

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services**
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting

Fond childhood memories propel a passion for possibility and sustainable fuel

Boeing’s SAF feedstock expert Onofre Andrade witnessed the transformative economic power sustainable biofuels had on his job-deprived rural village, while growing up in central-west Brazil.

When he was a young boy, his father joined with other farmers to form a co-operative that built a sugar cane ethanol plant. It still operates today. Prior to this co-op being developed, the sole source of jobs was farm labor.

“The sugar cane ethanol co-op provided much-needed jobs, and that sparked hope in the lives of many people I care about,” said Andrade. “The success of the ethanol plant catalyzed other co-ops and sparked capacity-building opportunities — including a co-op-led school started by my mother.”

Andrade joined Boeing before SAF was a hot topic, but his early experience continues to give purpose to him and his family.

Boeing’s SAF feedstock expert Onofre Andrade was inspired by seeing good jobs come to his rural village in Brazil when his father started a sugar cane ethanol co-op. (Onofre Andrade photo)

“I hope to inspire my kids the way my dad inspired me.”

Onofre Andrade, sustainable aviation fuel feedstock expert



Carissa Pajel at Boeing SAF lab. (Boeing photo)



Peter Nease and Clarence Santiago fueling ecoDemonstrator with SAF. (Boeing photo)

Advanced Technology

To meet the commercial aviation industry’s net-zero ambition by 2050, it will take an approach that includes SAF and other advanced technologies. Boeing has extensive experience on the “and,” through research, studies, testing and partnerships. The future of flight will incorporate the latest digital design, test and production tools, airframe, propulsion and systems technology, and different power and energy solutions will apply to different market segments and aircraft sizes.

Informed by the company’s extensive evaluation and testing of alternative propulsion sources and renewable energy and its research partnerships, and supported by Boeing’s expertise in commercial aircraft design and history of innovation on alternative energy and propulsion systems, Boeing has launched a new effort to conceptually design and assess the potential environmental impacts of “Future Flight Concepts.” These concepts are exploring applications of technologies including electrification and alternative fuels, such as hydrogen.

NASA awards sustainable flight program to Boeing and partners

In January 2023, NASA selected Boeing and its industry team to lead the development and flight testing of a full-scale Transonic Truss-Braced Wing (TTBW) demonstrator airplane through the Sustainable Flight Demonstrator (SFD) program. Through this unprecedented public-private partnership with NASA, Boeing and its industry partners are contributing more than half of the funding needed to shape the demonstrator program.

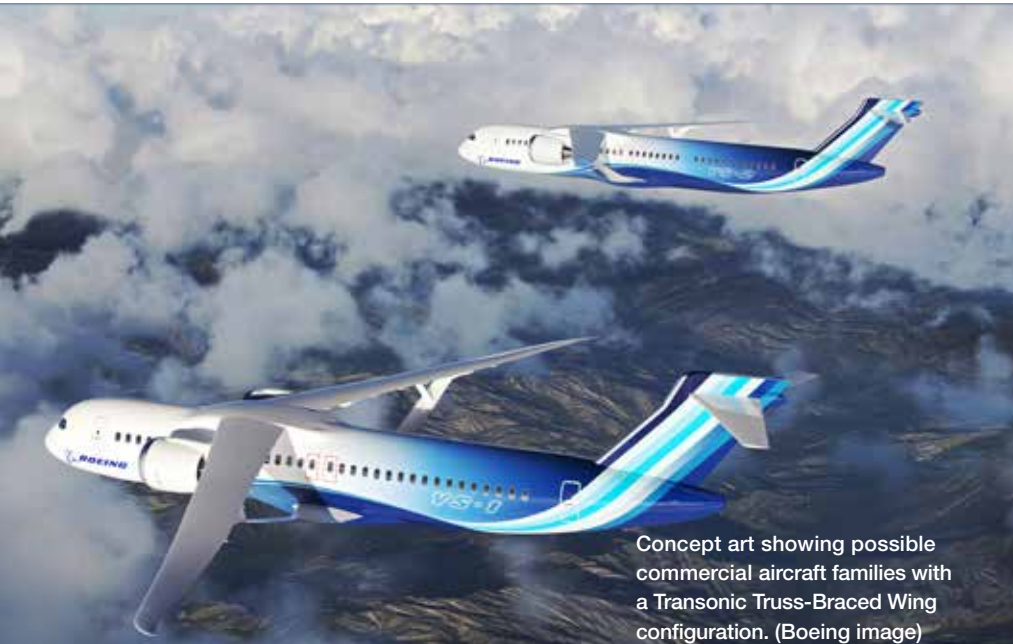
Why it matters: The technologies demonstrated and tested will inform future designs and could lead to breakthrough aerodynamics and fuel efficiency gains.

