ANNUAL REPORT

2020

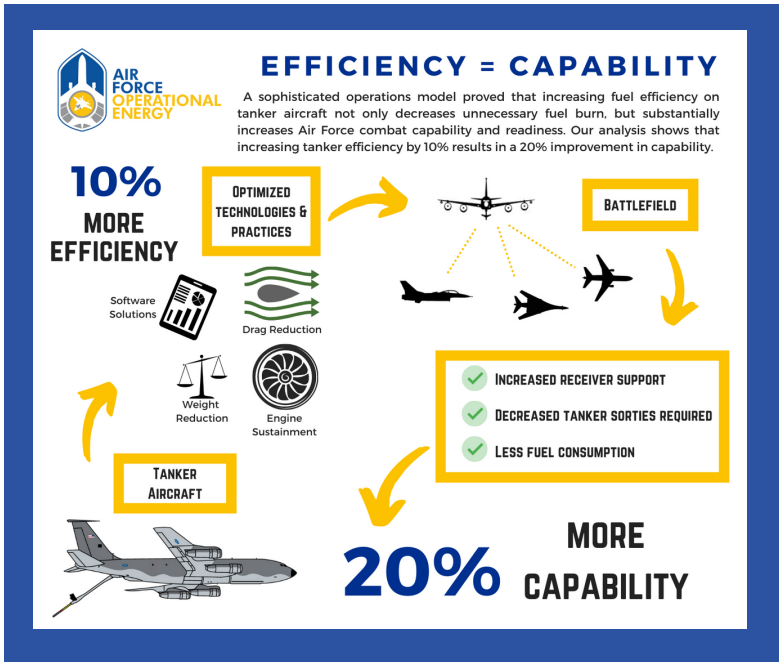
AIR FORCE OPERATIONAL ENERGY

AIR FORCE OPERATIONAL ENERGY

EXECUTIVE SUMMARY

The readiness and lethality of the Department of the Air Force are inextricably linked to operational energy and our ability to deliver air power to the warfighter when and where it is needed. Our focus is to increase combat capability and reduce fuel logistics risk in the battlefield of the future through technology advancements, process improvements, and cultural awareness of fuel use and supply shortfall vulnerabilities. In 2020, Air Force Operational Energy continued to build the foundation for a more optimized and combat capable force. Through collaboration with our partners across government, the Department of Defense, and the commercial aviation industry, we made important strides, not only to integrate energy-informed solutions into Air Force operations, but to lay the groundwork for future efforts.

Through wargaming, we demonstrated that legacy air refueling platforms with a 10% improvement in efficiency are 20% more effective on the battlefield, delivering more fuel to receivers with fewer sorties.



We aim to optimize aviation fuel use and mitigate operational risk to the warfighter through three key areas: technology, process and training. As part of this, we expanded the collection of fuel use data across all of our aircraft, enabling us to better detect gaps in efficiency and recommend solutions.

We supported the development of innovative software and modeling tools to streamline operational and strategic planning and reduce manpower and logistics requirements. We helped integrate energy scenarios into wargaming, informing basing strategy and investment priorities.

We worked with commercial airlines to identify best practices and state-of-the-art aerodynamic technologies, incorporating them into Air Force operations. We collaborated with military universities to educate Airmen and service members on operational energy and how they can operate more effectively.

To defend against 21st century adversaries and maintain our superiority, it's crucial we adapt and accelerate efficiency and capability. This report outlines our mission, vision, and goals while highlighting our 2020 achievements.

