

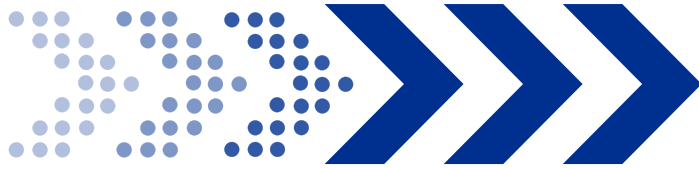


**AIR
FORCE**
OPERATIONAL
ENERGY

Annual Report

2019





EXECUTIVE SUMMARY

“As a service that provides global reach, global vigilance, and global power, are we thinking globally?”
- General David Goldfein, Air Force Chief of Staff

Now, more than ever, energy is vital to the Air Force mission to fly, fight, and win – in any theater around the world. Our global operations require a reliable fuel supply, and a resilient logistics architecture that can deliver power to Airmen anywhere, at a moment’s notice.

In 2019, Air Force Operational Energy laid the foundation to build a more optimized and lethal force in the years to come. As the Department of Defense’s largest energy consumer, the Air Force mission hinges on aviation fuel to continue to provide premier warfighting capability and protect our national interests. We remain dedicated to mitigating operational risks and providing energy-informed solutions that increase our readiness and elite airpower capability while dramatically reducing operating costs.

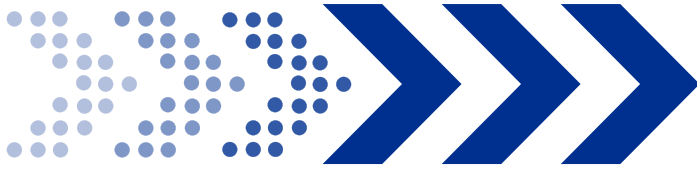


By collaborating with our industry and defense partners, we seek to increase the fuel efficiency of our aviation weapons systems through the research and development of advanced technologies in aerodynamic drag reduction and propulsion efficiency. We help streamline mission planning using comprehensive flight data capture and analysis and we work with operators to build innovative scheduling software for more effective use of our aircraft.

Our initiatives are a crucial part of the National Defense Strategy and we continue to align our efforts in accordance with our Strategic Goals and Objectives published in 2018. This report outlines our mission, vision, and goals and how we progressed in 2019.



Even small **OE** investments increase USAF **capability** in critical areas making us more **resilient** and more **lethal**



MISSION & VISION

MISSION

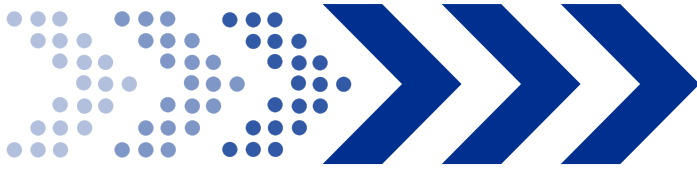
To enhance combat capability and mitigate operational risk to the warfighter through energy-informed solutions.

VISION

To create an energy-optimized Air Force that maximizes combat capability for 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 analysis
- 4** Support the production of energy-informed war plans
- 5** Educate the Force and build the culture for operational energy



GOAL ONE

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.

Prior to the establishment of our Data Collection Strategy in 2018, the Air Force had limited data on how aviation fuel was being used during operations, which led to significant barriers in identifying operational inefficiencies as well as understanding our logistical gaps. Since executing our strategy, we are able to drastically improve data collection across airframes and conduct in-depth operational analyses. At the end of 2019, we were collecting approximately **49 percent** of all available aircraft fuel use data and the rate has only continued to climb.

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.



Benefits of automated scheduling algorithms

\$70M

Potential annual fuel savings in the CENTCOM AOR alone

Developed global allocation and modern scheduling tools using agile methodology

In partnership with Air Mobility Command (AMC) and Kessel Run, we helped develop and fund Magellan, a software tool to globally allocate mobility aircraft and their associated crews over extended periods. Magellan gives operational planners more visibility for long-term scheduling of 'tails and crews' and increases planning flexibility to de-conflict recurring missions and high-demand periods.

Additionally, Magellan was built using a modern, agile approach which allowed for a shorter development timeline, continuous user feedback, and hands-on training for Airmen. As of November 2019, Magellan is delivering operational benefits to warfighters and saving over **300 labor hours per month** while the team continues to add features and capability.

