L

Power Alternatives Emerging Trends

FDOT

2043 FASP FLORIDA AVIATION SYSTEM PLAN

Appendix L

Power Alternatives Emerging Trends

Renewable energy sources such as wind farms and solar arrays are beginning to reach mainstream prominence for municipalities around the world. The latest trends in renewable energy generation have begun at airports, where unused property may house wind turbines or solar panels capable of supplementing the energy needs of airport facilities. Underused landside areas, rooftops, and many other areas have become prime locations to install renewable energy sources. As airports around the country begin installation of these systems, many changes are required. The following document provides background information and describes the efforts to improve their viability at airports. How this emerging trend will affect Florida airports and what the Aviation Office of the Florida Department of Transportation (FDOT AO) can do to accommodate its implementation are also discussed.

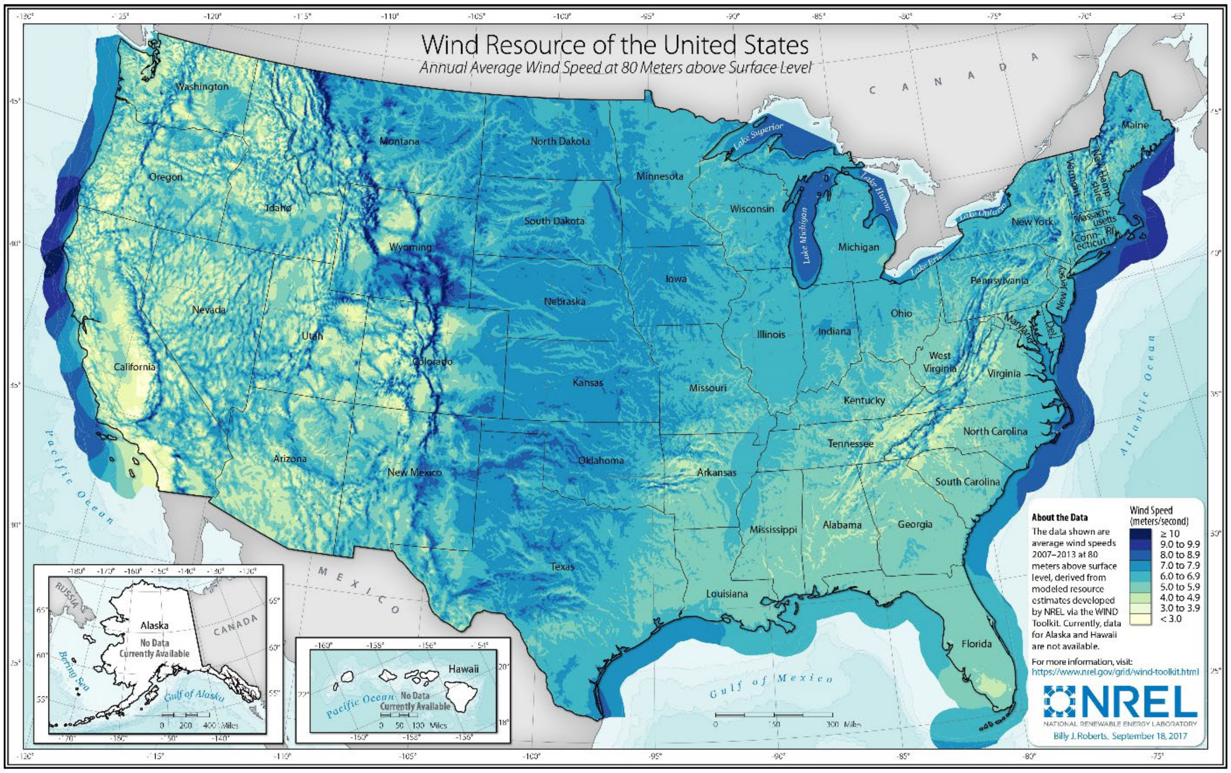
Background

Wind has been an energy source since ancient times, used for boat propulsion as early as 5000 BC. Likely the first practical use of wind as an energy source came in the seventh century, where wind caught by a series of sails was used in food production; the “windmill” converted the captured wind into rotational energy to “mill” grain. This application of rotational energy is also applied to mechanically pumping water, a technique popularized by the Dutch where windpumps siphoned water from lakes and marshes for use as arable farmland. By the late nineteenth and early twentieth century, wind-powered electric generators were developed to produce electricity from the same rotational energy used for centuries. The first electricity-generating turbine was invented in 1887, and it saw widespread adoption in rural areas where centralized power grids were beyond reach. While some of the earliest wind turbines were very small, anywhere from 5 to 25 kilowatts (kW) in 1908, their ease of construction and viability as an individual application almost anywhere on the planet meant they remained popular.

