Digital factory of the future

Boeing is utilizing an industry-leading technology to transform the way we design, test and build airplanes. Today, Boeing engineering teams are studying how recent lessons learned from across the company could shape the factory of the future — with digital transformation as a major driver.

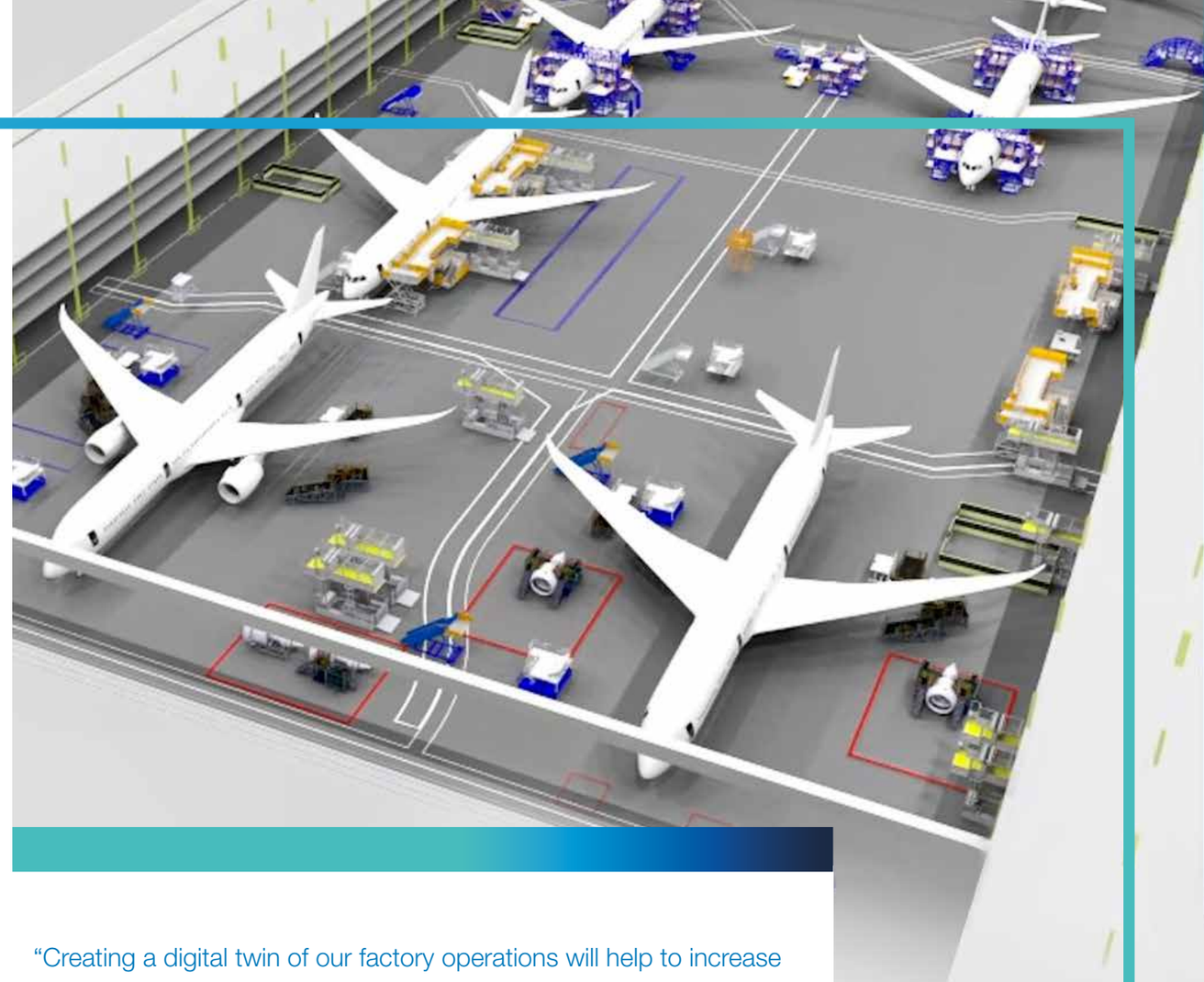
Why it matters: Stability and optimized performance is happening.

- Boeing's T-7A Red Hawk team was able to build the first several aircraft in simulations before production even started and then join the aft and forward fuselages in less than a half-hour, a process that would normally take days.
- Although commercial airplanes are larger and production requirements are different from military aircraft, Boeing teams will apply those learnings to future programs. That knowledge, combined with more than a century of development experience on other programs, will guide future production.