MISSION

To enhance combat capability and mitigate operational risk to the warfighter through energy-informed solutions

VISION

To create an energy-optimized Air Force that maximizes combat capability of the warfighter

GOALS

1. Identify and deliver optimal operations planning and execution solutions for existing gaps
2. Provide innovative energy solutions for new and legacy aircraft and systems
3. Furnish energy-efficient weapons system sustainment
4. Support the production of energy-informed war plans
5. Educate the Force and build the culture for operational energy

AIR FORCE OPERATIONAL ENERGY

SAVING TO REINVEST

Optimizing operational energy not only increases our combat capability - but decreases fuel costs - allowing those savings to be reinvested into operations, technologies, and processes **that support the warfighter**. If our near-term initiatives are fully executed by FY 2027, here are the savings possible:

BLADE COATING

$55M/year
fuel cost savings

PAGE 11

JIGSAW

$37M/year
fuel cost savings

PAGE 6

PRECISION FUEL PLANNING

$73M/year
fuel cost savings

PAGE 5

MAGELLAN

$26M/year
fuel cost savings

PAGE 7

MICROVANES & FINLETS

$17M/year
fuel cost savings

PAGE 8

VERTICAL WIPERS

$7M/year
fuel cost savings

PAGE 8

ENGINE WASH

$15M/year
fuel cost savings

PAGE 11

Operational Energy Savings Account

Under the authority provided by Congress in Title 10 U.S.C. 2912, the Air Force is implementing the **Operational Energy Savings Account (OESA) program** to incentivize energy-aware behavior and more efficient processes. By documenting fuel savings from previous operational energy initiatives, OESA allows those funds to be re-invested into other operational energy optimization efforts making it a self-sustaining program and providing significant return-on-investment.

Identify and deliver optimal operations planning and execution solutions for existing gaps

As part of our strategic vision, we seek to mitigate operational risk while optimizing mission planning and execution. Improving department-wide collection of fuel use data informs decision-makers and enables us to analyze how fuel and its logistics tail affect operations.

The insight garnered from this data is a driving force in our overall strategy and decision-making. Over the past year we have developed innovative tools and processes that directly address identified challenges in optimizing planning and execution.

Expanded data collection and analysis of aircraft fuel

Comprehensive, trustworthy data is essential to accurately analyze flight operations. Using the Air Force Cloud One computing platform, we helped develop real-time analytic pipelines to provide insight into aviation fuel usage and productivity, integrating multiple data sources to produce actionable insights into major weapon systems. As of December 2020, the Air Force collects approximately 50% of aircraft fuel use data, and we continue to grow our access and analysis capabilities.

The data has already led to lessons learned on how fuel planning affects aircraft availability and the impact of fuel efficiency improvements on Aerial Refueling Aircraft operational efficiency.

The Aerial Refueling Model (ARM), a wargaming planning tool, was used to assess how optimization affects combat capability in warfighting scenarios. The results linked fuel efficiency to improvements in endurance, fuel offload, and aircraft and crew requirements. The operational impact of increased fuel efficiency in this scenario was roughly twice the fuel efficiency gain.

Demonstrated reduced fuel consumption through precision fuel planning

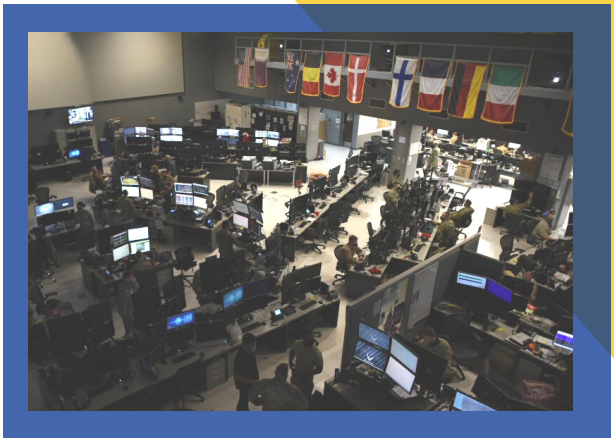
We evaluated 10 years of data on fuel planning and aircraft availability for the C-17 Globemaster III and the KC-135 Stratotanker. The results showed a correlation between precision fuel planning and aircraft availability, increasing the time aircraft are available for training and operational missions. Precision fuel planning ensures the aircraft only carries the fuel needed for the mission (including divert fuel), which reduces excess aircraft weight, therefore decreasing aircraft stress and unscheduled maintenance.

