WASP
WASHINGTON AVIATION SYSTEM PLAN

Memorandum

Re: Final Emerging Issues Paper
Aircraft Innovation

This technical memorandum summarizes recent trends in aerospace manufacturing innovation and potential impacts on the State of Washington.

Introduction

New aircraft entering the civilian aviation marketplace are increasingly likely to have unique operating characteristics due to innovation within the aerospace manufacturing industry. While new aircraft types and models have continuously been introduced into the marketplace since the beginning of the aviation age in the 20th century, recent trends in innovation within the experimental, light sport and normal category aircraft may have an infrastructure impact on airports within the Washington state system over the next 20 years.

This document identifies recent trends in the aerospace manufacturing industry in the context of aircraft innovation, and their potential impacts on infrastructure within the State of Washington airport system, and associated aeronautic and airport programs.

Industry Trends and Outlook

Alternative Fuels/Power Plants

Aircraft manufacturers have begun to make significant progress towards alternative fuel and power sources for general aviation aircraft.

Figure 1 - Airbus EFan Electric Aircraft

Development of aircraft using an electric motor instead of an internal combustion engine has been ongoing since the 1970s. Currently, electrically powered aircraft are primarily experimental or demonstration aircraft, however advances in lightweight motors and more powerful batteries will enhance the feasibility of electric aircraft. Several companies in Europe and the United States are developing electric powered aircraft for commercial use. Industry transition to electric propulsion may begin with trainers emerging over the next few years, followed by personal VTOL aircraft, and commercial grade platforms in the mid-term.

Figure 2 - Diesel Powerplant

The declining availability of Avgas in the United States along with the increasing environmental concerns and regulation of leaded fuels has driven innovation in fuel types and engine types. In addition to being cheaper than Avgas, motor fuel (such as Mogas and gasoline), and jet fuel (such as road diesel or Jet-A) are widely available for use by GA aircraft provided their engines are capable of using them. Over the past few years, several companies have developed new aircraft engines which can run on Mogas. Some engines are widely used, Rotax being one example. Additionally, other manufacturers have developed diesel engines which burn jet fuel. Cessna Aircraft has already developed at least two aircraft types with a diesel engine option: the Turbo 172 Skyhawk JT-A[1], and the 182 Skylane JT-A (although orders for this aircraft were halted in May 2015)[2].

Aviation biofuels are also beginning to enter the marketplace as an alternative fuel source. Biofuels have been approved for commercial use in aircraft since 2011, and have started to see limited use on commercial flights, primarily in Europe and Asia.

Innovative Experimental and Light Sport Aircraft

Light sport aircraft (LSA) are small, simple-to-operate, easy-to-fly aircraft that in the United States are generally classified as having a maximum gross takeoff weight of 1,320 pounds and a maximum level flight speed of 138 mph among other criteria.

Figure 3 - ICON Special Light Sport Aircraft

Two types of experimental and light sport aircraft are being developed with the potential to impact infrastructure at airports: the roadable LSA, and autogyro/tiltrotor/VTOL aircraft.

Roadable LSAs combine flying capabilities of an aircraft with a vehicle capable of being driven as an automobile. While roadable aircraft have been contemplated and constructed since the 1930s, they have not enjoyed commercial success and acceptance. Current efforts to bring a roadable LSA to market in the United States is typified by the Terrafugia Transition. The Transition has been under development since 2006, with anticipated first customer delivery scheduled for mid 2016. The Transition has a specified takeoff roll of 1,700 feet, a 100 mph cruise speed and 400 mile range in flight, and can reach ground speeds between 65 and 70 mph on the road[3].

Figure 4 - Terrafugia Roadable LSA

Autogyros or gyrocopters are a type of rotorcraft with a propeller to generate thrust, and an unpowered rotor to provide lift. Autogyros are not true VTOL (vertical take-off and landing) aircraft because most gyrocopters require a runway for takeoff and cannot hover since the rotor blades are not powered. Autogyros have been developed since the 1920s, but similar to roadable LSAs have not enjoyed widespread commercial success. Currently, autogyros are mainly used by military and law enforcement agencies because of their lower cost to purchase and operate compared with standard helicopters.

Figure 5 - Sportcopter SCII

Tiltrotor aircraft combine the vertical take-off and landing capabilities of a helicopter with the fixed-wing operation of conventional aircraft. The most recognizable tiltrotor aircraft currently is the Bell Boeing V-22 Osprey, which first entered service in the United States Marine Corps in the 2000s. Civilian tiltrotor aircraft are in development, such as the AgustaWestland AW609. The AW609 has flown as a prototype since 2003. FAA certification of the AW609 is anticipated in 2017 at the earliest. The AW609 is designed to be a true VTOL aircraft, with a maximum cruise speed of 275

Figure 6 - Agustawestland AW609 Tiltrotor

[1] The Wichita Eagle, *Manufacturers making progress with diesel-powered airplane engines*, http://www.kansas.com/news/business/aviation/article2102433.html, September 13, 2014.