It comes down to this: This will enable Boeing to predict performance of the production system and see how changes in the airplane design affect that performance, or vice versa. It will also allow teams to "build" the first several aircraft in a simulation, flattening the learning curve. Supplier readiness and success around first-time quality enables Boeing to operate more sustainably as a business.

By driving quality within the supply chain, Boeing demonstrates its commitment to sustainability by reducing rework and/or delayed parts in the value stream to minimize time lost and waste.

Video: Take a look at our future factory.



"Creating a digital twin of our factory operations will help to increase stability and optimize performance prior to physically building a product. We have long used models to predict aircraft performance and refine them with test data as it comes available. Similarly, we will build models to predict production system performance and refine them as systems come online."

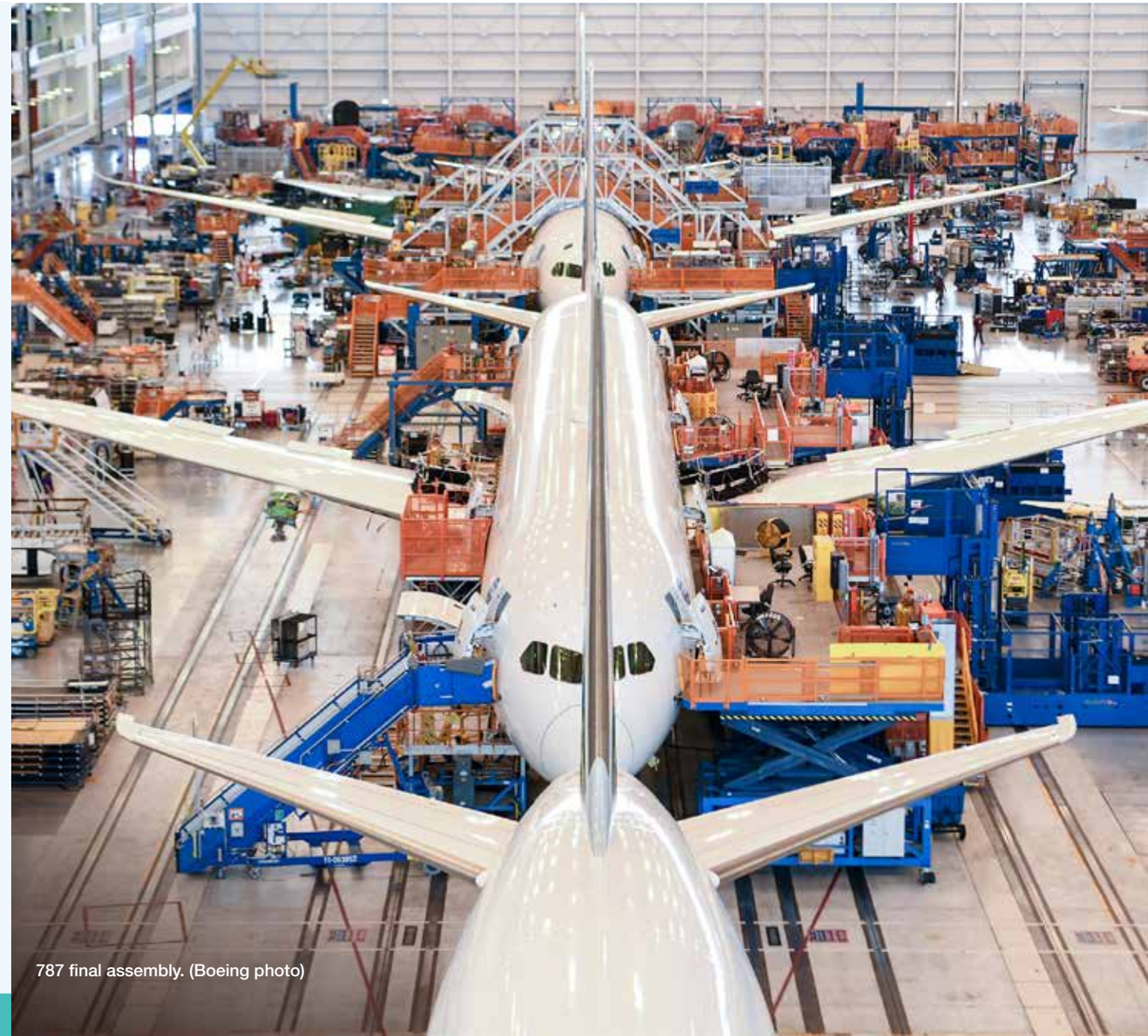
Howard McKenzie, chief engineer and executive vice president of Engineering, Test & Technology