Streamlined tanker planning and scheduling

When the digital tanker planning tool Jigsaw was first launched in 2017 by the Defense Innovation Unit, the benefits were rapid and impactful. It dramatically decreased time spent scheduling aerial refueling missions at the Al Udeid Air Base Combined Air Operations Center from 8-12 hours to 4 hours.

JIGSAW IMPROVED TANKER ASSET UTILIZATION BY 3.6%, REDUCING THE NUMBER OF REQUIRED TANKER SORTIES PER DAY BY 1.8

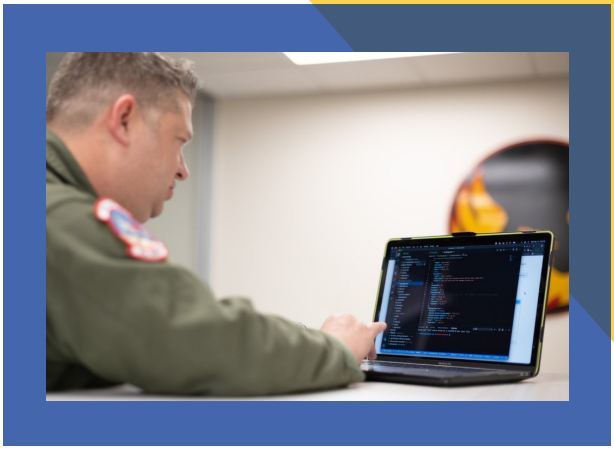
What's more, by increasing the effectiveness of each sortie, the Air Force could meet mission requirements with 180,000 fewer gallons per week and 9 fewer aircrews.



In 2020, we continued to support and fund the development and fielding of Jigsaw's auto-planning feature to further optimize tanker planning and scheduling. The plans will update in real-time to account for unexpected events. Jigsaw's automation capability reduces planning time to less than 30 minutes and increases scheduling efficiency by another 10%, equivalent to executing an average Air Tasking Order with five fewer tankers. These efficiencies enable the Air Force to maintain the same combat sortie rate while decreasing fuel use, and reducing risk.

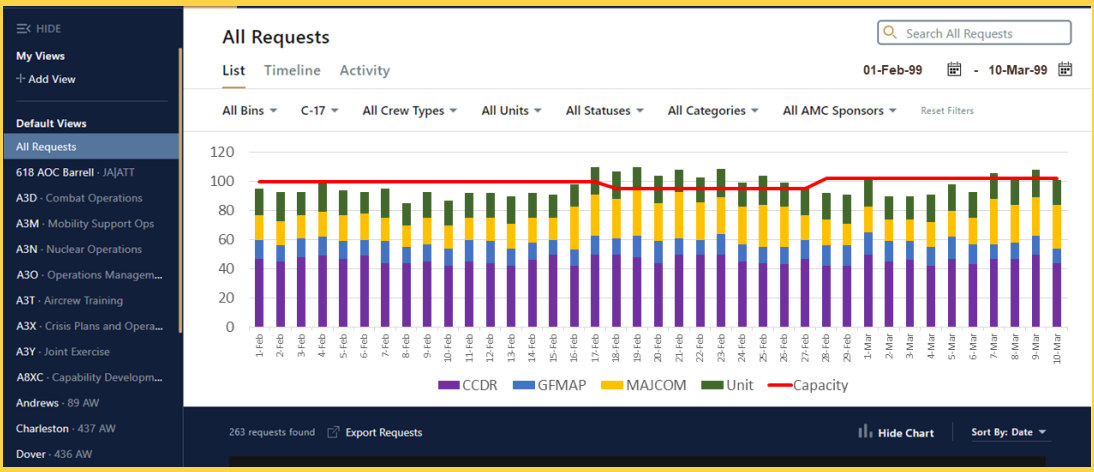
JIGSAW'S AUTOMATION CAPABILITY REDUCES PLANNING TIME TO LESS THAN 30 MINUTES AND INCREASES SCHEDULING EFFICIENCY BY ANOTHER 10%

