



Aircraft Access to SWIM for General Aviation

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AIRCRAFT ACCESS TO SWIM FOR GENERAL AVIATION

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ABSTRACT

The topic of Next Generation (NextGen) air transportation covers the benefits that NextGen offers to the commercial airlines. Required Navigational Performance, Optimized Profile Descents, etc. can provide significant cost benefits to airline operators, and provide air traffic control with more options to increase traffic flow at major airports. What is not often discussed is how the technology developments that serve NextGen can also be utilized by the various general aviation user segments.

Recent developments in portable and flight deck-mounted tablet devices have created opportunities to streamline communications between pilot and Air Traffic Control (ATC), and to enhance subscriber services that provide database updates including baseline data, aeronautical updates including Aeronautical Information Services (AIS) and Meteorological (MET) data, and other services that can provide the flight deck with up-to-date information required to safely complete a flight. Data links such as the Aeronautical Mobile Airport Communications System (AeroMACS) can assist with the initial negotiation of clearances, as well as provide real-time updates to the aircraft before the aircraft departs the airport, and can assist with taxi instructions upon arrival. Extending data link services to uncontrolled airports can provide connectivity to ATC, allowing the receipt of an Instrument Flight Rules (IFR) clearance, and the possible elimination of the clearance void time.

Providing the flight deck with a departure clearance from an uncontrolled airport through data link services eliminates the uncertain time between takeoff to the time that positive ATC control is established. This uncertain time is currently governed by the current method of using clearance valid/void times. Elimination of the clearance void time frees up airspace surrounding an uncontrolled airport since ATC has more positive control and surveillance of departing aircraft and increases positive air traffic control to notionally uncontrolled airports. Data link could also be utilized to close an IFR flight plan upon arrival at these same uncontrolled airports, again freeing up the approach for following aircraft and increasing traffic flow to an uncontrolled field.

Portable electronic tablet computing devices can provide capabilities similar to those hosted on certified electronic avionics. Given the appropriate policies, Apple® iPad® and other similar tablet computers carried onboard light general aviation (GA) aircraft can extend NextGen capabilities at low cost, especially to legacy aircraft, thereby reducing aircraft equipage costs to utilize NextGen services. The versatility of modern personal computing devices has made them popular, affordable choices across all classes of aircraft allowing all aircraft, regardless of onboard installed system equipage, can take advantage of NextGen features. The term Electronic Flight Bag (EFB) used within this paper refers to the device that pilots can use to access AIS and MET data. See Figure 1.



Figure 1. Personal computing device used as an EFB, “The Window to NextGen Services”

1.0 AIRCRAFT ACCESS TO SWIM (AAtS)

System Wide Information Management (SWIM) is an advanced technology program designed to migrate the FAA's ground information technology (IT) systems into an integrated, service oriented architecture (SOA) accessible to users of the National Airspace System (NAS). SWIM is intended to facilitate the addition of new Air Traffic Management (ATM) services and increase common situational awareness among NAS users (reference 1).

The NextGen goal of collaboratively shared functionality and information is within the grasp of a fully enabled AAtS solution. SWIM, will incrementally be the information management infrastructure through which the NAS exchanges data. Airline Operation Center(s) (AOC), Flight Operation Center(s) (FOC) and other NAS users will be exchanging much of this data and more with stakeholders within the NAS using the SWIM network on the ground. This level of information sharing allows the decision makers of the operators to have precisely the same information as the NAS decision makers reducing confusion and increasing collaboration.

While interaction between the ground partners is important to achieving NextGen, true Collaborative Decision Making (CDM) is only realized when the aircraft in the “triangle” is included (Figure 2, Conceptual CDM using AAtS). With the flight deck included in the data exchange, CDM can achieve a more tactical exchange of information with all of the relevant decision makers (reference 2).