A simulated view of what a future commercial factory could look like. The concept builds off of lessons learned from how the T-7A program operates in St. Louis — no fixed tooling, no holding fixtures. The part becomes the tool, which is a revolutionary concept. (Boeing image)

Sustainable Operations

Boeing appreciates sustainable aerospace starts inside our four walls. We are focused on continuous improvements in pursuit of the sustainable product life cycle across key elements including greenhouse gas emissions (Scope 1 and Scope 2), energy usage, water and waste management. We take action to decrease our impact through renewable energy procurement, targeted infrastructure and equipment investments, efficiency standards and conservation initiatives that include deployment of best practices and employee engagement strategies. Core to this strategy is the ongoing engagement of our employees each year through education and initiatives focused on ways in which they can reduce their environmental impact at work, and at home. Boeing's environmental strategy is guided by a comprehensive review and assessment of the most significant environmental challenges and risks facing the company, and our environmental priorities are set with internal and external stakeholders. The analysis includes direct input and perspectives on industry best practices and community requirements from diverse stakeholders, such as customers, environment-focused nongovernmental organizations (NGO) and the company's global leadership. The information helps Boeing identify and update our understanding of current and emerging sustainability issues that are critical to the company and our stakeholders. It also informs our next-generation environmental strategy and targets.

Since 2020, Boeing has achieved net-zero GHG emissions at manufacturing and work sites by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions.



787 final assembly. (Boeing photo)

Operational Targets Progress

Boeing invests in sustainable operations to reduce the impact of our manufacturing sites and is focused on conserving resources. We prioritize reducing emissions, energy, water and waste throughout our global operations and have set 2025 waypoints toward 2030 goals to share our progress and remain accountable as we increase production. Boeing's sustainable operations strategy is managed within the Global Enterprise Sustainability organization, in close partnership with stakeholders across the enterprise. Through our Sustainable Operations subcouncil, we track performance across the enterprise and at the site level to assess our progress, identify challenges and opportunities, and share best practices.

Performance Area[1]	2025 Targets vs. 2017[2]	2022 Progress Toward 2025 Targets and Drivers	2030 Targets[3]
Greenhouse Gas Emissions	Reduce emissions by 25%[1]	**31% Reduction** Procurement of renewable energy and renewable energy credits, low commercial production activity and infrastructure investments.	• Net-zero emissions.[4] • 55% GHG reduction from 2017. • 100% renewable electricity.
Energy[5]	Reduce energy consumption (natural gas, other fuels and electricity) by 10%	**11% Reduction** Conservation initiatives, infrastructure investments, remote working conditions and reduced production activity.	• 10% energy reduction from 2025.
Water[6]	Reduce water withdrawal by 20%	**19% Reduction** Increased water intake efficiencies and low production activity.	• 5% reduction from 2025.
Solid Waste[7]	Reduce solid waste to landfill by 20%	**40% Reduction** Conservation initiatives, vendor management and remote working conditions.	• 30% reduction in solid waste produced from 2025. • Over 90% diversion from landfill or incineration. • Zero solid waste to landfill certification where applicable at major sites.
Hazardous Waste[8]	Reduce hazardous waste by 5%	**9% Reduction** Projects to reduce unused and expired materials, and partnerships to reduce waste generation.	• 5% hazardous waste reduction from 2025.

1. Operational goals shown are absolute targets and not indexed to production levels or growth. 2022 performance was affected by changes associated with occupancy and operations during the COVID-19 pandemic, as well as conservation and changes in how Boeing purchases energy. The targets were established against a 2017 base year. The 2025 goals will act as a milestone to guide actions and progress to the 2030 goals.
2. All 2025 reduction goals were set with an operational boundary of the Core Metric Sites, which represent the majority (70%) of Boeing's operations, and includes emissions from electricity use and natural gas.
3. The 2030 reduction goals set with an operational boundary of The Boeing Company and includes all Scope 1 and Scope 2 emissions.
4. The net-zero achievement covers Scope 1 and Scope 2 emissions for all manufacturing and work sites within the company's operational control as well as Scope 3, business travel. This is achieved by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions.
5. Energy includes natural gas, other fuels and electricity.
6. Water data represents approximately 84% of operations square footage.
7. Solid waste numbers represent values determined from scale-weighed containers as well as calculated weights. Nonhazardous solid waste is sent to landfill for disposal. This measure applies to all waste streams where Boeing is responsible for waste disposal service as a normal part of daily operations (excludes remediation and construction-related waste).
8. Hazardous waste is determined from U.S. EPA hazardous manifest or equivalent government shipping documents. All types of hazardous wastes that are generated at a facility and are discarded from the site for disposal, and would be considered part of the environmental footprint of the site. Actual tons of all Production or routine wastes shipped as hazardous waste (excludes remediation and construction-related waste).