When combined with expected advancements in propulsion systems, materials and systems architecture, a single-aisle airplane with a TTBW configuration could see reduced fuel consumption and emissions of up to 30% relative to today’s most efficient single-aisle airplanes, depending on the mission.

Years in the making: The TTBW airframe concept is the result of more than a decade of development supported by NASA, Boeing and industry investments. Under previous NASA programs, including the agency’s Subsonic Ultra Green Aircraft Research program, Boeing conducted extensive wind tunnel testing and digital modeling.

“One of the key outputs of this activity is really the learning, the knowledge. What at the integrated airplane level ... will the benefits be? And depending on the results of this effort, and market conditions — that’ll dictate whether this shows up on a future commercial product.”

Todd Citron, Chief Technology Officer



Concept art showing possible commercial aircraft families with a Transonic Truss-Braced Wing configuration. (Boeing image)

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting

Wisk unveils self-flying, eVTOL aircraft

Wisk, a technology joint venture, is developing its 6th Generation aircraft. Designed with the **highest safety standards**, it will be the first candidate for certification of an autonomous, passenger-carrying electric vertical takeoff and landing (eVTOL) aircraft in the U.S. The Gen 6 aircraft has room for four passengers, carry-on luggage and personal items, can fly 90 miles (145 kilometers) and recharges in 15 minutes.

Why it matters: Wisk will be the first candidate for certification of an autonomous, passenger-carrying electric vertical takeoff and landing (eVTOL) aircraft in the U.S.

“Wisk is excited to partner with Boeing on the development of this autonomous aircraft. Our combined experience uniquely positions Wisk to succeed in this exciting new mobility market.”

Brian Yutko, CEO, Wisk



Wisk 6th Generation autonomous, passenger-carrying electric vertical takeoff and landing aircraft. (Wisk photo)



Space Launch System in flight.
(Boeing image)

Taking a SAF and other advanced technology approach

It will take a “SAF and” approach, not a “SAF or” approach, to achieve the **commercial aviation industry’s net zero ambition by 2050**. As part of our approach, which includes **SAF and other technologies**, Boeing continues to advance the **safety and viability of other energy carriers and their use on aircraft**. Since the mid-2000s, Boeing has conducted **six hydrogen technology demonstrations with crewed and uncrewed aircraft using hydrogen fuel cells and combustion engines**. Boeing successfully tested a cryotank designed for space with the capacity to hold 16,000 gallons of **liquid hydrogen** or the energy equivalent of the Jet A fuel in a typical regional jet.

Boeing was reminded of the challenges and opportunities associated with hydrogen with the recent Artemis mission. Chris Raymond, Boeing’s chief sustainability officer dives into more detail in this [Fortune article](#).

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting

Sustainability test bed turns 10

The Boeing ecoDemonstrator marked its 10-year anniversary in 2022 — accelerating innovation by taking promising technologies out of the lab and rigorously testing them in an operational environment.

By the numbers:

The program has tested over 225 technologies to help enhance safety, decarbonize aviation and improve operational efficiency and the passenger experience.

- Nine platforms served as flying test beds:
 - 2012: American Airlines 737-800.
 - 2014: Boeing 787-8 Dreamliner.
 - 2015: TUI 757.
 - 2016: Embraer E170.
 - 2018: FedEx 777 Freighter.
 - 2019: Boeing 777-200.
 - 2020: Etihad Airways 787-10.
 - 2021: Alaska Airlines 737-9.
 - 2022-2024: Boeing 777-200ER (Extended Range).
- Approximately one-third of those technologies progressed onto Boeing’s products and services, including:
 - More aerodynamically efficient winglets on the 737 MAX.
 - iPad apps that provide real-time weather and other information to pilots, enabling them to improve fuel efficiency and reduce emissions.
 - Custom approach path information to lower community noise.
 - Flight deck touch-screen displays and a camera system on the 777X that will enhance safety by helping pilots avoid ground obstacles.