Aircraft Access to SWIM (AAtS) is the description, protocols and policies that instruct the particulars to connecting aircraft to the SWIM SOA platform. The FAA's planning for AAtS does not, at this time, include any intent to stipulate, acquire or build any specific data link to move SWIM data to the cockpit. Rather, provisioning for AAtS is done by the operator based on the operator's desired functional use. The physical layer that connects an aircraft to the network that is providing SWIM services is an output of the requirements that are derived from the desired use as specified in the relevant industry standards and guidance as it pertains to the use. The logical layers above the physical layer that enables the data communication will be derived and specified by the AAtS architecture (in devel-

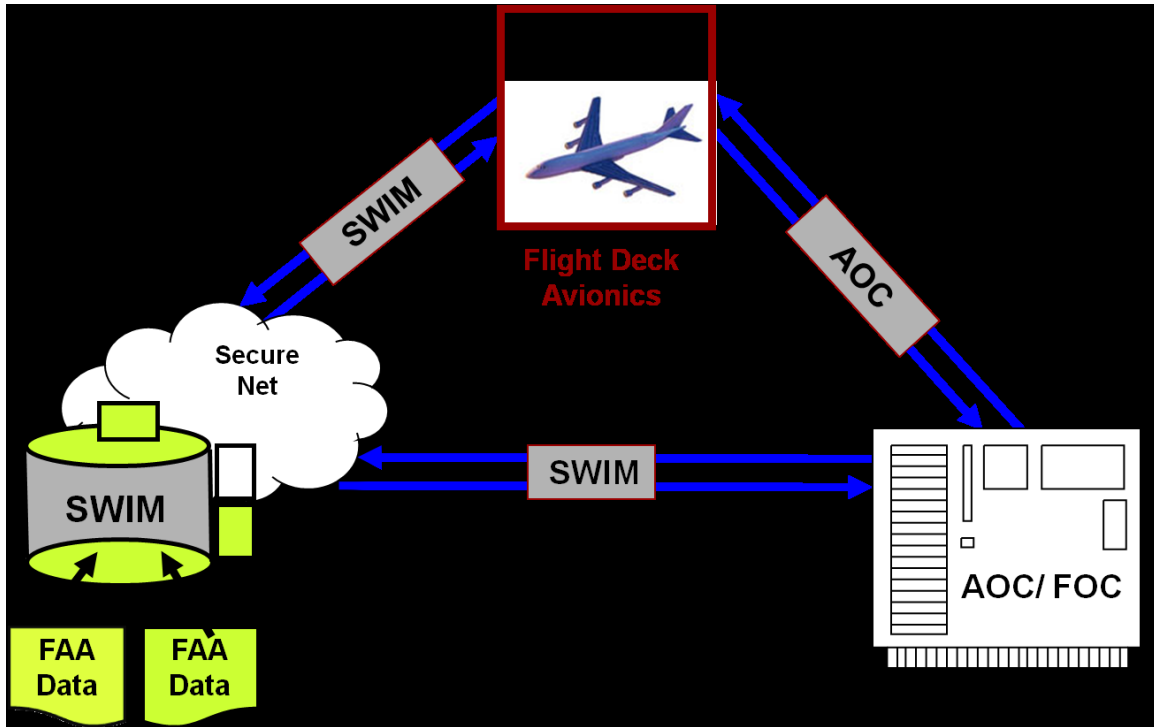


Figure 2. SWIM enables collaborative decision making (reference 2)

opment) and the individual implementations. An example of the physical layer includes AeroMACS (refer to paragraph 2.1.1) connectivity on the airport surface. Potential examples of in-flight AATS data links include satellite communications, EV-DO, and LDACS.

It is important to recognize that there are two paradigms for connecting aircraft to the SWIM SOA environment. One method involves the use of a proxy service and the other method is for the aircraft to be in full compliance with SWIM standards. In either condition, data could be bi-directional and is purely dependent on the individual implementation. Initially, any implementation for AATS will be in the form of the proxy service.

1.1 PROXY SERVICE

For the proxy method, a third party provider will act as a “go-between” between the aircraft and the SWIM infrastructure. In other words, the aircraft will exchange data with the third party provider using the third party provider’s operational approval methods and standards. The third party provider in turn will use the SWIM-enabled NAS services as a source to exchange data. The third party provider will pass information to and from the aircraft as follows:

- Unchanged—A simple pass-through where the data is merely moved through the third party provider in a transparent manner where there is no change in transport protocols
- Transformed—The SWIM-enabled data is “repackaged” into transport protocols to meet the third party provider proprietary protocols
- Value added—Proprietary commercially available information or data is added to the SWIM-enabled data as part of the third party provider service

Some important points for this method are:

- The aircraft itself will not be SWIM compliant under this concept
- A third party provider can take many forms: the operator, a commercial entity performing a data delivery service for the operator (e.g., an EWINS provider), an advisory broadcast service, etc.