Addressing Climate Change

We consider climate change to be an urgent issue. We support the goals of the Paris Agreement and encourage our value chain partners to do the same. Boeing achieved net-zero carbon emissions at manufacturing and other work sites and in business travel in 2022 for the third consecutive year, by expanding conservation and renewable energy use while securing carefully selected, third-party-verified offsets for the remaining greenhouse gas (GHG) emissions. Boeing strives to reduce operational GHG emissions, both during times of growth and during times of challenge. Our strategy for Scope 1 and Scope 2 emissions, which we detail in the following section, aligns to a 1.5 degrees Celsius global warming potential scenario, in support of the global climate goals.

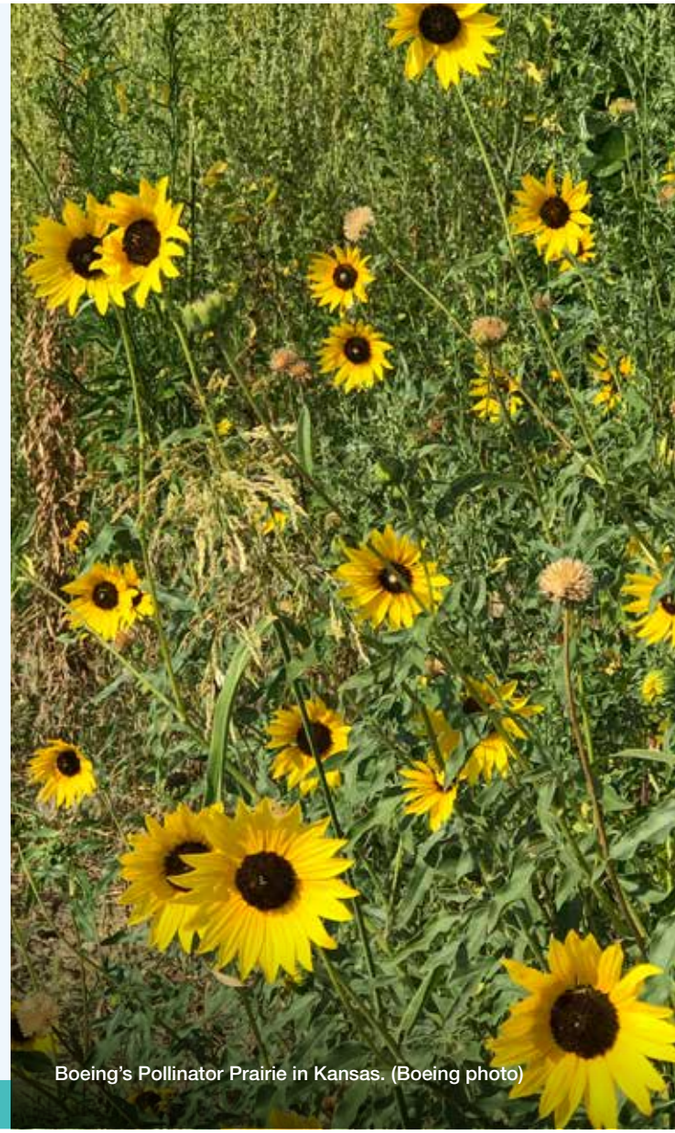
To achieve our goals related to the climate and to GHG, we actively monitor emissions, fuel use and energy efficiency. We have set 2030 targets for performance in each of these areas that aim to reduce absolute emissions, maintain net-zero emissions for Scope 1 and Scope 2, and increase our adoption of renewable energy sources. As part of Boeing's business continuity program, we also monitor the length and severity of business interruptions. The scope of monitoring includes damaging weather, natural disasters, pandemics and public health crises. It helps us understand how to increase resiliency in light of a changing climate.

Enterprise GHG emissions from operations are calculated after the conclusion of the reporting year. However, the emissions from natural gas and electricity usage at Core Metric Sites are calculated and monitored on a monthly basis through the use of utility bills and are continuously validated and updated throughout the reporting year. The emissions factors for these energy sources are validated at least annually and updated when appropriate following guidance from the World Resources Institute GHG Protocol. The energy data and emissions factors are verified as part of a third-party limited assurance process.

For the third year in a row, Boeing has achieved net-zero GHG emissions at manufacturing and work sites by implementing high-impact conservation investments, emphasizing and incentivizing conservation practices by employees, and increasing renewable electricity use while securing carefully selected, third-party-verified offsets for the remaining GHG emissions.