Helped launch mobility scheduling and allocation tools



With the innovation cell TRON, part of the Aloha Spark team, we supported the launch of Puckboard, a real-time collaborative scheduling engine used throughout the Mobility Air Forces community. The platform distributes live schedule updates to aircrew and is available from anywhere on the globe, on or off the DOD network. Additionally, we funded the purchase of security software for TRON to accelerate the software's mobile app development, data collection, and migration to digital forms.

Puckboard gives time back to Airmen and enables them to help revolutionize squadron scheduling through an open architecture, permitting seamless interoperability with other information systems and supporting supplemental planning services.



**a fictional scenario of the tanker allocation tool Magellan*

Similarly, we funded and supported the development of Magellan, an Air Mobility Command (AMC) software tool used to allocate mobility aircraft globally. The tool merged multiple manual processes into a collaborative, transparent platform to increase deployment readiness, saving planners an estimated 300 hours per month.

Magellan gives operational planners more visibility over long-term scheduling and enables planners to de-conflict airlift and aerial refueling requests during high-demand periods.

It also increases planning flexibility, allowing planners to quickly and easily adjust when priorities change. Magellan launched in April 2020 and reached initial operating capability in July, subsequently becoming an AMC system of record.

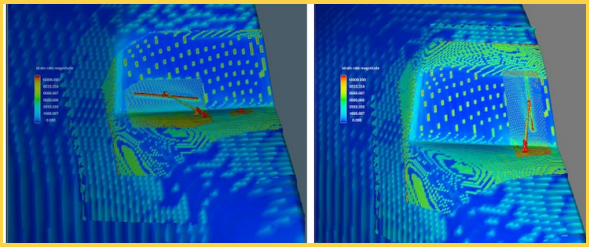
AIR FORCE OPERATIONAL ENERGY

GOAL 2

Provide innovative energy solutions for new and legacy aircraft and systems

As we face accelerating global competition and an increasingly complex battlespace, we must continue to strengthen the force by modernizing both new and legacy weapon systems. Investing in proven technologies and processes that optimize aviation fuel use and streamline operations will pay for themselves in readiness, lethality, fuel savings, and maintenance costs.

We partner with commercial and defense organizations to better understand what industry trends are emerging in aviation energy efficiency, and how the Air Force can take advantage of them to increase our combat capability. As part ofthis goal, we consider new and exsisting techhnologies and processes in aerodynamics, aircraft weight reduction, advanced propulsion, and mission optimization, and play an active role in the Air Force's capability development processes to better incorporate these solutions into tangible benefits.

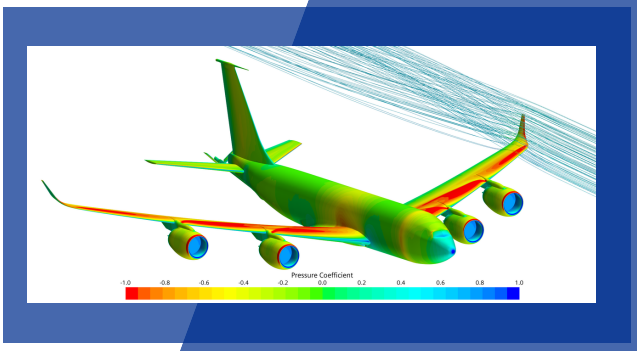


Computational fluid dynamics (CFD) analysis, conducted by Air Force Research Laboratory and Southwest Research Institute, shows the nose of a KC-135 Stratotanker, as the wiper blades are positioned horizontally (left) and vertically (right). The red indicates an area of high aerodynamic drag.