1.2 EVOLUTION OF SWIM COMPLIANT AIRCRAFT

SWIM is not intended to be a single service that has a specific date of implementation. However, SWIM is envisioned as an iteratively evolutionary data exchange platform with new services

and capabilities and technologies introduced over time. AAtS will likewise be evolutionary. The idea of aircraft connecting directly into SWIM is that—an idea, how it would look, and when the final goal of AAtS is reached is still to be determined. This assumes that there could be an end goal in the evolution of the SWIM concept of AAtS. Aircraft SWIM SOA compliance may be required for certain NAS services depending upon the intended use or sensitivity of the data from a safety or regularity of flight standpoint. In this situation the aircraft and NAS Mission services are paired by the SWIM implementation of a SOA. This “pairing” is done through the loose coupling of services. In order for this to occur, the aircraft itself needs to meet all SWIM compliance measures detailed in the *SWIM Service Compliance Requirements* (reference 3). Types of compliance protocols and measures include, but are not limited to:

- Metadata formats
- Security
- Messaging protocols

At this time this data exchange environment for the aircraft is still largely undefined. Defining this data exchange environment is one of the goals of the AAtS effort.

Within the source data shown in Figure 3 within is the connectivity that SWIM would use to provide AIS and MET data link services to users. Users in this context include air traffic controllers, AOCs, and the aircraft itself, thus ensuring shared situational awareness. shows a possible conceptual view of these relationships. Supporting applications residing in the aircraft's EFB computing system would receive, process, and display the data. An example: Receipt and depiction of airport digital NOTAMs and Special Activity Airspace (SAA). In this context, these NOTAMs would come directly from the source, disseminated by SWIM, and delivered to the aircraft using an appropriate data link. The data would then be displayed to the pilot to enhance aircrew situational awareness as well as for compliance with the operating rules. The AIS and MET data services are described in RTCA DO-308 (reference 4).

1.3 AIRBORNE INFORMATION SERVICES (AIS)

- Baseline Synchronization Service (BSS)
 - Ground-provided service only

- Updates (via data link) the aeronautical information resident in onboard databases (e.g., by vendor part number)
- Breaks with the paradigm of the 28-day AIRAC cycle, as “Syncs” could be on demand and more frequent than every 28 days
- Requires considerable (broadband) data link capabilities, such as the 802.16-2009 link being specified by RTCA's SC-223, for airport surface use.
- Aeronautical Update Service (D-AUS)
 - Ground and airborne service
 - Provides permanent and temporary changes of aeronautical information via data link
 - Ground AUS updates prior to departure would reduce in-flight bandwidth loading requirements
 - Direct display of NOTAMS on electronic charts

1.4 MET SERVICES

- **Planning Service (D-WPDS)** (Supporting decisions greater than 20 minutes)
 - These are decisions where the pilot has time to deliberate, and perhaps discuss options with ATC/AOC services prior to taking action.
- **Near-term Service (D-WNDS)** (Supporting decisions between 3 and 20 minutes)
 - These decisions are of a planning nature; however, they have limited time for deliberation or coordination with ATC/AOC.
 - Can become more of a tactical decision when new information reveals a hazardous condition near the aircraft position.
- **Immediate Service (D-WIDS)** (Supporting decisions needed within a few seconds to 3 minutes)
 - Immediate decisions to avoid or mitigate an in-flight hazard. Generally unilateral decisions taken by the pilot with no collaboration.
- Requires ensured delivery of data

Not shown in Figure 2 or Figure 3 is the requirement for a baseline synchronization of current and up-to-date navigational data bases, en route charts, approach procedures, and a host of other data for the onboard EFB that can save paper and make situational awareness easier in the cockpit. Connectivity to these databases can be achieved via use of the AeroMACs network on the airport surface.