In 2022:

- **2025 GHG Target Progress:** Boeing had a 31% reduction in GHG emissions compared to 2017. GHG emissions were 8% lower than anticipated for the year. Procurement of renewable energy and renewable energy credits, low commercial production activity and infrastructure investments contributed to reduction in emissions from the operational footprint. The implementation of long-lasting infrastructure improvements and the contracting of renewable energy allow us to build on emissions reductions each year.
- **2025 Energy Reduction Target Progress:** Boeing had a 11% reduction in energy consumed compared to 2017. Energy consumption was 6% lower than anticipated for the year due to the impact of conservation initiatives, infrastructure investments, remote work and reduced production activity.



Boeing's Pollinator Prairie in Kansas. (Boeing photo)

"Sustainability is something everyone should be thinking about. What kind of planet do you want to leave behind for future generations?"

Gregory Kurth, Mesa site facility maintenance engineer, Facilities & Asset Management

Boeing facilities prioritize conservation, energy efficiency and renewable energy

As energy consumption gives rise to GHG emissions, conservation and energy reduction measures help achieve both energy and GHG reductions.

Creating sustainable facilities:

Germany: Boeing's new distribution center in Hamburg meets high sustainability standards and will be seeking Gold certification from the German Sustainable Building Council. To minimize the environmental footprint, the building is equipped with a heat pump and a photovoltaic system will be installed on the roof in the later half of 2023.

U.S.:

- Mesa, Arizona, recently completed construction of a new composites manufacturing facility. A quarter of the electricity used at the site is solar power. This partnership between Boeing and the Salt River Project brings the company closer to achieving its 2030 goal of 100% renewable electricity.
- Switching to LED lighting in Boeing's Everett, Washington; Frederickson, Washington; and El Segundo, California, facilities is driving an annual recurring savings of 25.3 million kilowatt-hours, which is equivalent to powering more than 2,300 U.S. homes per year.

India: Boeing's new engineering and technology campus in Bengaluru will leverage multiple design elements, including efficient ventilation systems, LED lighting, rainwater recovery and solar power generation.

Boeing expanded its strong presence in Europe with a new state-of-the art distribution warehouse near Hamburg, Germany. (Boeing photo)

It comes down to this: Boeing will continue to invest in conservation and renewable energy projects to advance the company's operational environmental goals.

Conserving Resources

Engaging Employees in Conservation

Boeing has implemented multiple approaches to encourage the workforce to support conservation by fostering sustainable behaviors. Employees are a source of innovation; champions of projects and their combined actions contribute to achieving Boeing's goals.

The programs that Boeing utilizes to get employees involved and contribute to the enterprise sustainability goals are designed to reach all aspects of the workforce (Page 12). Elements of sustainability are embedded within the Boeing Production system content and linked to Lean methodologies that eliminate waste and promote more efficient, sustainable practices within operations. Additionally, Boeing provides behavior change training and encourages recognition programs to help employees develop sustainable habits and reward them for their efforts.

The approaches used include elements of gamification, which involves turning sustainable behaviors into fun and engaging programs. Key employee engagement avenues include:

- **The Conservation Best Practices program**, which is deployed across the enterprise to prioritize reducing energy, water and waste at our largest areas of operation.
- **The Energy Star Battle of the Buildings** competition to encourage employees to work together toward our sustainability goals and promote a culture of environmental stewardship.
- **Aerospace Sustainability Foundations Training**, an internal credential training that allows employees to learn more about sustainable aerospace and practices and how they can incorporate them into their work.

By emphasizing employee engagement throughout the sustainability programs, Boeing is benefiting local communities and utilizing the capabilities of its diverse workforce to achieve its operational sustainability goals.

Earth Month photo contest winners

Boeing's Earth Month celebrations included a photo contest. Participants had the opportunity to submit a photograph with a description of what sustainability means to them.

Winner: Kaitlin Brush Brevig, BCA, Interiors Responsibility Center

For Kaitlin, sustainability means being able to find secret beauty in nature, without negatively affecting it. Photo entitled "Fog Camano," located in the Puget Sound.

Runner-Up: Katie Ziegler, 777 Fleet Chief Office

For Katie, sustainability includes protecting the honey bees that pollinate plants, sustaining food sources for humans and animals. Factors threatening honey bees include pesticides, disease and their natural predators like the giant hornet. Making honey bees a regulatory and lifestyle priority is critical.

Employees more than double goal in annual conservation competition

While Boeing focuses on conservation every day, the company hosts an annual competition starting on Earth Day in April to encourage Boeing employees to take daily actions that advance sustainable operations.