Magellan enables the Air Force to level the curve of peak and off-peak periods of demand in global airlift and tanker allocation

Additionally, we facilitated development of Pythagoras, an auto-planning feature developed by Kessel Run to further optimization gained by initial efforts in the CENTCOM AOR with Jigsaw in 2017. The added capabilities of Pythagoras are estimated to increase schedule efficiency by approximately **10 percent** from Jigsaw's baseline, or the equivalent of removing five tankers from the average ATO. Realized efficiencies enable the Air Force to maintain the same combat sortie rate while decreasing fuel consumption, reducing the number of required deployed tankers, and enabling reallocation of crews to other critical missions.

Introduced policy for 5th generation fighters to fly at optimized airspeed

In 2017, our team conducted a proof-of-concept flight in coordination with AMC and Air Combat Command (ACC), demonstrating that refueling F-22 Raptors flying close to max-range airspeed during long-range transport missions (known as coronets) results in a decrease in overall fuel consumption, a decrease in flying-hour costs, and quicker arrival times for Airmen. After further analysis of the data, we determined that F-35 aircraft would also benefit from this practice.



In 2019, we initiated a policy change that directs planners to begin implementing this process for F-35 Lightning II aircraft. It is now standard practice for all 5th generation fighter aircraft during coronets. According to data from our demonstration, we estimate that flying closer to max-range airspeed decreases overall fuel consumption during coronets by approximately **6 percent** and saves **10 percent valuable flight hours** for training versus transit.

Optimized airspeed results in:

6%

decreased
fuel burn



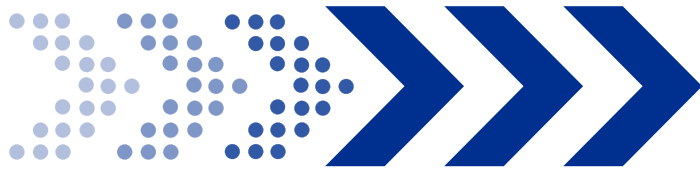
flight hours
for training

10%

\$13M

savings in
flight hour
& fuel costs





GOAL TWO

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 of this goal, we consider new and existing technologies and processes in aerodynamics, aircraft weight reduction, advanced propulsion, and mission optimization, and play an active role in the Air Force's capability development process to better incorporate these solutions into tangible benefits.

There are many opportunities to update our legacy aircraft for the 21st century fight. 'Bolt-on' parts like aft-body drag reduction devices (Microvanes, Finlets) and blended wingtip devices (winglets, raked wingtips) can seamlessly integrate into operations and begin reducing fuel demand immediately, some paying for themselves in a matter of months. Light-weight, corrosion resistant aero-structures can replace heavier parts on an attrition basis. Engines can be retrofitted with state-of-the-art technologies to improve performance and increase time-on-wing.

Our Key DoD Partners



AFWERX



With our eye on the future, we are tracking commercial developments in aircraft design such as lifting-wing body, over-wing / over-body nacelles, ultra-high bypass ratio turbofans, and boundary-layer ingestion. We're also monitoring progress on advanced powerplants like adaptive engines, megawatt aircraft, small turbines, fuel cells, and turboelectric generators.

Coordinated certification of aft-body drag reduction devices, Microvanes, on C-17s during airdrops

In 2019, we pursued research and funding for several low-cost/high-payback present day options for legacy aircraft. Microvanes are small “fins” attached to the aft end of the fuselage of heavy cargo aircraft to increase efficiency by streamlining airflow and reducing drag.

In 2019, we coordinated with AMC, the Air Force Life Cycle Management Center (AFLCMC), and the commercial product developers, to conduct live paratrooper testing to certify Microvane-equipped C-17 Globemaster III aircraft for personnel airdrop missions. This successful demonstration paved the way for the U.S. Army to conduct future airdrops on Microvane-equipped C-17s.