TFR or SAA airspace in real time could result in fewer airspace incursions. Another example would be Digital NOTAMS. If a lighting system at an airport became inoperative, the approach procedure is impacted. “Redlines” on the approach plate reflecting the new minimums resulting from the defective equipment would be displayed on the EFB. Also, all runway and taxiway NOTAMS would be displayed on the EFB in real

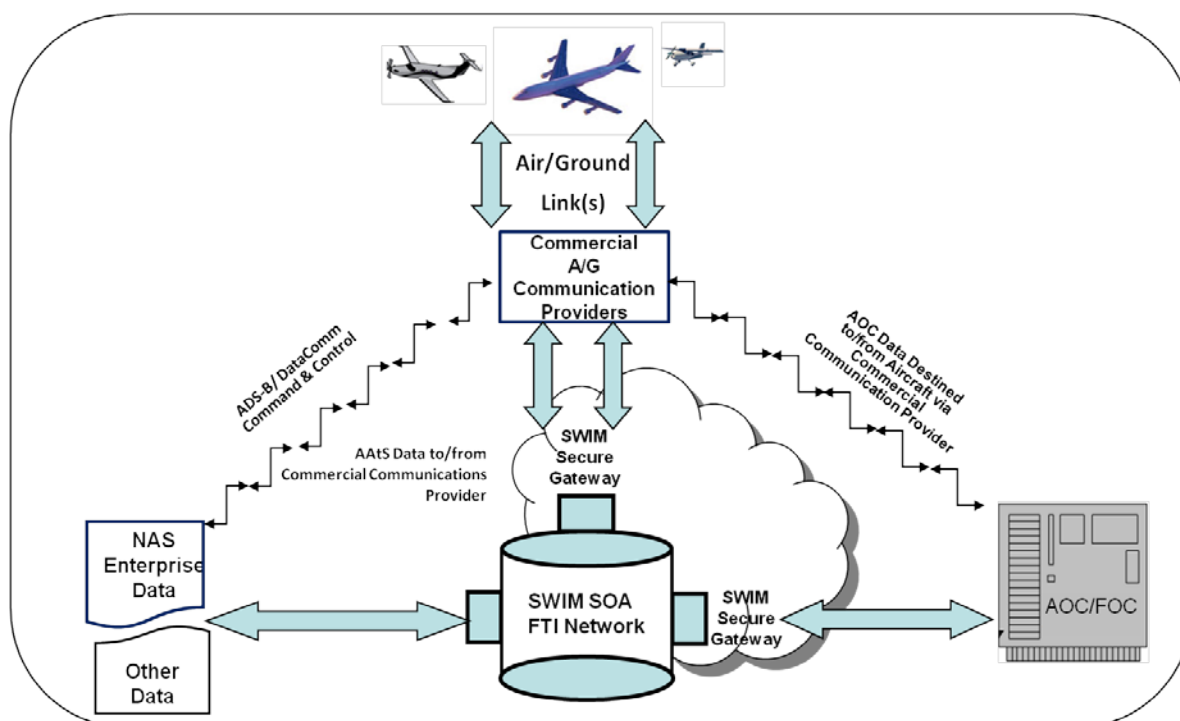


Figure 3. Notional AAtS Conceptual View

1.5 AIR TRAFFIC MANAGEMENT SERVICES

Flight crew trajectory negotiations within the SWIM application domain provide the capability for aircraft to collaborate with the Enterprise Services to share real time spatial information, identification, weather, security and operational status for all aircraft (reference1) to SWIM White Paper], providing the capability to enable real-time negotiation of four dimensional trajectory (4DT) between Air Navigational Services Providers (NASP) and aircraft.

An immediate opportunity to apply this functionality—in real-life—is real time display of SAA airspace, or airspace status. Currently, there is no way for the GA cockpit to display real time movements of Temporary Flight Restrictions (TFR) resulting from movement of VIPs. A graphical representation of the status of either a

time. A further example that would be meteorologically related would be Severe Weather Avoidance Program (SWAP) re-routings caused by adverse weather en route. In contrast with an airline that has dispatchers, GA does not. Enabling the GA aircraft access to the MET and SAA data sources enables GA pilots to work with ATC to identify appropriate alternate SWAP routes.

2.0 SWIM DATA DELIVERY VIA AAtS TO GA

SWIM or even AAtS does not specify the physical link that will connect the aircraft to the infrastructure supporting the aircraft. We prefer to state that the AAtS connectivity is radio agnostic, meaning that SWIM information could be carried by any means available that is authorized to interface to the NAS EA.

2.1 ON THE AERODROME SURFACE

GA aircraft currently use wireless connectivity on their smartphones to obtain their departure clearance. All updates to AIS/MET data are performed at home prior to arrival at the airport. Enabling real time updates to flight bag data, as well as relevant AIS/MET data prior to the flight over the airport surface wireless networks ensures that the flight crew has all relevant data prior to departure. Those GSM or CDMA smartphone devices will be capable of providing advisory information, however, they will not be able to utilize baseline synchronization services to ensure that the EFB has all current data.