For a wind turbine to be effective, it must receive a large amount of wind. Modern wind turbines generate energy by converting rotational kinetic energy into electricity. The degree of rotation is affected by the amount of wind received, which, in turn, is affected by the location’s geographical propensity for wind. **Figure 1** illustrates the average daily wind speed across the United States.

The highest wind speeds in the United States occurring over land are close to the peaks of mountain ranges, most notably in the Rocky Mountains. The Great Plains states of Nebraska, Kansas, and Oklahoma also provide excellent yields. Wind can also vary over bodies of water, and in many locations offshore wind farms are very effective. For the United States, the Pacific Ocean near Oregon and the Atlantic Ocean near Cape Cod, Massachusetts, are the areas over water with the highest windspeeds. Wind turbines produce the most energy in areas with higher wind speeds, but they remain viable in any environment.

Figure 1. US Wind Resource Availability Map



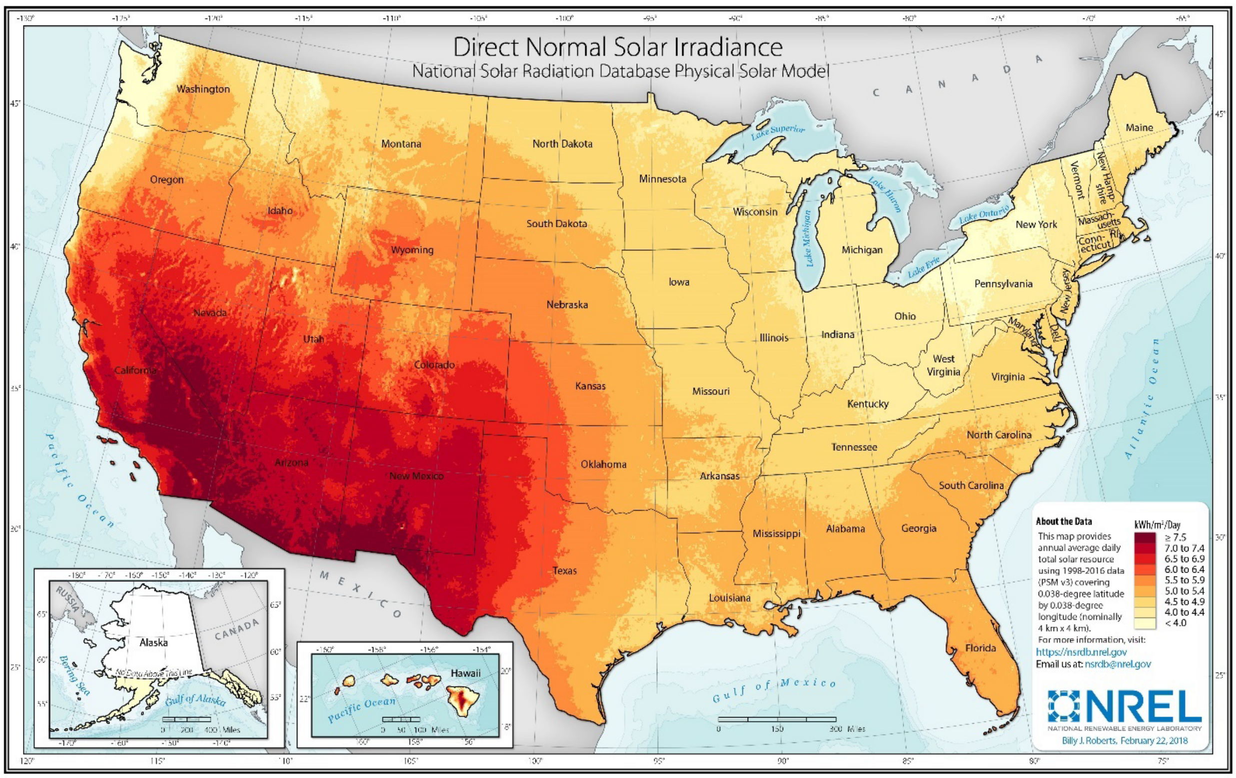
Source: National Renewable Energy Laboratory (NREL), September 8, 2017.