Installing microvanes on 222 C-17s will save over \$10M per year

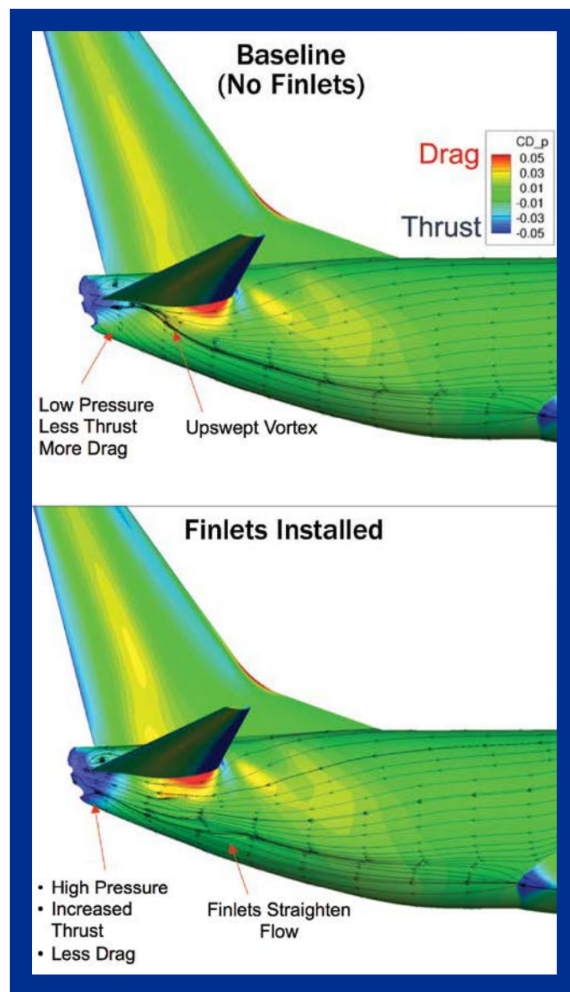


According to our research, adding Microvanes to cargo aircraft could garner over **2 million gallons in fuel savings** per year, equating to approximately 10 million dollars annually (depending on fuel prices and mission) if installed on all 222 C-17 airframes. Microvanes have been submitted into AMC’s FY22 Program Objective Memorandum (POM).

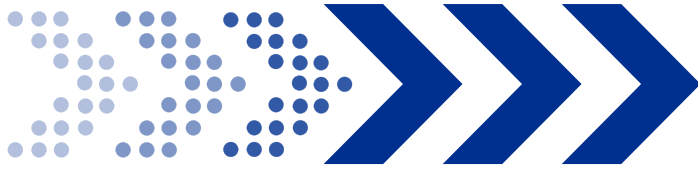


Sponsored funding award for drag reduction devices, Finlets, on C-130s

An alternative design of aft-body drag reduction devices, Finlets, improves aerodynamic airflow and reduces drag on cargo aircraft by redirecting vortices at the tail-end of the airframe.



With sponsorship from our office and Air Force Special Operations Command, the AFWERX Small Business Innovation Research (SBIR) program awarded Phase I funding to Vortex Control Technologies to begin initial design work for their aft body drag reduction devices, commercially known as Finlets, on C-130 Hercules aircraft. Finlets are estimated to reduce drag, and therefore fuel burn, by approximately **5 to 6 percent**, which could have a significant impact on range and endurance, as well potential cost savings, if implemented across the fleet.



GOAL THREE

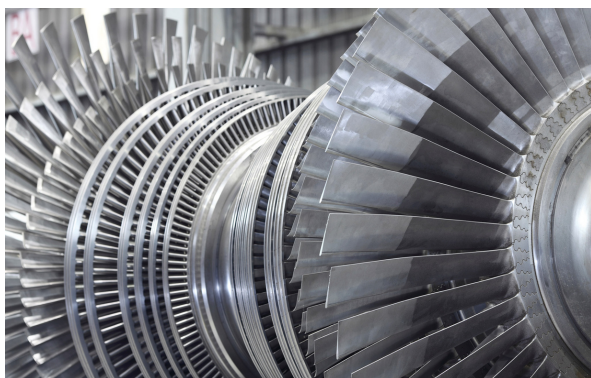
Furnish energy-efficient weapons system sustainment analysis

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 engines, resulting in improved performance, increased time-on-wing, fuel efficiency, and reduced maintenance for turbine blade aircraft.

The commercial airline industry has been refining engine maintenance initiatives for decades, and has seen steady efficiency improvements every year.

We're dedicated to learning from their best practices and integrating them into the Air Force where it makes sense. In 2019, our initiatives included the following engine blade optimization and sustainment efforts: compressor blade scanning, compressor blade coatings, and engine foam washing.

By working with the defense industry and commercial aviation entities, we are able to identify best practices and new innovative technologies in aircraft sustainment that will translate to increased capability and resilience for the Air Force.