[2] http://www.aopa.org/News-and-Video/All-News/2015/May/14/Cessna-not-accepting-182-JT-A-orders

[3] Terrafugia Transition Aircraft, http://www.terrafugia.com/aircraft/transition, accessed September 2015.

knots, and range up to 700 nautical miles with standard fuel tanks[4]. Tiltrotor aircraft, like the AW609, are being marketed for corporate use as the quickest method to travel point-to-point, avoiding potential congestion between an airport and one's destination by flying directly to a city center. Tiltrotors also would provide additional mobility options and flexibility for oil and gas operators and other resource development in hard to reach and offshore environments.

Figure 7 - Agustawestland Project Zero

Other General Aviation Aircraft

Very light jets (VLJs) are small jets, seating less than 10 passengers that cost substantially less than business jet aircraft. VLJs have a maximum takeoff weight (MTOW) of less than 10,000 pounds, and are able to use short, general aviation runways. This new category of aircraft includes the Cessna Mustang, Embraer Phenom, and the in development HondaJet, among others.

Figure 8 - Eclipse 550 VLJ

The current VLJ market consists of a new small offering in the established corporate market. Buyers include corporate flight departments, fractional and charter aircraft operators, and wealthy individuals. In the early 2000s, market interest in VLJs was considerably higher. However delays in development of one of the first and at the time most popular VLJ, the Eclipse 500, followed by Eclipse declaring bankruptcy in 2008, combined with the reduced demand following the economic crisis in 2008, caused VLJ demand to reduce significantly.

Figure 9 - Commercial Drone

The development of unmanned aerial systems (UAS) has accelerated over the last five years. Civilian uses of UAS are rapidly becoming more pronounced as the FAA develops and refines operating and certification criteria for this class of aircraft. UAS can be designed around multiple platforms. For example, UAS exist in fixed-wing configurations, VTOL/helicopter configurations, and hybrid combinations. Sizes of these aircraft also vary wildly, from microdrones that that be carried by their owner by hand to military drones such as the MQ-9 Reaper with a wingspan of 65 feet.

Commercial Aircraft

Trends in innovation for upcoming commercial aircraft appear to be focused primarily on reducing operating costs for the airlines by developing more efficient aircraft. This will be done by increasing aircraft wingspans and/or improved aerodynamics, decreasing aircraft weight through use of composite materials, and improved engine technologies to reduce fuel comsumption.

[4] AgustaWestland AW609 TiltRotor brochure, http://www.agustawestland.com/documents/17633750/26143301/body_AW609.pdf, accessed September 15, 2015

Figure 10 – Boeing 737 MAX

Two aircraft in development by Boeing, the 737 MAX and the 777X, are scheduled for deployment between now and 2020. The 737 MAX incorporates Boeing's Advanced Technology winglet with a split tip to improve aerodynamics and fuel consumption rates, while simultaneously keeping the aircraft's wingspan below 118 feet[5]. This keeps the newest 737 series aircraft within the FAA's Airplane Design Group III, which will not require changes to airfield geometry at airport's design to handle this aircraft's predecessors.

The Boeing 777X features a larger wingspan and improved engines to improve efficiency over the current 777 models in service. The 777X will be nearly 23 feet wider than the 777-300ER, but is anticipated to feature folded wingtips as a standard, which will allow the 777X to use the same airport gates and airfield facilities as the current 777 series aircraft[6].

Figure 11 - Courtesy Eric Paciano/California

Cruise-Efficient Short Takeoff and Landing (CESTOL) is an aircraft design concept that may increase capacity and reduce emissions. The future CESTOL aircraft is envisioned to have the size, range and speed to be operationally and economically competitive in substantial markets, justifying a large civil CESTOL fleet. These aircraft could serve large hub airports, satellite airports and local regional airports. They will leverage fuel-efficient, low-noise and low-emission technologies and operating procedures, and will operate in steeper descent/approach and takeoff/climb profiles, on runways used by conventional jet aircraft as well as shorter runways[7].

Anticipated Impacts on Infrastructure Needs

Several of the industry trends outlined above would have potential impacts on infrastructure needs at airports. The development of aircraft using alternative fuels or power sources, such as Mogas, road diesel, and electric motors is one such trend.