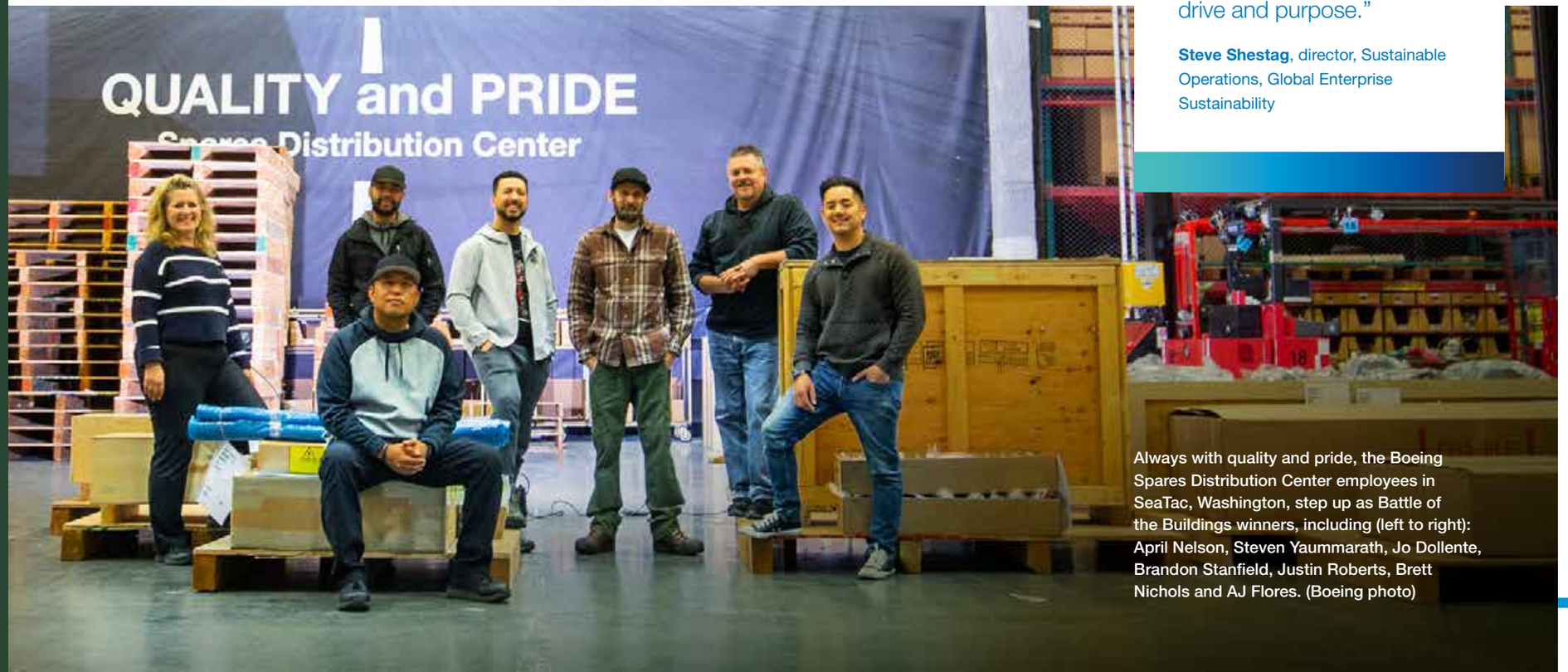
Employees across the globe took more than 231,000 60-second actions for the environment from Earth Day on April 22 to May 31, 2022. This was the equivalent of reducing carbon emissions by not driving 7.8 million miles (12.6 million kilometers). Top 60-second actions included using refillable water bottles, recycling and turning off equipment not in use.

Winners from across the globe:
The Battle of the Buildings competition among sites was based on the number of actions per capita and the winners in each category were:

- BGS
- Everett, Washington
- San Antonio
- Winnipeg, Canada
- Seattle Spares Distribution Center
- Berlin

"When employees engage in taking 60 seconds for the environment, we know it cuts costs, helps protect the environment and gives employees a sense of belonging, drive and purpose."

Steve Shestag, director, Sustainable Operations, Global Enterprise Sustainability



Always with quality and pride, the Boeing Spares Distribution Center employees in SeaTac, Washington, step up as Battle of the Buildings winners, including (left to right): April Nelson, Steven Yaummarath, Jo Dollente, Brandon Stanfield, Justin Roberts, Brett Nichols and AJ Flores. (Boeing photo)

Reducing Waste

Boeing is making strides to protect the land, water and air in our communities by reducing waste from work sites and our supply chain. Waste streams are as complex as our facilities, which range from office space to part fabrication to assembly of aircraft and space vehicles. Solid waste includes material that has been discarded or abandoned or that is no longer useful or usable and has been designated for removal. Items that are reused or reclaimed are excluded from solid waste. Boeing has dedicated teams working to prevent waste from going to landfills and to assess opportunities to return or reuse packaging for parts.