The efficiency of a wind turbine is measured by how effectively it can convert wind into energy. High wind speeds yield more power, as this creates many rotations to spin the generator. Wind may be collected from any height, but wind speeds generally increase with altitude. Taller turbines with larger rotor blades produce more electricity, as the larger surface area of the blades captures more wind. Wind is generally faster at greater altitudes, so placing blades higher up further improves a turbine's effectiveness. Increasing rotor size has come to prominence in recent years to greatly improve the energy generation capabilities of turbines. In 1990, the average wind turbine globally had a rotor diameter of 130 feet and generated 50 kW of power. By 2016, these numbers had risen to an average rotor diameter of 420 feet with 2,848 kW of output.

Modern solar technology, by contrast to wind, is the more recent result of a century-long process of iteration. The first solar panels were created in the mid-nineteenth century as results of scientific experiments discovering how light may be converted into electrical energy. Such solar panels would continue to be developed into the twentieth century, but the capacity and energy production capabilities of these early solar cells remained miniscule. The first viable Photovoltaic (PV) cells for energy generation arose in the mid-twentieth century, but they found limited success. The price of the highest-capacity PV cell of the era was created by Hoffman Electronics-Semiconductor Division, a 1955 PV offering 2 percent efficiency at a cost of $1,785 per watt. Photovoltaic solar panels only reached mainstream relevance into the twenty-first century as energy efficiency increased and, crucially, as the cost of PV cells plummeted. The average solar panel in 2022 has an efficiency of roughly 15 percent, while the cost per watt has dropped to $2.94.

As with wind turbines and wind, a solar panel must receive a large amount of sunlight to be effective. The PV array converts sunlight it receives into electricity. The best measurement of a solar cell's input is through Direct Normal Irradiance (DNI), the amount of solar radiation received by a surface perpendicular to the sun's current position in the sky. DNI varies significantly by geographic location and time of year, as climatological factors such as weather and season duration greatly impact solar irradiance. **Figure 2** illustrates the average daily DNI across the United States.

Figure 2. Direct Normal Solar Irradiance



Source: National Renewable Energy Laboratory (NREL), February 22, 2018.

A higher DNI typically correlates with a higher number of average sunlight hours per day, but this is not the only factor. DNI varies greatly by time of year, as the angle of the Earth's hemispheres changes by season. Summer occurs when one of the Earth's hemispheres is tilted towards the sun, creating a favorable angle for solar radiation to reach the Earth's surface. Winter, by contrast, sees one of the hemispheres tilted away from the sun, meaning more solar radiation is reflected off into space.

DNI is an effective tool for analyzing the effectiveness of solar PV arrays, as higher DNIs will provide higher inputs for solar paneling to convert into energy. Areas with the highest DNIs in the United States are concentrated in the southwest, particularly in California, Arizona, and New Mexico. These locations are considered prime locations for PV arrays, as high DNIs allow PV panels to produce more energy. While locations with higher DNIs are often seen as the most advantageous locations to install solar arrays, solar panels remain viable in all environments.

Many US federal agencies have begun integrating their own renewable energy projects to reduce carbon emissions and find a renewable source of energy to meet ever-growing demand. In the Federal Aviation Administration (FAA) Order JO 7400.2, *Procedures for Handling Airspace Matters*, Appendix 12 establishes an evaluation system of any wind turbine farm proposals that may pose a risk to air traffic. The most recent change to the order was published in November 2022. FAA Form 7460-1, *Notice of Proposed Construction or Alteration* may also be submitted to ensure proper notice and approval of any wind projects.

The FAA issued a final policy on airport solar projects in May of 2021 to establish best practices for airport solar projects. The *Review of Solar Energy System Projects on Federally Obligated Airports* requires airports to measure the visual impact of solar projects on pilots and air traffic control personnel. As more airports begin to implement solar projects, the FAA wishes to ensure these projects are installed with safety in mind. The solar projects should demonstrate they operate in a manner that will not cause solar glare, because it may prove unsafe for airport users and operators. The 2021 policy is the final policy and supersedes an interim policy from 2013.

