OPERATIONAL ADVANTAGE AND RESILIENCE THROUGH SUSTAINABILITY

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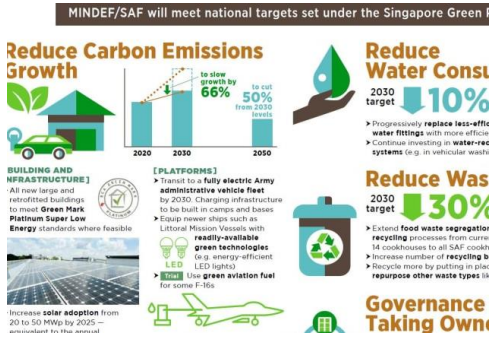
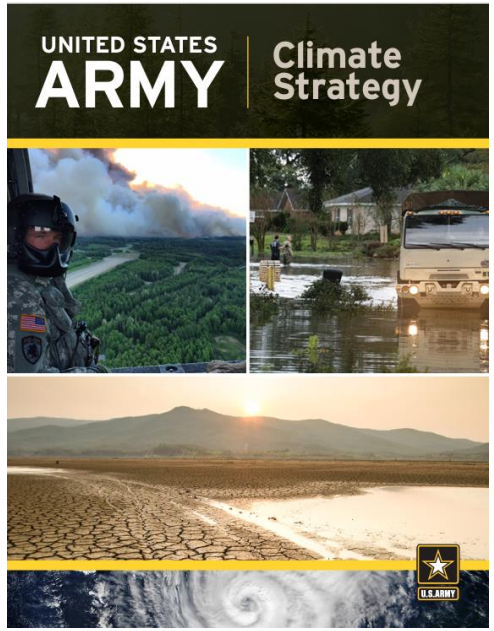
SUSTAINABILITY LANDSCAPE

- Climate change is a key **national security concern**
- Governments and society **expect action** on climate change
- **A more sustainable** military is more **operationally effective** and **resilient**
- Militaries are the **biggest source of emissions** for many governments with **Net Zero commitments**
- The Armed Forces are **not immune** to the impacts of the **wider energy transition**
- **Collaboration is essential.** No single entity, company, industry or government can stop climate change