Supported airframe drag reduction programs

We supported the advancement of several efforts from the Advanced Power Technology Office, spanning a wide range of potential capability improvements. For example, C-17 Microvanes™ are aft body drag reduction devices that could save the Air Force $10 million per year in fuel costs, with a return-on-investment of less than six months. In coordination with industry and Air Force Research Laboratory (AFRL) partners, we began to investigate the possible use and acquisition of KC-135 Finlets or Microvanes™, B-52 engine pylon fairings, vertical wiper blades (see left photo), and upgrades to C-130 Finlets. KC-135 vertical wipers could increase efficiency by 1%, saving an estimated $7 million per year in fuel.

Additionally, we collaborated with AFRL and NATO to support air wake (vortex) surfing for mobility aircraft, which has been shown to garner significant fuel savings of 6-10% on trailing aircraft.



Computational fluid dynamics (CFD) scan of KC-135. Photo by Aerotec

Supported increased range and endurance technologies

We worked with the acquisition and warfighter communities to advance the Air Force goals to 'cost-effectively modernize' and 'drive innovation.' In a year without appropriated funding, we leveraged OSD's Operational Energy Capability Improvement Fund (OECIF) to support the development and fielding of technological innovations to advance the "state of the art" and maintain a warfighting edge. We worked closely with the Air Force Research Laboratory (AFRL) to transition extended range technologies to the Air Force and Combatant Commands. For example, we supported the Ultra Long Endurance Aerial Platform (Ultra LEAP), an Unmanned Aerial System (UAS) that delivers high-endurance, cost-effective performance. It can remain airborne for 60 hours, which is unprecedented for its size class, and is currently being enhanced for up to 80 hours of endurance.

Ultra Long Endurance Aerial Platform (LEAP)

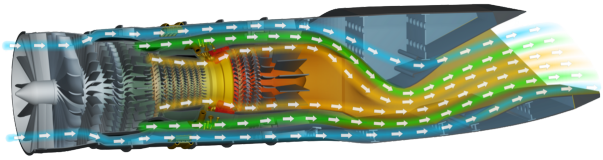
The Blended Wing Body (BWB) is one of the single most impactful technology opportunities for future Air Force aircraft, both in terms of capability increase and GHG emissions reduction. Cargo, tanker, and non-stealth bomber aircraft account for approximately 60% of the AF's total annual jet fuel consumption, about 1.2 billion gallons per year.

A future transition from tube and wing to BWB would yield a 30% increase in range and payload capabilities, and a 30% reduction in GHG emissions. This would equate to an annual fuel savings of $900M/year (current-year fuel prices and annual flying hours), and an annual CO2 emissions reduction of 3.3 million metric tons, which is the equivalent of replacing 726,000 gasoline-powered cars with electric cars.

DZYNE Blended Wing Body conceptual design

Pursued advanced propulsion efforts

We continued to support future acquisition of three-stream, adaptive engine technology for 5th- and 6th-generation fighter aircraft. By relying on a third stream of air that can be dynamically modulated between the engine's core and the bypass stream, an adaptive engine can provide increased thrust during combat conditions and increased fuel efficiency during cruise conditions. Fielding such engines would enable air power with increased range, reduced tanker demand, and additional cooling air for thermal management.



Three-stream adaptive engine, part of the Adaptive Engine Transition Program

Researched alternative fuels to provide increased resilience of the aviation fuel supply chain in energy constrained environments

Our research and analysis of conventional and alternative fuel certification processes, fuel additives, and fuel transfer and storage equipment, helped identify and begin to address supply chain problem areas for the Joint Force. We continued to team with DOD and Air Force stakeholders, such as the Air Force Petroleum Office, Air Force Research Laboratory, and Air Staff, to monitor production, pricing, and commercial use of alternative fuels.

Additionally, in partnership with AFRL, the Air Force Institute of Technology, and General Electric Global Research Center, we investigated the potential for liquid natural gas (LNG) as a second hydrocarbon fuel option for future Air Force aircraft.