Next Steps and Challenges

With the increasing success of renewable energy sources, the aviation industry is considering the next steps and challenges in mainstream industry implementation of these systems. The immediate benefit of wind and solar energy is that they are renewable energy sources free of carbon emissions. Any singular form of renewable energy is often installed in conjunction with other renewable energy sources and passive energy-efficient design to achieve “net zero” greenhouse emissions, fully offsetting greenhouse gas emissions with sustainable alternatives to reduce all emissions to zero.

The effectiveness of renewable energy sources is contingent upon the geographic availability of the resource, in this case wind and solar energy; a higher wind speed or DNI indicates a higher availability and greater potential energy output. The overland wind speeds received by Florida are generally average for the continental United States. This means wind turbines are viable in Florida but are not inherently the best sources of renewable energy. Florida does, however, receive significantly higher DNIs overall than other states, in part due to Florida’s tendency to receive clement weather throughout the year. This makes Florida an ideal state to construct solar panels. While high DNIs are not a prerequisite for solar arrays, areas with higher DNIs provide the optimal energy generation efficiency of PV cells. For both wind and solar the position and orientation of each unit is paramount to ensure maximum efficiency, so a site must be carefully chosen to deliver the highest yields.

Another notable challenge facing wind turbines and PV solar arrays is the technology itself. Not all energy from wind and solar radiation can be transformed into electricity, as no system can be 100 percent efficient. As an example, the Betz limit is the theoretical maximum efficiency of a wind turbine, where at most 59.3 percent of the kinetic energy from wind can be used to spin a turbine at sufficient speed to generate electricity. Most of today's wind turbines operate at 20 to 40 percent efficiency, last roughly 20 years once constructed, and require routine maintenance every six months. PV cells operate at a lower average efficiency of 15 to 20 percent, but they last longer at 25 years and require very little maintenance throughout their lifespans.

Wind turbines and PV cells have dropped in price considerably over the past several decades, but these systems can remain expensive to construct initially. The cost burden of installation also often falls solely on the property owner or, in this case, the airport itself, to construct. This creates a barrier to entry for many, as the upfront cost of installing a solar array may not prove beneficial in the short term. In the long term, however, the cost savings of wind turbines and PV arrays become more apparent. The FAA also offers many funding opportunities for airports seeking to lower their carbon emissions. The Voluntary Airport Low Emissions (VALE) grant is one such program, and it can cover much of an airport's costs associated with PV system installation. The VALE program was used by the Manchester-Boston Regional Airport (MHT) in Manchester, New Hampshire, to cover 95 percent of the cost to install its on-airport PV array.

While the cost of renewable energy has declined dramatically since the 1950s, some renewable energy sources cannot produce enough energy by themselves and require a series of units to achieve a high energy yield. This is especially true for solar panels, as a collection of PV cells using a significant amount of real estate is required to produce large quantities of energy. Energy generated by renewables is usually used to offset electricity produced from fossil fuels, as renewable energy systems cannot be selectively called upon when demand is needed; they function only as the wind or sun allows. Further, the amount of input (wind or sunlight) received by each unit must be substantial, as these systems rely entirely upon regular abundance.

The most significant challenge to the implementation of wind turbines, particularly at airports, is the size of modern wind turbines. Since they require many moving parts, most notably the rotating blades, wind turbines are significant structures that easily become obstacles. Such a system in use at an airport would pose a clear and present danger to any aircraft using the airspace, and wind turbines would require a very specific site away from aircraft traffic to function effectively on airport property. A modern high-yield wind turbine, which has an average height of 420 feet, would likely be too tall to meet most airfield design criteria required by the FAA in Advisory Circular (AC) 150/5300-13B, *Airport Design*.

By contrast, solar systems require very little maintenance, generate no noise, and can operate independently of any moving parts that may create obstructions. Because of this, PV arrays can be mounted almost anywhere with a flat surface: on rooftops, in fields, or suspended on poles. Solar installations are also modular, meaning shipments of solar paneling, wiring, and other equipment can be easily delivered to the installation site. In addition, many solar panels are remarkably resilient. Most solar panels can withstand winds of up to 140 miles per hour, making them capable of withstanding winds from a Category 4 hurricane.