SUSTAINABLE AEROSPACE FIRSTS

2008

Diamond DA20

Virgin Atlantic 747

2009

The Boeing 787 Dreamliner

South Carolina 787 Final Assembly Facility

2010

U.S. Navy F/A-18

C-17 Globemaster

2011

International Aerospace Environmental Group

2012

ecoDemonstrator 737-800

Phantom Eye

2014

2015

small-scale farmers in South Africa

Boeing uncrewed demonstrator

2016

Transonic Truss-Based Wing

2018

ecoDemonstrator 777 Freighter

carbon composite fiber

2019

Cora electric air taxi

2021

100% SAF capable airplanes by 2030

testing SAF emissions

cryogenic fuel tank technology

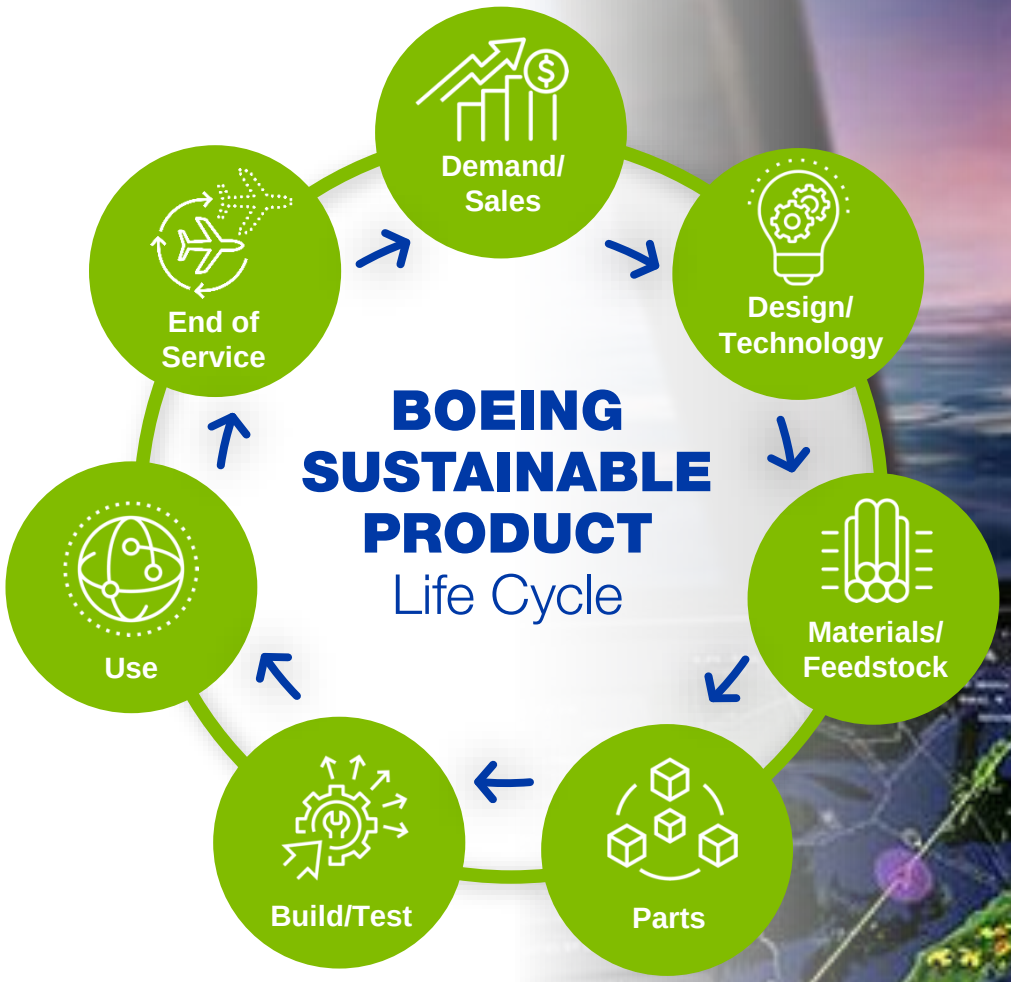
2022

2M gallon SAF procurement

Alder Fuels partnership

2021_Boeing_Sustainability_Report.pdf

SUSTAINABILITY IS BUILT IN



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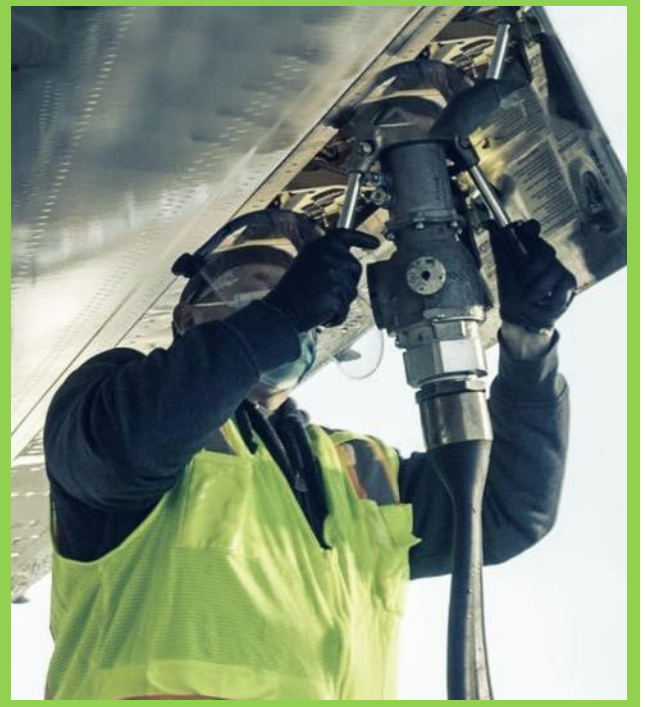
EVERYTHING FOR ZERO

Fleet renewal

Operational efficiency



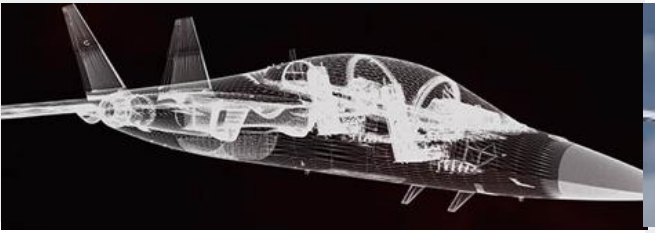
Renewable energy

Advanced technology

OPERATIONAL ADVANTAGE & RESILIENCE THROUGH SUSTAINABILITY

Digital design & Manufacturing

Dramatically reduce the time, cost and resources (material and energy) required to develop new weapons systems, Out innovate hostile nations**.**



Fleet renewal

Delivering greater warfighter capability and better environmental performance (E3-E7, KC-135-KC-46)

Digital tools (Mission Accelerator)

Reduce fuel burn – stay on station for longer, fly further, carry more payload. Optimize maintenance and avoid unnecessary part changes. In both cases reduce logistics burden and associated force protection.

Sustainable Aviation Fuel

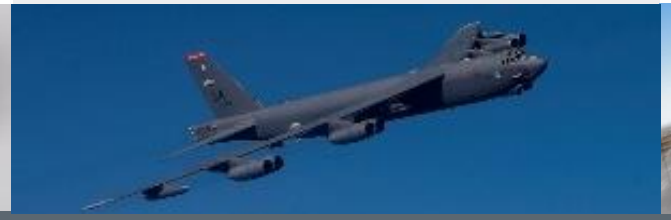
Creating fuel local to operations at home and potentially during long term deployments. Fragmented supply landscape but new opportunity for strategic and operational resilience

Responsible supply chain sourcing & additive manufacturing

Reduces vulnerabilities in the supply chain.