LNG-powered turbine engines, currently used for industrial ground power and marine propulsion applications, hold promise as a future alternative for Air Force jet propulsion. Since these "aero-derivative" turbines are able to operate with either petroleum-based jet fuel or LNG, this technology would maximize battlespace fuel options, distribute logistics risk, complicate enemy targeting of fuel storage and distribution networks, and enhance aircraft thermal management capabilities.

Furthermore, because LNG contains more energy per unit mass than jet fuel (with comparable volumetric energy density), LNG-powered bomber, mobility, and tanker aircraft provide opportunities for increased payload and fuel offload capabilities. Furthermore, initial research into the possibility of LNG-powered future fighter aircraft revealed that with marginal (< 5%) increase in fuel volume, potential exists for significantly enhanced thermal management capabilities, as well as increased payloads (due to the lighter fuel).

The Air Force is now better positioned to support changes in the defense alternative fuels strategy and provide operational flexibility based on fuel availability in specific regions and circumstances. Additionally, we sponsored a project to build a system for carbon dioxide capture and conversion to jet fuel to explore the possibility of increased energy agility. Over the course of 2020, the project team completed the system build and captured nearly all of the required material for conversion into fuel during 2021.

Furnish energy-efficient weapons system sustainment

Innovation doesn't stop at the production line. The energy solutions we support go beyond simply introducing new technologies and parts. We seek to optimize the Air Force through sustainment of legacy performance, increased time-on-wing, fuel efficiency, and reduced maintenance for turbine blade aircraft.

Collaborated with industry to ensure overhauled legacy engines deliver optimized engine performance

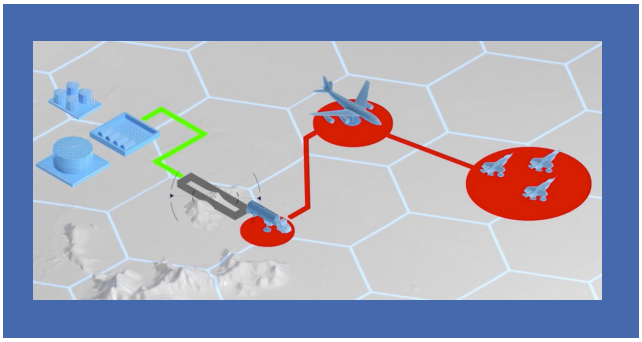
We liaised with multiple defense industry and commercial aviation entities to identify industry best practices and technologies in aircraft sustainment that could potentially translate to the Air Force. Our goal is to ensure overhauled legacy engines deliver optimized engine performance and efficiency. In 2020, we focused on testing three methods to achieve this: applying innovative material coatings on engine compressor blades, using infrared and laser scanning methods to inspect and optimize alignment of engine components, and finally, updating how we wash our engines.

Top: Aircraft engine compressor blades Bottom: Nucleated foam during engine washing on the CV-22 Osprey

We initiated two projects to certify blade coatings on the F108 and F117 engines, seeking to confirm the technology's ability to improve blade durability and engine performance. We also supported and funded testing of compressor blade scanning for the F108 engine at Tinker Air Force Base in Oklahoma. Lastly, we sponsored an AFWERX Small Business Innovation Research (SBIR) program to pilot test the use of nucleated foam during engine washing on the CV-22 Osprey, which promises to increase aircraft performance while reducing maintenance requirements. We're also working with the Air National Guard at Rickenbacker Air Force Base in Ohio to test similar detergent wash methods on the KC-135 Stratotanker.

Support the production of energy-informed war plans

Through our wargaming efforts, we help provide the Air Force and joint services with a more realistic view of the risks and challenges related to operational energy and fuel logistics, and drive energy-informed leadership decisions in basing strategy and investment priorities. Our team of subject matter experts participates in on-going discussions and working groups with our wargaming partners to develop solutions to these complex challenges.



