundations for advanced emissions, noise and contrail controls.
- Continued to develop Integrated Transportation Airspace Mobility Services, an automation framework to support integrated airspace with new entrants, such as drones, electric vehicle take-off and landing aircraft, commercial space vehicles and established air traffic services.

Value chain partners

- Supported a transatlantic 100% SAF flight by a Virgin Atlantic Boeing 787 Dreamliner with our all-electric APS5000 auxiliary power unit.
- Supported the first 100% SAF flight by an Emirates Airbus A380 widebody with one of the aircraft's four GP7200 engines and our PW980 auxiliary power unit running 100% SAF.
- Supported the first 100% SAF transatlantic flight by a Gulfstream G600 powered by our PW815 engines.
- Supported test flights of the Embraer Phenom 300E with one PW535 engine running on 100% SAF.
- Supported the first 100% SAF flight of an AW139 helicopter powered by the PT6C-67C engine.
- Launched a collaboration with the world's No.1 regional turboprop aircraft manufacturer, ATR, to achieve 100% SAF readiness in PW127 series engines by 2025.
- Announced a collaboration with Airbus Canada and the SAF+ Consortium on next-generation SAF research and testing, including flight testing blends of up to 100% SAF on an Airbus A220 aircraft powered by GTF engines.
- Awarded funding by the Department of Energy's Hydrogen Shot Initiative to work with university, national lab and industry partners to develop advanced fuel-cell and hydrogen infrastructure technologies to support the commercial adoption of clean hydrogen.

Without public-private collaboration on SAF innovation, 2050 goals may be in jeopardy

Increasing the production and utilization of SAF is a critical step for achieving the air transportation sector's net-zero CO_2 emissions goal by 2050.

The November 2023 Conference on Aviation and Alternative Fuels (CAAF/3) marked an important milestone when ICAO and its member states agreed to a collective global aspirational goal to reduce CO_2 emissions in international aviation by 5% by 2030 through the use of SAF, low-carbon aviation fuels and other cleaner energies for aviation.

SAF is widely recognized as the most important energy transition path to achieving the industry's net-zero goals. Though it's growing at a fast pace, total SAF production today and, in the near future, is projected to be lower than envisioned a few years ago. In addition, actions and policies to meet SAF goals are still being developed.

CHALLENGES

- Today, production and deployment of SAF is estimated at **approximately 0.2%** of the global demand for jet fuel.
- SAF prices are currently **two to five times higher** than the price of conventional jet fuel.
- SAF policies are expanding across the globe, supported by both incentives and mandates; however, SAF manufacturers would need to **scale up production** significantly to reach targets aligned with the CAAF/3 goal.
- Certain governments are taking steps to deploy supporting policy, but **wide uncertainty remains** regarding global policy deployment to support investment needed to meet goals.
- It is technically possible to meet SAF goals, but it **requires an urgent, coordinated government-industry response** to implement investment in the energy sector globally.

WHAT WE'RE DOING

- **Demonstrating the compatibility** of RTX engines and auxiliary power units with SAF through flight demonstrations on blended and unblended SAFs.
- **Researching and testing emerging SAFs** by collaborating with industry, government and other stakeholders in public-private partnerships such as the SAF+ Consortium.
- **Providing input on SAF policy** and collaborating on industrywide SAF standards alongside peers through ASTM International, Commercial Aviation Alternative Fuels Initiative, IAEG and ATAG.
- **Supporting government policies and initiatives** that stimulate investment in production capacity of SAF, reduce costs and encourage greater industry uptake.

Learn more from Graham Webb, chief sustainability officer at Pratt & Whitney.

DIVE DEEPER

Read a statement by the CTOs of seven of the world's major aviation manufacturers, including Pratt & Whitney, calling on governments to support public policies to increase the supply of SAF while ensuring a consistent and predictable demand through harmonized global measures.