Modifications & upgrades

Through life upgrades to increase capability and reduce fuel burn (more time on station).



Training systems

(surrogate, synthetic, augmented, collective – T-7, Gladiator, Red6)

Reduced peacetime emissions, better preparing crews for real world threats and saving hours on front line jets.

Energy resilient infrastructure

Ability to operate off-grid at home and deployed. Reduced logistics burden when deployed (with reduction in associated force protection costs) and reduced financial costs at home.

SAF: INTEROPERABILITY

- We have enjoyed decades of **common standards** around Jet Fuel
- There are now **seven types of SAF** approved for commercial use but militaries are inconsistent in which platforms they approve to use which type of SAF
- The EU, UK and others are introducing **SAF mandates**
- SAF is already flowing into the global **jet fuel supply chain**
- We now have a in issue in terms of **Civil-Military** Interoperability and **Military-Military** interoperability
- Unless this is solved militaries will need to create **independent fossil fuel supply lines**
- We need alignment between military and commercial standards. This would also allow the military to buy SAF, supporting energy resilience and the scaling up of the SAF sector (as NATO supports)

SAF: RESILIENCE AND FREEDOM OF ACTION

- SAF will be produced in a **more fragmented way** than fossil fuels due to the nature of the feedstocks (agricultural waste, municipal waste, industrial waste gases, etc.)

- SAF provides an opportunity to produce fuel on shore from various pathways. This provides **strategic resilience**

- Technologies such as power to liquid provide an opportunity to achieve **local SAF production** at major long term deployments where sufficient energy can be provided. This could be highly significant in terms of freedom of action and **freeing operations from traditional supply lines**

SAF: DECARBONISATION

- Within defence, aviation is typically a **major source of emissions**
- SAF has the **largest potential** for near-term and long-term impact
- **Air Forces' emissions** have some similarities to airlines, the Air Transport fleet (like long haul fleets) tend to create the bulk of emissions
- **Commercial derivative fleets** will follow the technology roadmaps of the commercial sector
- **Fast Jets** (as we know them today) will be unlikely to have any alternative to hydro carbons

COMMERCIAL INDUSTRY VIEW

		2020	2025	2030	2035	2040	2045	2050
~27% of CO2 emissions	**Commuter** 9-50 seats <60 minute flights <1% of industry CO2	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
	Regional 50-100 seats 30-90 minute flights ~3% of industry CO2	SAF	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
	Short haul 100-150 seats 45-120 minute flights ~24% of industry CO2	SAF	SAF	SAF	SAF potentially some Hydrogen	Hydrogen and/or SAF	Hydrogen and/or SAF	Hydrogen and/or SAF
~73% of CO2	**Medium haul** 100-250 seats 60-150 minute flights ~43% of industry CO2	SAF	SAF	SAF	SAF	SAF potentially some Hydrogen	SAF potentially some Hydrogen	SAF potentially some Hydrogen
	Long haul 250+ seats 150+ minute flights ~30% of industry CO2	SAF	SAF	SAF	SAF	SAF	SAF	SAF

Source: ATAG Waypoint 2050 Report

ELECTRIFICATION

Architecture

Battery electric

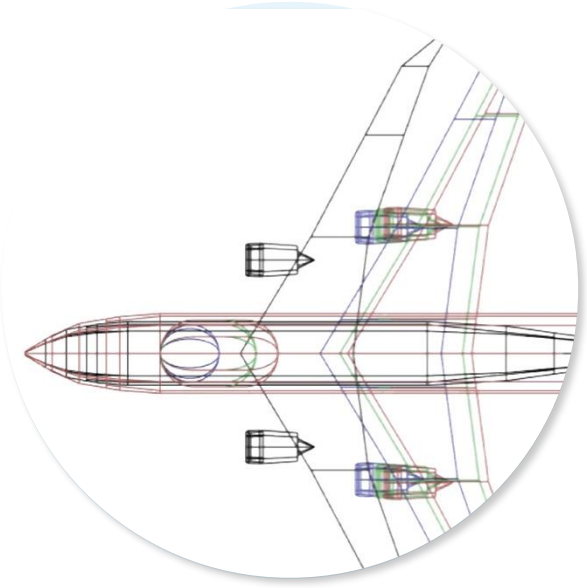
Fuel cells

SAF &
Electrification

HYDROGEN

Hydrogen fuel cells and combustion

Onboard and airport storage and distribution



Airplane-level integration

SAF & Hydrogen

Composite cryotank