Energy informed wargaming helps to identify innovative solutions in fuel logistics.

Supported comprehensive wargaming scenarios that examine the fuel logistics supply chain

Our team focused on improving Integrated Life Cycle Management processes and fuel supply logistics across the Air Force to enable a more energy resilient force. We coordinated with the fuels, logistics, and wargaming communities to model energy demand and network risk during gameplay, allowing us to better identify shortfalls, and the second and third order effects of adversaries' efforts to target fuel supply chains.

The development of modeling and simulation tools, like the Air Refueling Optimization and Planning System, helps account for the total fuel supply network and identifies prospects for energy multiplier effects to enhance combat capability.

Sustained joint service relationships and shared lessons learned and initiatives

In 2020, we contributed subject matter expertise to support the execution of multiple new wargames. Supported by the data gathered from the Joint Force Energy Wargame in 2019, SAF/IEN participated in the Navy led Pacific Energy Distribution and Critical Infrastructure wargame to directly analyze the vulnerabilities of infrastructure and distribution systems during a conflict and assess the operational impact of improving these systems. We also participated in and provided analysis for Futures Game 20 to evaluate future force design and equipment that will best posture our force to win in a near-peer competition. Insights from these and other efforts inform Departmental efforts to ensure a more responsive and resilient global force.

Educate the Force and build the culture for operational energy

Fostering an energy-aware culture within the Air Force is critical to optimizing our fuel consumption. We develop educational and training materials that highlight the importance of operational energy for readiness and combat capability, while demonstrating how increased efficiencies lead to more combat engagement time, more training opportunities for Airmen, and lower sustainment costs.

Pursued research opportunities with civilian and DoD universities

In 2020, we refocused the education strategy to pursue research opportunities with civilian and DoD universities. We developed a key partnership with the National Security Innovation Network by establishing an operational energy presence in two key project areas: X-Force and Hacking for Defense. During the summer, X-Force interns from the Georgia Institute of Technology, Howard University, and Princeton University developed a prototype to analyze risk to the energy supply network, filling a critical gap in Air Force capabilities. In the fall, a new group of X-Force students from Arizona State University continued working this problem by gamifying the existing risk prototype. Concurrently, Hacking for Defense students at the University of Virginia supported our strategic engagement goals by developing a new strategy to incentivize energy efficient behaviors. We also received civilian student support through a summer internship with the Massachusetts Institute of Technology Sloan School of Management, resulting in a digitized approach to tracking each office initiative.

H4D

GEORGIA TECH

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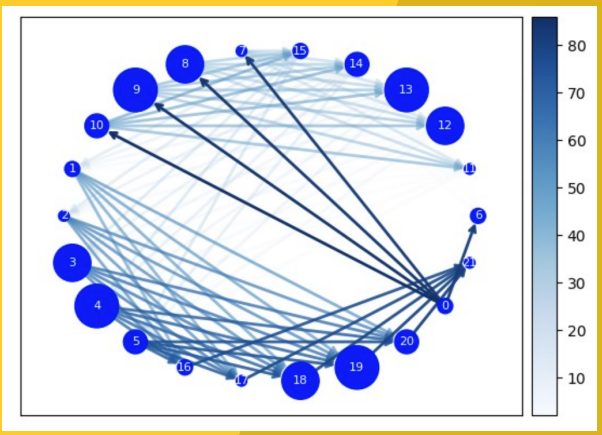
UNIVERSITY of VIRGINIA