Boeing generates hazardous waste primarily from a variety of research, manufacturing and facilities maintenance processes. Hazardous waste may be recycled upstream or downstream, as on-site or off-site reclamation and avoided generation through processes that extend useful life of consumable chemicals to avoid hazardous waste. We look to reduce hazardous waste in upstream activities by preventing or reducing the amount of hazardous waste generated through extending system life through contaminant removal. Downstream, we look at hazardous waste generated from site operations. We implement several recycling and recovery activities to reduce the need for new chemicals.

Progress Toward 2025 Hazardous and Nonhazardous Waste Goals

- **Solid Waste – 40%** reduction compared to 2017. The continued trend of increased remote working conditions influences the overall reduction in solid waste. Conservation initiatives and vendor management continue to be opportunities to drive further reductions.
- **Hazardous Waste – 9%** reduction compared to 2017. Hazardous waste was 1% higher than anticipated during the year. Benefits from implementing conservation initiatives were outweighed by key events across the enterprise, including a historical flood event in St. Louis, which caused an unplanned increase in hazardous waste disposal from a water treatment system.

The Stingray gets Lean

As the U.S. Navy's uncrewed aerial refueler, the MQ-25 Stingray is a model of efficiency, in the air and on the production line.

The digitally engineered aircraft features a highly efficient engine and lightweight composite skin, allowing it to stay in the air much longer, using little fuel itself to complete its mission.

Within the factory setting, robotic automation and advanced assembly techniques eliminate the need for drilling during aircraft assembly.

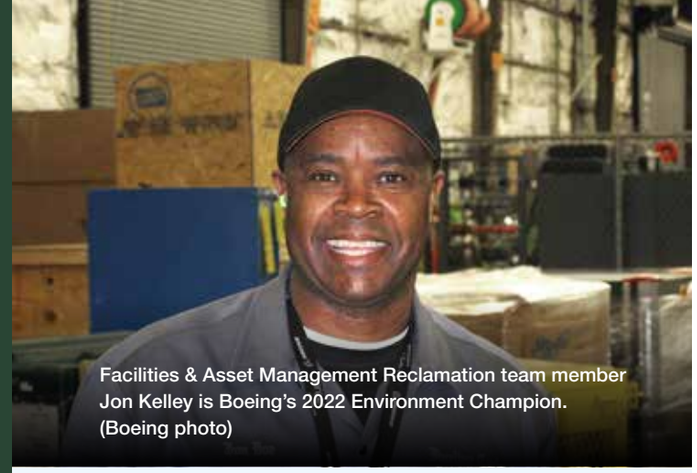
Now, the futuristic aircraft is setting new standards for efficiency with a renewed focus on reducing waste through Lean manufacturing.

Across Boeing's production system, teams are building momentum with Lean principles. The MQ-25 is the first program within Boeing Defense, Space & Security to undergo a renewed focus on Lean.

A focus on the customer: "We know what Lean means to our Navy customer — operational excellence, stability and execution," Troy Rutherford, MQ-25 vice president and program manager. "When we focus on removing waste from the system and listening to those who do the work, then production, innovation and creativity all take a huge leap forward. We're excited to be the first program to engage with the Lean workshops."

What is Lean? Lean is a way of thinking and acting that enables us to solve problems and continually improve. It is the foundation of Boeing's production system and embraces just-in-time delivery, error-free production and continuous flow. Lean helps spot and eliminate waste, wherever it is found, which also reduces costs.

The MQ-25 Stingray is an uncrewed aircraft system, designed for the U.S. Navy, providing robust refueling capability. (Boeing photo)



Facilities & Asset Management Reclamation team member Jon Kelley is Boeing's 2022 Environment Champion. (Boeing photo)

Boeing Recognizes 2022 Environment Champion

Jon Kelley, Facilities & Asset Management Reclamation team member, brings heart, commitment and skill to reduce waste to landfill, conserve valuable resources and ensure the company is compliant with regulations that protect the environment and the public.

In 2022, Kelley was recognized as the Environment Champion for his environmental passion and 40 years of commitment to Boeing. Throughout his career, Kelley has done more than his job required for conservation and protection of the environment and public safety. By doing this, he has helped Boeing's Puget Sound sites maximize the conservation of materials and properly handle regulated materials, while providing guidance to business partners.