2.1.1 THE AERODROME SURFACE AERONAUTICAL MOBILE AIRPORT COMMUNICATIONS SYSTEM (AEROMACS)

The FAA's Futurecomms Committee determined that to provide wireless communications on the airport surface, technology based upon the IEEE 802.16 2009 or mobile WiMAX would be adapted to the 5,092 MHz to 5,150 MHz frequency band previously dedicated to Microwave Landing System (MLS) services. RTCA Special Committee 223 was established in November of 2009 to adapt the WiMAX profile and generate the Minimum Operational Performance Specifications (MOPS). AeroMACS has been chosen by the FAA Futurecomms study along with EUROCAE as the international standard for mobile communications on the airport surface. Potential uses for AeroMACS (reference 5) include:

- **Connectivity to aircraft and support vehicles on the airport surface**—These include de-ice, baggage handling, tug, and any other vehicles that support the safety and regularity of flight. This application falls under the Aircraft Owner/Operator, Airport Authority functional domain.
- **Wireless connectivity to airport navigational aids and remote aviation services such as remote voice radios, maintenance feeds, etc.**—This application falls under the Airport Infrastructure functional domain.
- **Connectivity to aircraft owner/operator specific databases**—These could be maintenance related databases such as service

history records, aircraft performance data, along with access to databases supporting onboard systems as well as update services supporting various owners/operators personal EFB applications.

- Airport maintenance vehicles that provide maintenance services to the airport movement area—This falls into the airport authority functional domain.
- Access to the latest Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services.

The first document to be published by RTCA's SC-223 is the AeroMACS profile. This document adapts the current WiMAX profile documentation for use on airport surfaces, adjusts the operational frequency band to 5,000 MHz, identifies the spectral mask requirements, and ensures that all AeroMACS systems deployed at airports worldwide are compatible with each other. Connectivity to an aircraft departing in one country or location will thus have ensured connectivity at the destination country's airport. Prototypes of AeroMACS have been tested at locations including the NASA Glenn Research Center which confirmed profile settings in a real airport environment.

Connection to AeroMACS will be based upon an Internet Protocol (IP) based scheme. Each aircraft will have its own IP address. A common Authentication Authorization and Accounting (AAA) server will support authentication for the entire AeroMACS network. Secondary AAA servers can be located at lower levels at the application layers for subscribed services. The interface between the flight crew/pilot and AeroMACS can be via an EFB in a transport category aircraft or a personal computing device in a light general aircraft. Transport category aircraft would make use of a 5,000 MHz transceiver connected to an onboard server which would then forward the data to an appropriate display. General aviation aircraft could make use of a "dongle" which would then connect a portable electronic device utilizing hosted applications that provide EFB capability to the AeroMACS system. Already, Windows® based PCs and Apple® iPads® have been successfully connected to an AeroMACS network by the Harris Corporation using an external AeroMACS subscriber station.

As envisioned, AeroMACS would provide data link connectivity on the airport surface and would provide multiple services over the five functional domains, including (reference 5):

- Air Traffic Management/Air Traffic Control
- Aeronautical Information Services and Meteorological Data (AIS/MET),
- Aircraft Owner/Operator data
- Airport authority data, and finally
- Airport infrastructure data

It is the Air Traffic Management/Air Traffic Control sources that relate to Mission Services family of applications which is of special interest in this paper. Managed data is gathered to provide the GA pilot with appropriate meteorological and aeronautical data relevant to his flight, while SWIM services will provide ATC communications that supplement ATC clearances without directly affecting the trajectory of the aircraft.

2.2 IN-FLIGHT

AATs does not specify the methods that provide the physical connection between the aircraft and SWIM. Further in-flight uses for SWIM in the cockpit enable Collaborative Decision Making between the flight crew and ATC and AOC services in the following services to enable

- Aeronautical Information Services
 - Real-time SAA information, including real-time updates to charts, plates, and other navigational aids
- Meteorological Information Services
 - Severe Weather Avoidance Procedures that can assist the GA pilot by providing alternate trajectories to avoid weather events
- In flight trajectory negotiation required during flight to enable:
 - Optimum profile descents while merging into approach points in the terminal environments.
 - Parallel track negotiations
 - Sequencing negotiations
 - Re dispatch or diversion negotiations,

3.0 SWIM CAPABILITIES

The automation that SWIM provides to the flight crew reduces cockpit workload and enhances

safety by sharing CDM between the cockpit and ground services. (As defined by Figure 3.)