Engine sustainment efforts

lead to **2-3%**
fuel savings annually



Funded testing of infrared scanning of engine compressor blades


Blade defects decrease engine efficiency and power, while increasing fuel burn (specific fuel consumption) and exhaust gas temperature, resulting in decreased aircraft availability due to a greater need to service engines more frequently. Additionally, defective compressor blades can pose a safety threat if not replaced in a timely manner. By implementing cost-effective and reliable blade inspection and maintenance, we ensure engines are performing optimally, while enhancing aircraft readiness.

In 2019, we supported and funded the testing of compressor blade scanning and refurbishment on the F108 engine, which operates on the KC-135 Stratotanker.

The tests demonstrated scanning allowed maintainers to identify blade defects quickly and accurately, decreasing the time spent inspecting blades manually and allowing them to better locate which blades needed to be refurbished or replaced. Our analysis indicates this method improves engine performance and decreases fuel burn by approximately **2 percent**, while also decreasing maintenance related costs in parts, unscheduled engine replacements, and labor hours.

COMPRESSOR BLADE SCANNING


Using advanced infrared and laser technologies, the Air Force is scanning engine compressor blades to optimize performance and improve fuel efficiency.








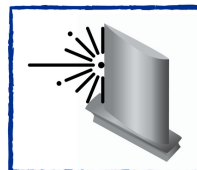

Engine arrives at depot for maintenance to address degraded performance.

Advanced technology methods scan compressor blades for performance optimization.

Individual blades are intelligently aligned and integrated back into service.



-  Reduces fuel burn by up to **2%**
-  Optimizes engine performance
-  Engine runs cooler
-  Incorporates latest commercial tech

FUEL MORE FIGHT

www.safie.hq.af.mil/OpEnergy

Supported certification of turbine blade coatings

Innovative technologies to prevent wear-and-tear of turbine compressor blades are under development by defense and technology companies. Specialized blade coatings, for instance, can be applied directly to the blades to help prevent erosion and damage caused by engine ingestion of dust, sand, ice, and other debris during flight.

In 2019, we advocated for the certification of an advanced erosion resistant coating for compressor airfoils on the F117 engine, which operates on the C-17. According to commercial tests, the coatings allow the airfoil to retain surface finish during engine operations and result in greater time on wing, enhanced performance, lower carbon emissions and engine temperatures, and potential fuel savings up to **3 percent**.

SMART ENERGY SOLUTIONS:

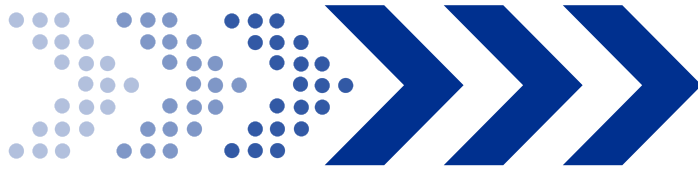
OPTIMIZED ENGINE PERFORMANCE

MORE FLIGHT HOURS

Pursued a pilot program on engine foam washing

We teamed up with Air Force Special Operations Command on a proposal for a pilot project that will evaluate the benefits of foam washing on the CV-22 Osprey engine, which, like many Air Force aircraft, operates in harsh environments. We also worked with the Air Force Research Laboratory's Advanced Power Technology Office (AFRL/APTO) to identify opportunities to demonstrate and evaluate this method on AMC aircraft. Based on commercial studies, we expect foam washing will improve performance, reduce engine temperatures, and decrease fuel burn.



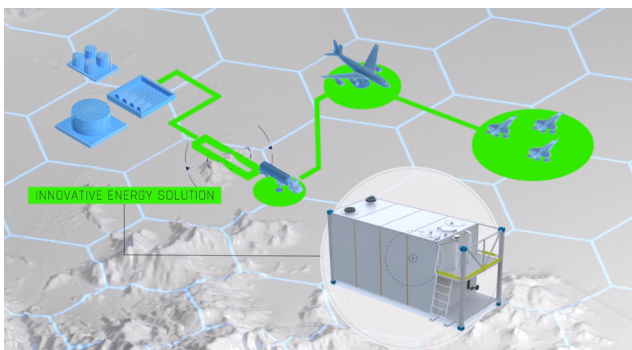


GOAL FOUR

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.

In 2019, we made significant progress integrating operational energy and related logistical issues into Air Force and Joint wargaming - focusing on the complete energy network. In collaboration with our sister services and aligned organizations, we incorporated realistic energy scenarios into game play, strengthening our understanding of the impact of fuel on future basing and logistics. Additionally, with Air Force Warfighting Integration Capability (AFWIC), Rapid Global Mobility Division, we co-led a workshop series on incorporating logistics-informed analysis into the investment decision-making processes for future Rapid Global Mobility force requirements.