“I am proud of the ecoDemonstrator’s role in pioneering the use of sustainable aviation fuel (SAF) for the industry. Not only has almost every one of our platforms flown on SAF, we conducted the industry’s first commercial flight on 100% SAF in both engines in 2018 with FedEx Express and tested SAF emissions with NASA. That is what we do — partner across the industry to help safely decarbonize aerospace.”

Rae Lutters, ecoDemonstrator program manager

The 2022 Boeing ecoDemonstrator, a 777-200ER (Extended Range) flies on a blend of 30% SAF and 70% conventional jet fuel. (Boeing photo)

 **Video:** [See flying lab.](#)

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting

Partnerships

Boeing partners for a clean energy economy

Throughout 2022, Boeing joined forces with innovative partners from around the world to scale renewable energy and sustainable technologies for a more sustainable aerospace and future.

Why it matters: Boeing is aware that no one entity can decarbonize the commercial aviation industry alone. It will take “everyone” to achieve the industry’s net zero ambition by 2050. We recognize the significant capital investment required in the journey and appreciate the partnership and support of the financial community to channel liquidity into the ongoing transition pathway.

- **Avolon and SkyNRG:** Boeing partnered with Avolon, ORIX Aviation, SFS Ireland and SkyNRG to identify opportunities for a commercial-scale SAF production facility in Ireland. The country is a global leader in aviation finance and airline operations with a planned growth of renewable energy sources. The study will be completed in 2023.
- **Alder Fuels:** Boeing has committed to support testing and qualification of Alder Fuels-derived SAF on its airplanes to further grow the global SAF market. This technology enables the conversion of sustainable forest and agricultural residues into a low-negative carbon “greencrude” for jet fuel conversion — displacing the typical jet fuel need by up to 75% in the U.S. The first plant will be completed in 2024.
- **ACT FOR SKY:** Boeing is a member of ACT FOR SKY, a voluntary organization of 19 companies that works to commercialize, promote and expand the use of SAF produced in Japan.



At the Farnborough Airshow in June 2022, Boeing and Mitsubishi Heavy Industries announced we will build on our decades-long partnership. (Boeing photo)

- **Mitsubishi Heavy Industries (MHI):** Building on their decades-long partnership, Boeing and MHI agreed to study sustainable technologies for a low-carbon society. Their focus areas include green hydrogen, carbon capture, electrification, sustainable materials, emissions propulsion technologies, new aircraft design concepts as well as new feedstocks and technologies for SAF production.
- **NASA:** Boeing and NASA continued their partnership testing the emissions from SAF. This year, the team conducted tests on the 2022 Boeing ecoDemonstrator, a 777-200ER (Extended Range) with Rolls-Royce Trent 800 engines and a 787-10 with GENx-1B engines ([see Page 44](#)).
- **Rocky Mountain Institute and Five U.S. Airlines:** Boeing, along with five major U.S. airlines and others, joined the Contrail Impact Task Force led by the Rocky Mountain Institute to explore the formation, impact, and mitigation of persistent condensation trails, or “contrails,” and their climate effects.
- **Roundtable on Sustainable Biomaterials (RSB):** Boeing has been a member of the Board of Directors since 2021 and has chaired RSB’s SAF Policy Platform to advance stakeholders’ collaboration on renewable energy.
- **SpiceJet, Council of Scientific and Industrial Research-Indian Institute of Petroleum (CSIR-IIP):** Boeing partnered with these organizations to explore SAF use in India, supporting the country’s environmental goals and self-reliance initiative. Boeing is currently assisting in the certification process for SAF developed by CSIR-IIP by providing review and support.
- **Virgin Atlantic:** In December 2022, partnering with Boeing, Virgin won the UK Department for Transport’s 100% SAF Trans-Atlantic Flight Fund Competition. This UK government initiative, which will see a 787 cross the Atlantic on 100% SAF in 2023, will showcase the spectrum of sustainable aviation approaches to the flying public and inform our journey toward routine commercial industry 100% SAF flights by 2030.