3.1 SWIM INTEGRATED APPLICATIONS —MADE POSSIBLE WITH PORTABLE COMPUTING DEVICES

An aircrew personal computing device utilized as an EFB that is provided with access to the same sources that the flight computational systems use would enable hosted applications on those portable computing devices/EFBs to perform intelligent decision support processing to supplement the trajectory clearances issued by ATC. In addition, the EFB could receive updated information on airport and SAA status, enabling increased airspace access that may be dynamically changing due to changes resulting from actual SAA usage. Notice that there will be a difference in the intended function of the data that is delivered from SWIM services, and the ATC trajectory clearances and instructions. ATC clearances are provided by the FAA's voice radio services, or in the future (for transport category aircraft) over Data Comm (CPDLC) Services using the NAS operated VHF radio system. SWIM derived data for situational awareness may arrive via another data link radio. This secondary data link could be either AeroMACs for airport surface communications, or another link that could be used en route. An application within an EFB that integrates data from the SWIM sources with the trajectory clearance negotiation could reduce cockpit workload.

Additionally, upon landing, a flight crew of a transport category aircraft could receive their taxi clearance as a text message over a VDL radio. From a human factors standpoint, it takes more work to read a clearance than to hear the taxi instructions in the flight crew headset. GA aircraft would likely continue to receive their taxi clearance over VHF voice. Nevertheless, if the EFB automatically were able to visually represent the taxi line to follow on an airport diagram as a result of receipt of the taxi clearance using SWIM services, the workload for the flight crew would be reduced, and the desired result of lower airport incursions and excursions could result.

3.2 SWIM CAPABILITIES EXPANDED TO GENERAL AVIATION

In an airline scenario, the integrated features that SWIM enables provide for integrated partici-

pation between the airlines dispatch function (AOC) and the aircrew. This participation is in all phases of flight, from gate-to-gate, and in support of flight trajectory negotiations based upon expected weather and aeronautical information such as SAA status. This integrated capability that SWIM coordination would provide between ATC and air transport category aircraft is well documented. Once the trajectory is agreed upon and the clearance is delivered via DataComm, automation enters the updated trajectory into the Flight Management System (FMS) of the aircraft, and the flight begins. In GA, there is no dispatch function.

What has not been documented to date are the capabilities that SWIM data could provide to legacy small GA aircraft that are NOT equipped with an FMS, and are likely to only fly under 14 CFR Part 91, or, at best, as a short-haul 14 CFR Part 135 operation. It is in this low-end case that an affordable display (especially for legacy GA aircraft) is needed. In large transport aircraft purchased new SWIM capable avionics is only a small percentage of the overall value of the aircraft; however, equipage cost to update legacy, smaller 14 CFR Part 23 GA aircraft could approach 100% of their hull value.

Figure 4 shows a possible GA interface architecture to any data link radio. As an example, the recently introduced portable SkyRadar receiver device provides Flight Information Services—

Broadcast (FIS-B) weather to an iPad®, and makes use of the above architecture. In this implementation, the data link radio connects to a wireless router which then connects to an iPad®. Full Internet accessibility to the iPad® is dependent upon which network that the data link radio has access to, and its authority to establish a connection.

There are many commercial software applications on the market today that can potentially provide similar functionality once connected to SWIM data in flight and on the airport surface. Among them are Wing-X by Hilton Software, ForeFlight, and FlightGuide. Each of these are popular among GA pilots. Several of these products provide AIS and MET products. If the GA data link radio is able to access a network that can establish a connection to Wing-X, for example, immediate downloads of SAA status and weather downloads are possible in real-time. Furthermore, applications could be developed or adapted to access SWIM enabling 4D negotiations prior to clearance delivery. It remains to be seen whether or not clearance void times could be issued via a 4G/LTE connection via a cell phone; however, LTE could be one possibility of a means to obtain the flight clearance from ATC at a *non-towered airport*. Of course upon landing, closure of an IFR flight plan could also be possible.