Lengthy planning periods and review by the FAA for any renewable energy projects are also potential challenges. A specific review for solar installations in FAA's *Review of Solar Energy System Projects on Federally-Obligated Airports* mandates airport solar projects perform a visual impact study to confirm the installation would have little to no impact on pilots or air traffic control personnel. The policy only applies to federally obligated airports (those accepting federal funds buying land or developing airport property) with Air Traffic Control Towers (ATCTs). However, the standards for measuring ocular impact set forth in the policy add further complexity to the installation process of PV systems. Strategically siting PV arrays can mitigate or outright eliminate solar glare, but coatings and texturing options are also available for paneling to minimize glare without compromising performance. These impacts on optical glare are in addition to the design standards set for the locations of all airfield facilities in AC 150/5300-13B. FAA Order JO 7400.2, Appendix 12 presents additional regulatory approvals for wind projects constructed on airport property.

How Does This Affect Florida Airports?

Florida has one of the largest, busiest, and most dynamic state aviation systems in the country. It is home to 129 public use commercial service and general aviation airports. The many natural features of Florida create a unique environment to generate renewable energy. Florida airports may benefit greatly from renewable energy sources as the bourgeoning aviation system of Florida places strain on the system's energy capacity.

Some airports in Florida have already installed their own renewable energy projects, most notably with solar projects at Lakeland Linder International Airport (LAL), Orlando International Airport (MCO), and Tallahassee International Airport (TLH). The following summarizes the potential effects this emerging trend might have on airports across Florida:

- **Logistical Challenges** – Supply chain issues remain a significant concern following the COVID-19 pandemic, where production in many industries is limited and distribution logistics remain strained. As a result, supply challenges may persist into the immediate future. This could create challenges for airports in acquiring the wind turbines or PV cells necessary for energy generation to be possible.

- **Physical Airport Infrastructure** – Wind turbines or PV installations would ideally be installed on airport property in an area free of obstructions, such as on vacant land. PV arrays could also be located on the rooftops of airport buildings. The intent is that energy generated from wind turbines or PV arrays would reduce the airport's need for external power sources, thereby replacing energy generated off-airport from non-renewable sources. Any PV infrastructure must conform with ocular glare standards, and all renewable energy sources must conform with AC 150/5300-13B.

- **Geographical Considerations** – Florida's geographical location lends itself well to providing many sunny days for optimized solar energy production and, to a lesser extent, a ready supply of wind for wind energy production. A drawback of this climate is an abundance of marshlands in much of the state that makes building any type of structure, much less a large and complicated wind turbine or PV array, exceedingly difficult. In addition to construction issues, local marshlands may be home to any number of protected species of flora and fauna, potentially requiring Environmental Impact Statements and permitting for construction within these areas. As an attractive alternative to building over the top of potentially sensitive marshland, the floating PV array installed at MCO helps to power the airport terminal while constituting a much smaller impact to the Airport's natural geography.

- **Cost and Technological Advancement** – The technology surrounding wind turbines and PV systems is ever changing, and they only become more advanced over time. The cost of renewable energy sources has declined over the past few decades, and their ability to generate energy has dramatically increased. Systems that were installed two years previously are immediately surpassed in terms of cost, efficiency, and energy generation. For this reason, wind turbines and PV systems are quickly becoming some of the cheapest long-term sources of energy. In 2022, the average price per kilowatt-hour of fossil fuels was between $0.05 and $0.17, while the cost of wind was only $0.02 to $0.06 and solar was $0.03 to $0.06.

- **Hesitation to Change** – Finally, renewable energy, particularly wind and solar power, is a power source that many view with skepticism. To many its renewable energy status belies its usefulness as a consistent energy source, as solar panels can only be effective if there is sunlight, and wind turbines can only be effective if there is wind. The initial investment in renewable systems is also often seen as unachievably high, and the rapid advancement of renewable energy technology can lead some to believe newly installed renewables will be obsolete after only a few years. Additionally, renewable energy remains an emerging trend at airports, as only a few have recently begun installing their own systems. Without a firm set of case studies or guidelines, installation of these systems on airport property with airport funds can prove daunting.

Ways that the FDOT AO Can Assist

The FDOT AO can facilitate communication among different stakeholders to resolve the implementation challenges associated with renewable energy systems. The following recommendations offer methods to assist airports in the installation of renewable energy sources. They are categorized into items that can be addressed through implementation of the Florida Aviation System Plan (FASP) 2043 and other broader actions that the FDOT AO can promote.