What’s next: The commercial aviation industry’s ambition is to achieve net-zero carbon emissions for global civil aviation operations by 2050, while also growing the societal benefits of air transportation. Boeing will continue to work across sectors and industry to ensure the benefits of aerospace remain available for generations to come.

Contents

Introduction

Approach & Governance

People

Products & Services

Global Aerospace Safety

Sustainable Product Life Cycle

Innovation and Clean Technology

Fleet Renewal

Operational Efficiency

Renewable Energy

Advanced Technology

Partnerships

Operations

Communities

Reporting

University partnerships strengthen sustainability at Boeing

Why it matters: Strong university partnerships are one way Boeing demonstrates that it is looking outside the aerospace industry to give and receive support for research and development and to attract top talent.

Here are some universities partnering with Boeing on sustainability:

- **Yale Center for Natural Carbon Capture:** In April 2022, Boeing pledged \$10 million to research efforts in natural carbon sequestration to scale natural solutions to mitigate GHG. The Center’s focus is on near-term solutions that can capture approximately one gigaton of CO₂ per year, the equivalent to current annual airline emissions. This approach offers potential co-benefits such as improved soil health and biodiversity conservation.
- **University of Sheffield:** Boeing is the founding member of the Energy Innovation Center (EIC), which is focused on driving SAF development. In early 2023, the EIC was announced as the UK’s SAF Clearing House, in partnership with the University of Dayton, reinforcing the critical role this first-of-its-kind facility in the UK will play in the global ecosystem. The EIC builds on Boeing’s long-standing relationship with Sheffield, which started with the co-founding of an advanced research center for manufacturing and led to the opening of Boeing’s first European manufacturing facility, demonstrating a successful model for university and industry collaboration.

Fossil-Free Future for Aerospace: His Majesty King Charles III visits Cambridge University, when he was Prince of Wales, to see plans for a new Whittle Laboratory building that would act as a hub for the university-led Aviation Impact Accelerator (AIA), of which Boeing is an official industry adviser, focused on accelerating the move toward the commercial aviation industry’s climate goals. (University of Cambridge photo)

- **University of Cambridge:** In 2023, Boeing is celebrating 20 years of collaboration with the University of Cambridge. Among other research projects, Boeing is partnering with the university’s Whittle Lab on its Aviation Impact Accelerator (AIA) to draw from a multidisciplinary range of expertise. AIA develops interactive, evidence-based models, simulations and visualization tools for decision-makers and others to understand low-emissions flight pathways, complementing our own Cascade tool. The AIA tool will help Boeing and interested parties understand how policies, scenarios and technology transitions support the industry’s net-zero carbon emissions from commercial aviation by 2050.
- **Cranfield University’s Digital Aviation Research and Technology Centre:** This partnership focuses on technologies that are relevant to the operational efficiency pillar of our sustainable aerospace strategy.
- **Villanova University:** The Resilient Innovation through Sustainable Engineering (RISE) Forum advances corporate sustainability by identifying and applying data-driven sustainability solutions. Boeing has access to faculty and graduate students who possess the technical expertise to examine real-world problems by evaluating various technologies or operational innovations through a systems perspective.

What’s next: We will continue to partner with academic institutions at the forefront of sustainable aerospace research.



Alicia Piscitelli. (Boeing photo)

Studying sustainable materials in forestry waste: University partnerships nurture the sustainability talent pipeline, which benefits graduates and the company. Alicia Piscitelli secured a position on Boeing’s Research & Technology team after completing three company internships and earning both master’s and doctorate degrees from Villanova’s sustainable engineering program.

Boeing’s circular economy expert and Associate Technical Fellow (see Page 30), Christin Datz, was Piscitelli’s master’s thesis adviser as she researched ways to advance the sustainable product life cycle. Piscitelli’s doctoral research focused on renewable feedstock material for thermoset polymers used in interior aircraft composites. She studied ways to synthesize phenolics with renewable feedstocks derived from pine root oil and forestry waste.

Most recently, she’s helping Boeing to find sustainable ways to manage polymers at the end-of-life phase of the sustainable product life cycle.

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting

Boeing partners with decision-makers for sustainable aerospace

Boeing is working with decision-makers and policy institutions globally to create tailor-made paths forward to decarbonize commercial aviation.