PRINCETON UNIVERSITY

NATIONAL SECURITY INNOVATION NETWORK

MIT MANAGEMENT SLOAN SCHOOL

ASU Arizona State University

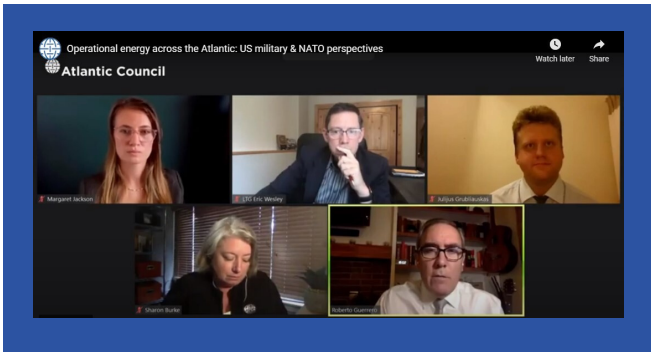


This interactive model demonstrates the risk that accumulates when transporting fuel. Created by Air Force Operational Energy Summer 2020 Intern Project.

Engaged with stakeholders and leadership

In 2020, we continued to enhance and implement our communications and engagement strategy, aligned with National Defense Strategy and Air Force initiatives. Through multi-channel communications and content development, awareness campaigns, leadership engagement, and targeted and consistent messaging, we helped inform Airmen about smart energy solutions and their benefit to our combat capability and mission readiness.

Throughout the year, our leadership participated in several high-level speaking engagements, conferences, and symposiums (both virtual and in-person) to inform targeted groups of stakeholders about the importance and impact of our initiatives.



AVIATION WEEK NETWORK

OELS2020 SUMMIT | OPERATIONAL ENERGY & LOGISTICS

Atlantic Council

DEFENSE TECHCONNECT INNOVATION SUMMIT & EXPO

Launched Airmen Powered by Innovation campaign

In July, we launched an Airmen Powered by Innovation campaign with AFWERX, focused on operational energy efficiency, to solicit ideas from Airmen on how to create a more optimized force. We received multiple submissions including vertical stacking pallets for improved cargo loading, F-15C weight removal, B-52 aerodynamic efficiencies, and others, which are being pursued by our office and other Air Force organizations.

Initiated behavior and culture change strategy

We researched peer-reviewed papers and reports on behavior and culture change to create an in-depth messaging and communications strategy aligned with building an energy-informed force. This led to the beginning of a community-based social marketing plan, which will be further developed and implemented in 2021.

AIR FORCE OPERATIONAL ENERGY

CHALLENGES

An on-going challenge for the Air Force is the lack of awareness in operational energy issues, and an Air Force culture that does not necessarily prioritize efficient operations.

In previous years, due to a lack of positive and consistent messaging, many Airmen assumed that optimized operations meant cutting flight hours, or decreasing combat capability, to save money. We are now aware of this misperception and are actively working to inform Airmen about the benefits of optimized operations for combat capability through targeted messaging and content, as well as education and training.

Focusing on strategic messaging research, stakeholder analysis, content creation and distribution, and relationship building has allowed us to improve the effectiveness of our communication and engagement.

Efforts to insert operational energy content were sometimes met with resistance due tightly packed course schedules. Airmen believe that they have more pertinent information to address during lessons and training. We are aware of this challenge and are adapting to ensure the approach helps Airmen understand operational energy education is a valuable supplemental portion of existing course work.

However, there remains skepticism that future conflicts with peer adversaries will drive the Air Force to fuel-limited operations, despite wargame findings to the contrary. If the Air Force continues to assume that future combat will not be fuel-limited, investments to optimize energy use during wartime air operations will not be prioritized and we will have no choice but to take on significant operational risk.

AIR FORCE OPERATIONAL ENERGY

CLOSING

We must continue to pursue innovative ways to create an energy optimized Air Force

The demand for energy is increasing with every passing year. Aligning our collaborative efforts with the National Defense Strategy in an effort to mitigate operational risk is paramount for the Air Force's ability to operate on the global spectrum.

We continue to modernize our airframes, engines, and operational planning tools, which has proven to increase our operational effectiveness and combat capability. We must continue to educate and equip the force in order to make operational energy strategies a critical priority needed to remain ready and capable to fight.

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