Integrated energy scenarios into the Air Force Title X wargames

In 2019, we shepherded the successful integration of the operational energy network, from refinery and bulk transport, to storage, transit, and delivery of fuel to the end-user, into Air Force Title X wargames (Global Engagement '18 and Futures Game '19) and Air Force Materiel Command's (AFMC) wargame (Long Duration Logistics Wargame '18). This led to the planning, coordination, and development of the 2020 wargaming series emphasizing operational energy capabilities and challenges.

Supported development of the first energy-focused joint wargame

2019 was the first year that the joint forces have ever conducted a wargame focused solely on energy and fuel logistics. Over the year, we provided strategic support and subject matter expertise to develop the Joint Forces Energy Wargame (JFEW), sponsored by the Office of the Deputy Assistant Secretary of Defense (ODASD) for Energy. Hosted by the U.S. Indo-Pacific Command (USINDOPACOM), the capstone event was executed in August 2019 at Camp Smith, Hawaii, and resulted in identification of shortfalls in Air Force operational energy capabilities when supporting joint missions.

A critical outcome of the JFEW was awareness that the Air Force needs to be lighter and leaner in its energy and fuels logistics support.

We are working with Air Force fuels, logistics and technology development communities to develop capabilities that would make us more agile and survivable in contested environments and to influence the Planning, Programming, Budget and Execution (PPBE) process for realization of these investments.



Introduced modeling and simulation tools that increase wargaming reality

We work with the wargaming community and industry partners to develop and enhance digital tools that account for fuel demand and all aspects of the operational energy supply network.

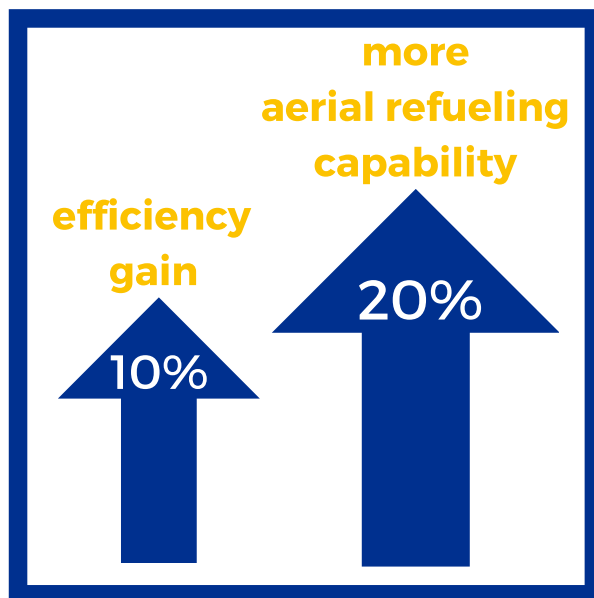
In 2019, we partnered with AFWIC, the Air Force Petroleum (AFPET) office, and AFMC to update existing modeling and simulation tools for use in energy-focused wargames.

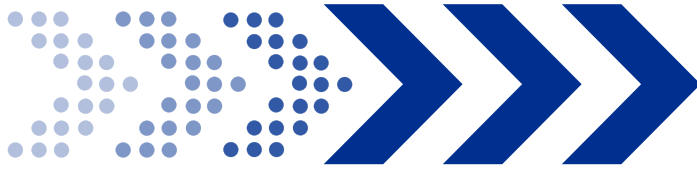
As part of this effort, we teamed up with the Office of the Secretary of Defense’s Cost Assessment Data Enterprise (CAPE) to augment the Standard Wargame Integration Facilitation Toolkit (SWIFT).

SWIFT was instrumental to the execution of the Joint Forces Energy Wargame (JFEW). Known as JFEW-SWIFT, the tool displays fuel consumption rates and degradation of fuels related infrastructure and support equipment in real-time, while also recording data for future analysis.