Why it matters: The commercial aviation industry’s ambition of net-zero carbon emissions by 2050 has multiple levers to work toward meeting this target. SAF is seen as the best solution to accelerate toward this goal as it is a drop-in solution to the aviation ecosystem.

Around the globe: Here’s a snapshot of Boeing’s global policy partnerships.

- **Americas:** Partnering with International Air Transport Association (IATA), Boeing hosted a SAF Roundtable at the IX Summit of the Americas and asked heads of state to develop sound policies to incentivize the production of SAF across the western hemisphere, highlighting the potential of the region. Boeing also partnered with seven airlines from across the Americas, using nearly 400,000 liters (106,000 gallons) of SAF for commercial flights during the week of the summit, avoiding the release of over 214 tonnes of CO₂.
- **Australia:** SAF will unlock its share of an extra \$10 billion each year in GDP, generating 26,000 jobs, while reducing emissions by around 9%. Boeing and Bioenergy Australia hosted a panel at the Prime Minister’s Sydney Energy Forum to accelerate the production of SAF, where the Australia Transport Minister announced plans for a Jet Council. Boeing also chaired the SAF Alliance of Australia and New Zealand to make key policy recommendations on scaling SAF.
- **China:** Boeing and Peking University Institute of Energy released a report that compiles results of a yearlong research effort into SAF, the basis of a plan to decarbonize air travel in the world’s second-largest commercial aviation market.

Boeing Global Sustainability Policy & Partnerships Vice President Brian Moran (right) is joined by Mohamed Al Ghailani, Boeing’s sustainability lead for Middle East, Türkiye and Africa, at COP27, where they engaged with government, industry and civil society partners. (Boeing photo)

- **Europe:** Boeing became a member of the European Commission’s Renewable and Low-Carbon Fuels Value Chain Industrial Alliance. As part of the Aviation Working Group, Boeing is partnering with the European policymakers to inform how to scale production and uptake of SAF. In 2022, Boeing also took the lead as Sector Champion for Aviation in the World Economic Forum’s First Movers Coalition (FMC), which has assembled 24 of the world’s leading companies. All airlines and air transport companies in this sector have set a target to procure 5% of their fuel demand as advanced SAF. The group works to overcome technology barriers and bring forward supply with the intent of striking binding commitments between buyers and sellers.
- **Middle East:** Boeing discussed real-world climate actions at the 2022 COP27 via panels and keynotes with partners and stakeholders, amplifying that the only way to keep 1.5 degrees C alive is through cross-sector partnerships, strategies, regulation and data to keep all parties on track.
- **Singapore:** Boeing joined the International Advisory Panel (IAP) set up by the Civil Aviation Authority of Singapore to develop Singapore Sustainable Air Hub Blueprint by 2023. Boeing provided insight into IAP’s report on scaling SAF and improving air traffic management to create a conducive policy framework for the region’s busiest aviation hub. Boeing also briefed the Association of Southeast Asian Nations Air Transport Ministers on key strategies for sustainable aviation, encouraging further discussion amongst the member states on accelerating regional cooperation.
- **UK:** Boeing hosted the seventh Jet Zero Council meeting in its offices, presenting its Cascade tool to the Secretary of State for Transport and Secretary of State for Energy and Net Zero. The work of the council is crucial for the UK Jet Zero Strategy. Boeing was appointed co-chair of the Defence Supplier Forum Climate Change and Sustainability Aviation Group with the Royal Air Force. Boeing also leads a NATO group on behalf of the UK focused on accelerating military adoption of SAF to support defence sustainability and energy security.



- **U.S.:** The SAF Grand Challenge engages federal government agencies to develop a comprehensive strategy for scaling up new technologies to produce SAF on a commercial scale from renewable or waste resources. Objectives include: expanding SAF supply and end use; reducing its cost; enhancing its sustainability; supplying at least 3 billion gallons of SAF annually by 2030; and sufficient SAF to meet 100% of aviation fuel demand by 2050, which is projected to be around 35 billion gallons per year.

- What’s next:** Boeing will continue to work closely with governments, customers and decision-makers globally to achieve our shared goal in 2023 and beyond, including:
- Partnering on SAF road maps across the APAC region, including Australia, New Zealand, Southeast Asia and Japan.
 - Helping to develop Australian Jet Zero Council.
 - Advocating to policymakers, the finance community and suppliers through regional workshops with FMC around the world to build local capacity for SAF supply, enhance demand commitments and unlock commercial challenges.
 - Supporting the release of global SAF guidance on future supply and demand issues for buyers and sellers.
 - Working closely with the UAE government on shaping sustainable transport agenda at COP28.