Kelley constantly redefines his job by raising the bar of efficiency and standard of quality. Leaning on his decades of experience, Kelley has helped to develop tools and training methods to increase his team's efficiency without compromising safety or quality. He further demonstrates his commitment to sustainability by training and inspiring employees to prioritize conservation and cross-functional collaboration.

Kelley humbly describes his work as simply: "Doing the right thing to keep things out of the landfill."

Boeing honors employees who embrace environment

Employee innovation recognized: Below is a sampling of the 15 environmental leader winners in six categories that focused on reducing waste, energy and water use.

- **In Everett, Washington,** 260 Boeing employees from 40 organizations generated 1,800 sustainability ideas to consider for future products in a "sustainability lab."
- **Seattle** employees reclaimed about 2,500 gallons of water per day at the Seattle Developmental Center by reconfiguring piping and installing a more efficient system.
- **Winnipeg** employees conserved electricity equivalent to 60 homes' annual use by installing occupancy sensors and upgrading LED lights, saving almost 720,000 kWh yearly.
- **A Mesa team** worked with the local utility company to lessen demand on high peak utility days during summer months by programming the Building Automation System to improve processes and generate 5,400 kWh, which earned rebates of $30,000 annually.
- **An Everett team** reduced the amount of solvents required to flush paint pumps by removing filter housing. The result cut solvent use by 12 gallons per airplane and more than 10,000 pounds per year, saving almost $19,000.
- **In Chennai, India,** employees reduced GHG emissions by consolidating shipments and transitioning from air to sea shipments for India suppliers.

Boeing subsidiary Liquid Robotics was recognized for its Wave Glider Ocean Microplastics Demonstrator project for ocean plastics education and demonstrated the company's commitment to sustainability. (Boeing photo)

Reducing water consumption

Boeing sets rigorous water use reduction targets at our manufacturing sites to preserve this natural resource for the environment and our communities. Boeing's water is sourced from local public utilities (surface, ground and reclaimed water) and company generation (on-site well, on-site reclamation and rain capture). This sourced water supports manufacturing, sanitation, drinking water, cooling and irrigation across the company. The majority of our water is from public water supply systems, and most consumption measurement is from water system revenue-grade meters. Water used within our facilities is discharged to public sanitary sewer systems. In some cases, Boeing pre-treats wastewater before discharging it to public sanitary sewer systems, in compliance with regulatory requirements. Boeing does not set voluntary effluent discharge standards beyond those set by regulation.

Boeing specialists work to identify efficiencies, best practices and new technologies to reduce water use and identify alternatives. We monitor irregularities that may require action and created a Conservation Best Practice program to minimize water use, applying many water management techniques endorsed by the U.S. Environmental Protection Agency.

In 2022, we achieved a 19% reduction compared to consumption in 2017. Water consumption was 7% lower than anticipated with sites implementing conservation initiatives to increase water intake efficiencies and with production activity remaining low. Building off the reductions seen by 2025, Boeing will transition to an absolute reduction goal to focus on the most water-intensive processes across the company.

Biodiversity and Environmental Compliance

Boeing owns thousands of acres of habitat across five locations that are being protected or restored. Each habitat is actively managed and maintained by site employees, nonprofit organizations or contract biologists. For some locations, additional agreements and monitoring are in place to ensure all legal, contractual and certification requirements are met.

Each habitat is certified by the Wildlife Habitat Council (WHC), with three certified at the Gold level. The WHC's certification program is the only voluntary sustainability standard designed for broad-based biodiversity enhancement and conservation education activities on corporate landholdings.

- **Avian Project Award:** Awarded to Boeing for monitoring targeted species and food sources — and being managed by adapting to the environment. The Grasshopper Sparrow is also a happy recipient.
- **Grasslands Project Award:** Awarded to Boeing for monitoring of vegetation, wildlife use of vegetation, wildlife use and evaluation to create next steps for the project.
- **Pollinator Project Award:** Awarded to Boeing for monitoring targeted species and food sources yearly, and recognizes a policy integrated into overall site operations to minimize, eliminate or apply responsible use practices of pesticides and herbicides.

Sustaining biodiversity from Seattle to Charleston

The big picture: The WHC helps companies like Boeing advance biodiversity, sustainability, employee engagement and community relations goals with programs that translate sustainability goals and objectives into tangible and measurable on-the-ground actions. WHC Awards recognize programs and projects that demonstrate excellence in corporate conservation. Boeing's restored Emery Landfill in Wichita, Kansas, was recognized with three awards in 2022 (see left column for details).