FASP 2043 Recommendations

- **Provide Funding for Installation of Renewable Energy Systems** – The FDOT AO can assist airports in providing funding for the installation of renewable energy systems. This could be from the establishment of a dedicated funding source or through prioritizing the installation of these systems when distributing funds from existing funding sources. This would be beneficial to airports especially if the installation of such infrastructure is not eligible for funding from federal sources like the Airport Improvement Program (AIP) or VALE grant.

- **Include Measurement of Sustainable Energy Generation as a Part of FASP 2043 Performance Metrics** – Inclusion of how airports across Florida implement sustainable energy can help airports and the FDOT AO understand where gaps may lie with installing such systems. This includes the development of performance metrics and the continual evaluation of these metrics to measure this emerging, ever-evolving trend each time the state aviation system is evaluated. This can help focus the development of infrastructure to promote renewable energy systems as well as future financial planning efforts for both airports and the FDOT AO in accommodating this emerging trend.

Other Recommendations

- **Encourage Airports to Install Renewable Energy Systems** – The FDOT AO can encourage Florida airports to coordinate with local wind and solar companies to install renewable energy systems. Likewise, the FDOT AO can serve as an advocate for state airports in communicating with manufacturers, distributors, and installers so that Florida airports may call upon a robust network of renewable energy resources. Financial incentives such as tax breaks and rebates could also be used to encourage airport operators to install their own renewable energy sources.

- **Promote Benefits and Reliability of Renewable Energy** – The FDOT AO can introduce an educational campaign about the benefits and reliability of renewable energy. Airports benefit from wind and solar energy in several ways, including a reduction in carbon emissions and long-term energy generation cost savings. Some uncertainty concerning the reliability of renewable energy is likely, as wind energy relies entirely on the availability of wind, and solar energy relies on sunlight. The FDOT AO can use e-mail, publications, social media, and other communication channels to share information such as the benefits and growing efficiency of renewable energy. The FDOT AO can also provide links to the communication campaigns of wind and solar companies to learn more about these products, and they can also invite these companies to conferences and other events to discuss renewable energy with attendees.

- **Promote Funding Opportunities for Airport Renewable Energy Projects** – It is very important that the FDOT AO regularly promote funding opportunities available to airports for renewable energy projects. Many programs, such as FAA's VALE program, could be used to cover almost entirely the costs of a renewable energy system's installation.

- **Encourage Use of Local Producers, Distributors, and Installers of Renewable Energy Inputs** – Florida has one of the busiest state aviation systems in the country; thus, demand for all aspects of aviation, including energy, is generally higher than in other states. Given this elevated level of activity, the FDOT AO can encourage airports interested in renewable energy projects to use local wind and solar companies in Florida to minimize the carbon footprint of any inputs for new projects. As an example, this could include the local production of PV cells. It could also include transport of the cells to the site, and final installation of the array.

- **Coordinate with Environmental Regulators** – As renewable energy projects increase in prominence at airports, the FDOT AO can advocate with federal and state environmental regulators to transition a portion of an airport's energy supply to sustainable alternatives. Additional concerns surrounding environmental conditions, such as construction impacts to native flora and fauna, remain relevant to implementation. Other concerns, however, such as optical glare from solar paneling, may be unfamiliar to regulators. This unfamiliarity could result in new regulations that limit the implementation of airport renewable energy projects. By communicating with regulators, the FDOT AO can help prevent potential environmental regulations that negatively affect airport renewable energy projects.

Conclusion

The implementation of renewable energy airport projects in Florida is an important stepping-stone in meeting the energy needs of the future while promoting sustainable goals. As with any emerging trend and its transition to mainstream industry acceptance, the implementation of renewable energy projects at airports will take time before it can reach mainstream relevance at Florida airports and within its aviation system. The FDOT AO serves an important role in helping to facilitate this industry change by leading communication efforts about its benefits to the operators and users of its system. Likewise, the FDOT AO also serves an important role assisting its airports in transitioning to renewable energy, including providing a robust network of resources for interested airports. By implementing the recommendations for the FDOT AO to promote and provide access to wind and solar resources, Florida can continue to be a world-class leader in supporting the needs of its airports and aviation community.