On a net-fuel life-cycle emissions basis, SAF has the potential to reduce CO_2 emissions by an estimated 30-90% depending on the feedstock pathway, with a current average of 70%, making it a key element of the roadmap to net-zero CO_2 emissions by 2050.

For our roadmap, we adopted a mid-range industry forecast for SAF deployment.

Innovations in the defense and space sectors

Our defense customers are accelerating their efforts to increase their climate resilience and reduce their emissions, while carrying out mission-critical operations. To support these ambitions, we are developing and introducing new technologies and more advanced, efficient jet engines, power systems, electronic systems and environmental observing systems.

DEVELOPING HIGH-EFFICIENCY ENGINES FOR MILITARY AIRCRAFT

JetZero is evaluating RTX's engines for its full-scale blended-wing body (BWB) aircraft demonstrator, which has the potential to cut fuel burn and emissions by 50% for both military and commercial applications.

JetZero is developing its BWB concept for both military and commercial airline applications.

Separately, by extending our support for engine performance improvement services for C-17 Globemasters, we are helping the U.S. Air Force and eight international partners improve the F117 engine's fuel efficiency, which annually is expected to:

Save up to
6.5M
gallons of fuel

Reduce CO_2 emissions by up to
63.5K
metric tons

Save around
$29M
in fuel costs

LEVERAGING ADVANCES IN COMMERCIAL AVIATION IN DEFENSE

We are adapting RTX solutions designed for commercial aircraft to deliver advanced electric power systems for next-generation military aircraft. For example, the 1 MW electric generator we are developing for the U.S. Air Force Research Laboratory could be paired with a fuel-burning engine, which would provide more onboard electric power than ever before and form a hybrid-electric propulsion architecture. This would also help increase fuel efficiency to maximize aircraft range, minimize aerial refueling needs and reduce carbon emissions.

In addition, in 2023, we successfully tested our Enhanced Power and Cooling System (EPACS), which is targeted to provide the F-35 significantly more cooling capacity while drawing less power, thus unlocking new performance for the aircraft.

REVOLUTIONIZING ENERGY DISTRIBUTION IN MILITARY OPERATIONS

Working with two value chain partners, RTX is helping the Defense Advanced Research Projects Agency design and develop wireless optical power relays that could revolutionize energy distribution within military operations. The team aims to develop "speed-of-light" energy networks to unlock power from new, diverse energy sources, including space. This would dramatically reduce the amount of room needed for fuel storage and the engine volume required, potentially resulting in smaller, lighter-weight aircraft and ground vehicles.

MONITORING EARTH'S CLIMATE AND ENVIRONMENT

From predicting weather patterns to monitoring wildfire spread, we are helping our customers by developing and deploying space technologies that can remotely monitor our planet to help us understand changes in climates and the environment.

SUPPORTING OCEAN HEALTH THROUGH INNOVATION

In 2023, Raytheon engineers reached a milestone in the development of the Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR) sensor, completing the critical design review stage and entering the build and test phase. GLIMR will help NASA better understand the physical and biological conditions in coastal and ocean ecosystems in the Gulf of Mexico, parts of the southeastern U.S. coastline and the Amazon River. As the space agency's first ocean hyperspectral imager in geostationary orbit, GLIMR will allow scientists to track coral bleaching, chlorophyl and plankton health, oil spills and harmful algal blooms.

Read more.

EARTH REMOTE SENSING FOR CLIMATE CHANGE

Our Visible Infrared Imaging Radiometer Suite (VIIRS) helped NASA and NOAA (National Oceanic and Atmospheric Association) track the spread of the 2023 Canadian wildfires. This helped better target efforts to battle the fires in British Columbia, Alberta, Ontario and Quebec. Using VIIRS data, scientists can also measure cloud and atmospheric particle properties, ocean color, sea and land surface temperature, ice motion and temperature, and the amount of sunlight reflected from the Earth's surface.

1000 Wilson Blvd.
Arlington, VA 22209 U.S.A.

www.rtx.com