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services**
 - Global Aerospace Safety
 - Sustainable Product Life Cycle
 - Innovation and Clean Technology
 - Fleet Renewal
 - Operational Efficiency
 - Renewable Energy
 - Advanced Technology
 - Partnerships
- Operations
- Communities
- Reporting



Gonzaga University Senior Design students receive the Adient Aerospace Ovation seating; left to right in photo: Hannah Dunn, Micah Donald, Brady Jurgens, Emily Andresen. (Zack Berlat, Gonzaga photo)

Lighter seats lift efficiency

Boeing’s Cabin and Interiors and Payloads Engineering teams are finding innovative ways to reduce waste, emissions and weight during the product life cycle for complete customer solutions that promote sustainability. One of those ways involves a group of college students in Spokane, Washington. Boeing and joint venture aircraft seating partner, Adient Aerospace, joined with Gonzaga University’s School of Engineering and Applied Science students to support a sustainability-focused research initiative. The students are using Adient Aerospace’s Ovation seat prototype to study cabin product design, manufacturing and maintenance to find new approaches to increase sustainability measures.



Gonzaga University senior design students Brady Jurgens, Hannah Dunn, Emily Andresen and Micah Donald study Ovation seat design and structure. (Zack Berlat, Gonzaga photo)

- Contents
- Introduction
- Approach & Governance
- People
- Products & Services
- Operations**
 - Quality
 - Sustainable Operations
 - Operational Targets Progress
 - Addressing Climate Change
 - Conserving Resources
 - Reducing Waste
 - Biodiversity and Environmental Compliance
 - Responsible Supply Chain
 - Enterprise Security and Data Privacy
- Communities
- Reporting



Habitat restoration along the Lower Duwamish Waterway in Seattle. (Boeing photo)

OPERATIONS

Responsible and Resilient

Quality

We design quality into every aspect of our business and drive personal accountability to ensure quality in everything we do and in every product we deliver. We promote quality with our people, our culture, metrics and oversight.

The Boeing Quality Management System (QMS) has a foundation in AS9100, which is the internationally recognized and premier aerospace QMS standard. Boeing aims to flow down AS9100 certification and compliance to its suppliers in order to enable effective and efficient processes that meet multiple customer, statutory and business requirements.

QMS and the company’s Safety Management System (SMS) work together and are built into the company’s organizational structure, policies, processes, procedures and resources. Our customers and our regulators have extremely high expectations of Boeing, and these systems help to operationalize safety and quality in order to meet those expectations.

We incorporate safety and quality metrics into our primary annual incentive structures, further driving our focus across the enterprise at every level of the organization. We operate with four enterprisewide operations councils focused on strengthening quality, manufacturing, supply chain and program management in every program. We deliver quality through a relentless commitment to integrity, safety and sustainability, which is fundamental to our mission.

[Learn more about our approach to quality.](#)



The T-7A Red Hawk is manufactured with a new proactive quality tool called Requirements Consumption Review. (Boeing photo)

A sustainable approach to supplier quality success

Boeing is expanding a new proactive quality tool called Requirements Consumption Review (RCR) to ensure suppliers fully understand all requirements prior to building a product — and it’s significantly reducing waste and rework down the line to enable first-time quality.

Why it matters: The program is having a positive impact on quality.

- Boeing conducts the review for newly designed products or products that have moved to a new supplier and that may generate a defect, for example, given the part’s complexity.
- RCRs have resulted in a 95% first-time quality yield, compared to 60% for similar parts that did not involve the tool.
- First deployed across Boeing’s Defense, Space & Security business, RCRs are now being implemented across Commercial Airplanes and Global Services as well.

“When we send a purchase order to a supplier, it can be a detailed process to ensure we receive high-quality products that meet our exacting requirements. This early involvement approach involves a cross-functional team that works proactively with the supplier to go through the purchase order together, including all the critical technical requirements, and establish confidence and clarity from the start. It also demonstrates that we are invested in their success.”

Doug Ackerman, vice president of Supplier Quality