Analyzed compound effects of Operational Energy efficiencies

In 2019, we leveraged Modeling and Simulation tools routinely used in our support of wargaming, to show fuel efficiencies can extend combat capability for the direct benefit of the warfighter. Our analysis showed when applying capabilities like winglets on KC-135s, combined with other Operational Energy efficiencies (e.g. engine compressor blade coatings), fuel efficiency improvements on tankers would be roughly doubled in terms of their battlefield impact. We found that operating tanker missions more efficiently produced cumulative effects by combining less fuel burn, more receivers, and fewer tanker sorties. Effectively, a **10 percent** increase in fuel efficiency realizes a **20 percent** increase in overall aerial refueling productivity.





GOAL FIVE

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.

We work with Air Education and Training Command, Air University, the Air Force Academy, and Major Commands, to include our operational energy materials in their curriculum where relevant.

Through strategic engagement and awareness campaigns, we strive to increase Airmen's understanding of smart fuel consumption and the benefits it provides to the Air Force.



Incorporated operational energy into education and training

As part of our effort to build an energy-aware culture, we collaborated with the Air Force Institute of Technology (AFIT) to offer two graduate courses in defense energy systems: Future Department of Defense Energy Systems Engineering in Fall 2019, and Aviation Systems Engineering in Winter 2019. We worked with AFIT professors and AFRL subject matter experts to build the course syllabus and research focus for each class. In support of our initiatives, students supplemented their coursework with energy-focused research studies including: Coronet Mission Analysis (Cost Optimization of Fuel), Department of Defense Alternative Jet Fuel, and UAV Fuel Cell/Battery Optimization.

At the United States Air Force Academy (USAFA), our on-site team liaison continued to incorporate operational energy messaging into educational opportunities, including wargaming courses and cadets' capstone research. Additionally, USAFA held its first cadet-run Energy Action Month, focused on infusing operational energy into USAFA's core strategy courses and internal messaging.

**Without fuel,
there is no fight**

Increased engagement with congressional stakeholders

Throughout the year, we continued to build strategic relationships with House Armed Services Committee and Senate Armed Services Committee congressional staff members and representatives to inform stakeholders of the operational benefits of energy-optimized initiatives. More specifically, we briefed senior Professional Staff Members on our initiatives for energy in wargaming, modernized mission planning technology, and legacy aircraft drag reduction, as well as our investment strategy. These briefings proved vital to making a case for funding energy optimization initiatives in future budgets.



Growing our network

18

speaking engagements

9

feature articles

124k

unique visitors to website

44k

Facebook visitors

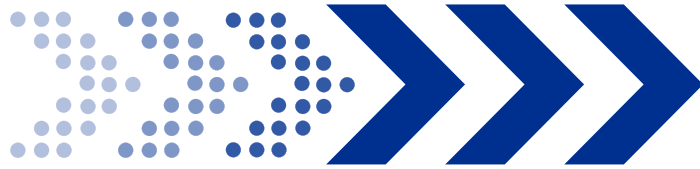
494k

Twitter visitors

Built digital presence and leadership engagement

In 2019, we continued to enhance and implement the communications and engagement strategy established in 2018. Through multi-channel communications and content development, awareness campaigns, leadership engagement, and targeted and consistent messaging, we helped inform Airmen about smart energy practices and the impact these practices have on maximizing combat capability and mission readiness.





CLOSING

As the **threat of global power disruption rises**, our competitors will continue to advance their warfighting capabilities and attempt to exploit any perceived gaps in our readiness. To hold our strategic advantage and maintain the international rule of law, we must go beyond a 'business as usual' approach and anticipate growing threats to our Nation's security.

Aviation fuel is foundational to the Air Force's ability to operate effectively from anywhere in the world - but we must be vigilant in optimizing fuel demand, addressing logistical gaps, and mitigating operational risk.



As we've laid out in this report, there are numerous opportunities we can begin implementing today to increase our energy resilience and combat capability. By providing Airmen with 21st century tools, we can streamline mission planning and better predict vulnerabilities. Through advanced technologies and processes, we can decrease fuel consumption and related maintenance issues for both new and legacy airframes - reinvesting cost savings into future warfighting capabilities. As we look into the future, we can begin planning and executing the process for modernizing our engines and airframes, with energy optimization as a key factor in our acquisition strategy and decision-making.

Now is the time to prioritize operational energy and provide the tools needed to remain lethal and ready for the next generation of air warfare.

Aviation fuel is foundational to the Air Force's ability to **operate effectively** from anywhere in the world - but we must be vigilant in optimizing **fuel** demand, addressing **logistical** gaps, and mitigating **operational** risk.



AIR FORCE OPERATIONAL ENERGY

NO FUEL NO FIGHT