AATs or any data linking solution for higher than advisory use purposes requires digital sources

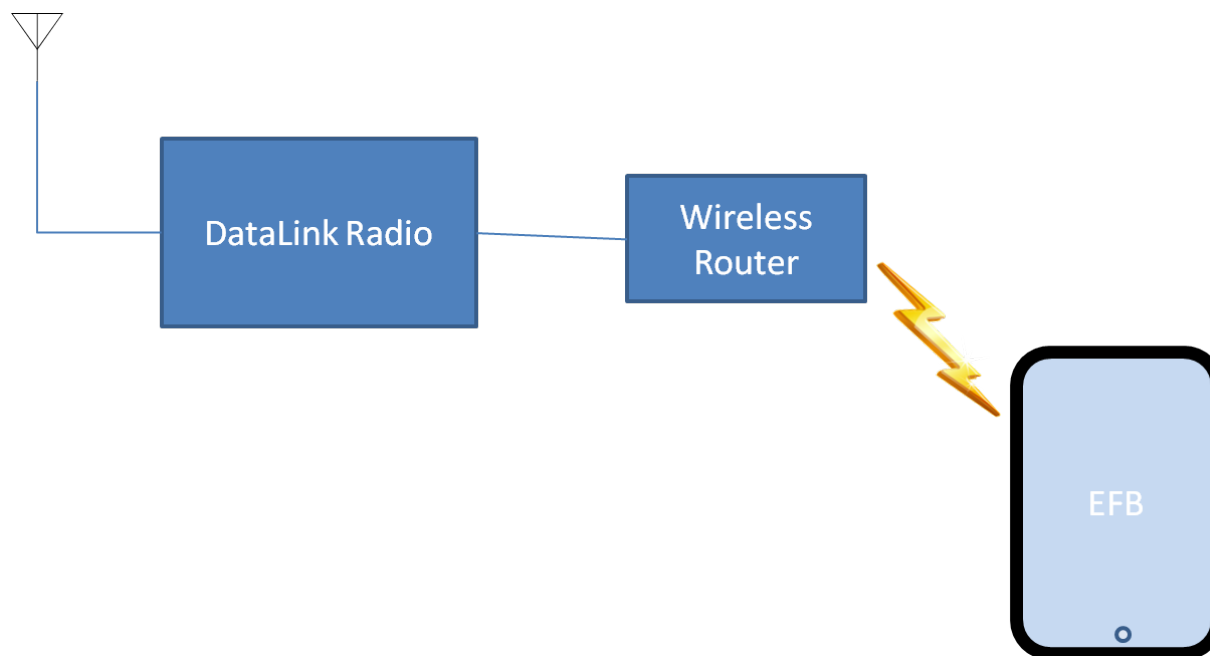


Figure 4. Notional GA EFB Interface Architecture

that are approved for operational use. This is important for two reasons:

- Status of SAA airspace displayed on the display must be valid or a pilot deviation is possible.
- Meteorological data that affects the aircraft's trajectory needs to be correlated with the ANSP Services that provide the automation that would modify the aircraft trajectory.

3.3 AIM—WHAT MAKES AAtS VIABLE?

For several years, FAA has been working to overhaul its outdated NOTAM system and bring it into the digital age. This effort has been assigned to FAA's Aeronautical Information Program. Intent is to develop source data that is

accurate, current, and XML-based. In the AIM vision, the data originator, rather than a third party, enters the data into a data base. Additions, changes, and deletions, are all made by the originating source. With the speed of the Internet, once the data is posted, it is posted for all to see and use. There are two major components to this effort: The FAA's Federal NOTAM System, and FAA's Aeronautical Common Services (ACS). The Federal NOTAM System is the initial umbrella effort that will provide digital services to users that will meet the FAA's criteria for Advisory-use services. The ACS effort (to be commissioned in several years) will provide data that meets higher design standards and thus can be used to meet functions that require higher certitude. AIM along with MET data will be sourced by SWIM.

4.0 CONCLUSION

This paper illustrates the potential that AAtS services have for general aviation. A method to access SWIM and NAS source information utilizing low-cost computing devices to display SWIM information shows that it is possible for legacy GA aircraft to access SWIM services without bearing a large equipage cost. Future data link sources such as AeroMACS and other airborne

links can be interfaced to all EFB devices through the use of either a dongle or media converting devices. Providing all aircrews with access to SWIM information will provide for automation in the GA cockpit, reducing the workload of a single pilot operation. The resulting Collaborative Decision Making (CDM) environment will improve aviation safety.

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