As electric powered aircraft emerge, the infrastructure need becomes how to recharge, or exchange batteries, for these aircraft while they are parked on an apron or in hangars. While aircraft parked in hangars would more than likely be able to recharge through the hangar's electrical outlets, aircraft parked on tie-down aprons would not be able to recharge given current infrastructure layouts. The parallel with ground vehicles would be electric charging stations being deployed in city centers for hybrid and electric vehicles to recharge while parked. For commercial operations, including flight training, high amperage, fast chargers, or battery exchange may be needed to support short turn times. Also, battery exchange may require a secure location for battery storage and charging. Similar systems for itinerant aircraft parked at aprons, or increased accommodations for these aircraft in hangars with electrical outlets would be required should these types of aircraft come to market in any significant numbers.

5 737 MAX Design Highlights, http://www.boeing.com/commercial/737max/#/design-highlights, accessed November 2015.
6 Boeing 777X Technical Specs, http://www.boeing.com/commercial/777x/#/technical-specs, accessed November 2015.
7 CESTOL Impact on U.S. Airport Network Operations, International Powered Lift Conference, London, UK, July 2008; http://thehill.com/images/stories/whitepapers/pdf/Sensis_IPLC_08_Couluris.pdf

With its declining availability, more and more general aviation aircraft currently using Avgas will likely see a transition to a new fleet of small aircraft using engines capable of using non Avgas fuel sources, such as Mogas, diesel, or Jet-A fuels. The effect on infrastructure needs at airports would likely be a combination of changes in types of fuels being offered and the amount of space needed for airport fuel farms at general aviation airports. Typically, fuel tank considerations for GA airports are currently discussed in terms of number of tanks and gallons of Avgas and Jet-A available. Depending on how the aviation market responds to all the factors and options surrounding the Avgas availability trend, a combination of additional fuel options beyond Avgas and Jet-A (such as Mogas and diesel), and increases in Jet-A storage (to account for increasing number of aircraft engines capable of processing Jet-A fuel).

Roadable LSAs impact on infrastructure needs at GA airports would likely be limited to access concerns between the airport's runway/taxiway system and the public roadway system. Parking and maneuverability concerns for a roadable LSA would be small due to their dimensions in both aircraft and ground vehicle modes being of a similar size to standard small fixed-wing aircraft and a passenger automobile, respectively. Access concerns would be applicable mainly to itinerant roadable LSAs seeking to leave the secure area of an airport's airfield environment to enter the ground transportation network. Since access to/from the airfield is typically gated and secure for larger GA airports, access in and out of the perimeter is restricted. Should roadable LSAs become more prolific this access challenge would need to be addressed.

Increasing numbers, varied designs and sizes of autogyros, rotorcraft, and tiltrotor aircraft present potentially the largest infrastructure impact for general aviation airports. Currently, with few exceptions, the large majority of based and itinerant aircraft at airports are fixed-wing, utilizing the runway and taxiway system to arrive and depart. Layouts and configurations of facilities with a more pronounced share of rotorcraft/VTOL operations are appreciably different than standard airports accommodating fixed-wing aircraft.

Two examples of this are Boulder City Municipal Airport (BVU) in Boulder City, Nevada, and Grand Canyon National Park Airport (GCN) in Grand Canyon, Arizona. Both airports have significant amounts of helicopter operations due to the tour activity related to their proximity to Grand Canyon National Park. At BVU, a large percentage of the main parking apron is devoted to rotorcraft operations for two of the airport's fixed base operators (FBO). At GCN, the two main helicopter tour operators are located in areas not connected to the airport's runway/taxiway/apron system. In both cases, there are operational challenges due to the increased interaction of fixed-wing aircraft operations and helicopter operations, although this is more pronounced at BVU given the centralized location of the helicopter parking apron in relation to the rest of the apron and the airport's three runways.

Increasing availability and use of autogyros, rotorcraft, and tiltrotor aircraft would potentially drive a need for additional areas devoted for heliport/helipad purposes. While combining these areas with existing infrastructure devoted to fixed-wing parking and taxiing areas is possible, depending on the number and operations of rotorcraft at a facility in comparison to fixed-wing aircraft and operations it may prove advantageous and ultimately safer to separate these uses to different areas of an airport. Additionally, tiltrotor aircraft present challenges in terms of providing hangars at their base airport. Tiltrotor aircraft, like the V-22 Osprey and the ASW609 mentioned above, have their rotors in the elevated horizontal position while parked on aprons or in hangars. The hangar dimensions to house this type of aircraft is significantly different when compared with a fixed-wing aircraft of similar size and use. For example, the wingspan of the ASW609 is 35.4 feet, but when the two rotor lengths are included, the total width of the aircraft is approximately 56 feet at a height above ground greater than most aircraft handling a similar number of passengers.

Potential infrastructure needs related to the VLJ aircraft category are primarily focused on runway length. While these aircraft may be capable of take-offs and landings on runways with less than 5,000 feet in length, most corporate flight departments require aircraft operations be conducted on runways of at least 5,000 feet. Since the development of the VLJ market of aircraft is focused on corporate operators and fractional ownership companies (such as NetJets), airports seeking to accommodate these aircraft need a primary runway length of at least 5,000 feet for corporate jet operators to consider using that facility.

General aviation airports that currently do not have a 5,000-foot primary runway and seek to accommodate a VLJ type aircraft or larger business jet aircraft face a parallel infrastructure need in addition to runway length. Most airports with primary runways less than 5,000 feet in length typically fall into the FAA Airport Reference Code (ARC) category of B-II or lower. Should the design aircraft of an airport change from a prop or turboprop aircraft to a jet aircraft due to increases in activity from VLJ or larger business jets, an airport's ARC would likely increase into a C-I or C-II category. FAA runway design standards significantly increase in several elements between A/B-I or A/B-II ARC categories and the C-I and C-II categories. **Table 1** shows changes in some of these elements between an ARC B-II standard and an ARC C-II standard.

Table 1: Runway Design Standards Comparison

Design Criteria/Element	ARC B-II Standard	ARC C-II Standard
Runway Width	75	100
Runway Safety Area (Length Beyond Runway End x Width)	300 x 150	1,000 x 500
Runway Object Free Area (Length Beyond Runway End x Width)	300 x 500	1,000 x 800
Runway Centerline to:		
Parallel Taxiway/Taxilane Centerline	240	300
Aircraft Parking Area	250	400

Notes:
1) All distances in feet
2) Runway design standards for runways with not lower than ¾-statute mile visibility

Source: FAA Advisory Circular 150/5300-13A, Change 1, *Airport Design*

Summary

Several categories of new aircraft have the potential to enter the civilian aviation marketplace over the next 20 years. In the general aviation marketplace, these innovations currently appear to focus on alternative fuel and power sources, experimental and light sport aircraft, increasing use of various rotorcraft designs (such as gyrocopters, tiltrotors), aircraft with VTOL capabilities, a VLJ corporate market, and the explosion of UAS usage. Each of these categories has the potential to impact infrastructure and infrastructure needs at airports within the State of Washington airport system in various ways.

The first impact is on fueling and power infrastructure. The declining availability in Avgas nationwide and the trend transitioning smaller GA aircraft to non-Avgas sources of fuel has the potential to increase the availability of Jet-A fuel on airports and the introduction of additional fuel options, such as diesel and Mogas. This means additional fuel tanks and/or larger fuel tanks at airport fuel farms. Should electric powered aircraft development accelerate, charging capability for aircraft parked at apron tie-downs will drive need for additional infrastructure.

While experimental and light sport aircraft have continued to increase in popularity in the aviation community, these aircraft typically do not create unusual impacts to infrastructure at an airport beyond the need for apron and hangar space. The development of roadable LSAs, however, would introduce the need to address access issues between the runway/taxiway system and the ground transportation network due to security perimeters at most airports.

Increasing numbers, varied designs and sizes of autogyros, rotorcraft, and tiltrotor aircraft present potentially the largest infrastructure impact for general aviation airports. These aircraft would drive a need for additional areas devoted for heliport/helipad purposes. Additionally, tiltrotor aircraft present challenges in terms of hangar areas, apron space, and dimensions not currently applicable to fixed-wing aircraft.

Finally, infrastructure needs related to VLJ aircraft are focused on runway length and FAA airfield design criteria. VLJ aircraft may be capable of take-offs and landings on runways with less than 5,000 feet in length, most corporate flight departments require aircraft operations be conducted on runways of at least 5,000 feet. Significant increases in FAA safety areas around runways occur once general aviation airports begin accommodating larger amounts of jet activity to the point where an airport's runway and taxiway infrastructure needs to be designed to serve jet aircraft.

As part of the WASP, WSDOT Aviation convened working groups to discuss aviation issues. A working group was established to discuss Aircraft Fuels. This group recommended the following actions be considered:

POLICY CONSIDERATION: WSDOT should reconsider the aviation system and expand it to include heliports and future 'droneports'.

POLICY CONSIDERATION: WSDOT should meet with city councils and similar forms of government to discuss a possible increase in heliports and droneports and related zoning and ordinance topics.

POLICY CONSIDERATION: WSDOT should continue to promote and encourage aeronautics and aerospace innovation.

POLICY CONSIDERATION: WSDOT should continue to monitor the evolution of VTOL aircraft and possible future modal connections at road interchanges and park-and-rides.

POLICY CONSIDERATION: WSDOT should host working groups to explore possible future infrastructure needs associated with aircraft innovation, and possible revision of SCIP and Airport Aid grant programs.

POLICY CONSIDERATION: The FAA should change the light sport weight limit from 1320 lbs. to 1600 lbs. (related more to aircraft innovation than fuel)