Enterprise Architecture Report for Airborne Wireless Networks

for

ICT 4010 Enterprise Architecture

Andrea Pudlo

University of Denver University College

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Faculty: Steven Else, Ph.D.

Executive Summary

Airborne Wireless Networks (AWN) is a developmental stage company with plans to change the way the world experiences broadband connectivity. Working from a 2001 patent it recently purchased, the company aims to use commercial aircraft as “mini-satellites” to create a high speed wireless mesh network known as the Infinitus Superhighway™ (AWN 2017). This paper discusses the following five architecture issues for AWN and recommended solutions to make their goal a reality: implementing its mesh network through establishing ground- and air-based partnerships while successfully completing operational testing; designing and developing the technology to make the microwave relay station equipment effective; incorporating sensors and network monitoring to gain valuable insight for network capacity planning purposes; creating an efficient and scalable information technology (IT) delivery model; and developing an effective customer relationship management (CRM) business process.

This paper recommends cost-effective solutions to help AWN reach its target architecture over the next year. First, the company must complete Phase I testing in March 2017 to pass the initial FAA certification process for the equipment. Second, the company must take steps to establish a Cloud Computing model to deliver the necessary IT services for the company to reach its strategic goals. This includes the need for a superior cloud-based CRM application with a self-service portal for customers. Additionally, AWN will need to continue to negotiate effective partnerships with backhaul networks as well as cruise ship companies and oil rig companies to create a complete mesh network to support the airborne portion. Finally, the company will need to finalize the hardware and software for Phase 2 testing in March 2018.

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Background

Airborne Wireless Networks (AWN) is a California-based aviation company that plans to provide worldwide broadband connectivity by using commercial aircraft as “mini-satellites” in a mesh network (AWN 2017). Each participating aircraft will act as an airborne repeater or router, sending and receiving broadband signals to create the Infinitus Superhighway™ (SEC Filing 2017). The company envisions their solution as filling the connectivity gap left by undersea cables, ground based fiber optics, and satellites which due to expenses and other disadvantages have not provided worldwide connectivity to date. As a wholesale carrier network, AWN’s primary customer-base will be worldwide data and communications service providers rather than end users. However, the increased level of connectivity around the world should enable telecommunications companies to start providing low cost, high speed services to rural areas, to island nations, to ships, and to oil rigs as well as a faster more reliable option for aircraft passengers and crew.

AWN is working from a patent issued in 2001 to Joseph Lai that it purchased in 2016. The patent discusses putting light weight, low power, and low cost microwave relay station equipment on commercial aircraft. Marius de Mos, the company’s Vice President of Technical Affairs and Development, was involved with the patent “from its conceptual stage” and felt the time was right to pursue the concept now that technology had caught up (Kjelgaard 2017). With the skies filled with aircraft day and night over land and water, AWN envisions a truly worldwide web of connectivity possible with no single point of failure unlike those found in traditional networks consisting of cell towers and satellite systems. This type of network will offer greater reliability, throughput, and nearly 100% real-time performance (AWN 2017).

As a startup in the design and development stage of its product, AWN is taking a minimalist approach in the organization of the company. Currently, there are only six employees (SEC Filing 2017). The company has chosen to outsource basic functions like the design and maintenance of its website as well as its public relations. Additionally, AWN has retained the services of companies with expertise not only in the FAA certification process but also in the design of onboard equipment rather than choosing to rely solely on company employees. Figure 1 in the Appendix shows the initial organization of the company and its six employees with an Actor/Role Matrix.

Identification of Major Architecture Issues

Implementation

- The company plans to implement a mesh network consisting of ground stations and commercial aircraft to deliver worldwide broadband connectivity.

Technology

- The company must design and develop the microwave relay station equipment for onboard the aircraft and at ground stations.

Data, Information, and Knowledge

- The company plans to use network traffic monitoring and analysis measurements as well as sensors on the equipment to gain insight to network traffic characteristics for capacity planning purposes.
- The company needs an appropriate delivery model for IT services.

Business Process

- The company needs to establish a Customer Relationship Management business process with a single shared view of the customer base.

Analysis of Architecture Issues

As a startup company in the developmental stage of its unique product—aircraft-supplied broadband connectivity, AWN faces a broad array of challenges. This paper will discuss architecture issues in the areas of Implementation, Technology, Data, Information, and Knowledge, and Business Process. For each architecture issue area, the paper will give first an overview of the how the issue affects AWN. Then it will describe the base architecture, or where the company currently stands. Next, the paper will discuss where the company wants to end up with its target architecture. Finally, the analysis section for the specific architecture issue will conclude by identifying the gaps in capabilities the company faces in transitioning. In the next section, the paper will go on to provide recommended solutions, detailing why alternate paths are not the best choice for this company. This will be followed by a high level roadmap with a timeline for the transition to the target architecture. In order to realize their vision of an airborne mesh network providing worldwide broadband connectivity, AWN will need to consider each of the issues presented in this paper and consider its transitional approach with the solutions provided. Figure 2 in the Appendix gives an overview of all the company's high level goals as they relate to the architecture issues presented in the paper.

Implementation

AWN envisions creating an airborne mesh network to provide worldwide broadband connectivity. A mesh network is one in which all nodes cooperate to distribute data across the network reconfiguring around any broken paths with self-healing algorithms. The company plans to create this type of network by using commercial aircraft as repeaters or routers to send and receive broadband signals from one aircraft to the next to create a "digital

superhighway in the sky" (AWN 2017). AWN intends to incorporate ground stations to fill gaps in aircraft coverage in order to complete the mesh network.

Base Architecture

In order to create its mesh network, AWN is currently working on establishing partnerships to form the basis for both the ground and air portion of its network. AWN signed a deal with Electric Lightwave Holding on December 27, 2016 for that company to serve as the ground link for AWN's mesh network (Kjelgaard 2017). Electric Lightwave Holding operates 12,500 miles of fiber optics cable network in the Western United States and has an undersea cable to Hawaii. As the first step toward getting the microwave relay station equipment on commercial aircraft, AWN partnered with Air Lease Corporation (ALC) in January 2017. ALC is an aircraft leasing company which purchases aircraft from their manufacturers and leases them to over 200 airlines across 70 countries (ALC 2015). With its large network of international airline customers, ALC will serve as AWN's exclusive marketing agent (Get Connected 2017).

With both of these partnerships in place, AWN plans to test the mesh network concept in March of 2017 as part of the FAA certification process. The company leased three 757-223s from Jet Midwest Group to conduct test flights from Roswell, New Mexico to Kansas City, Missouri equipping the planes "with external top- and bottom-mounted directional antennas and internal electronics" (Croft 2016). If initial testing is successful, AWN plans to apply for a Supplemental Type Certificate for a second type of aircraft to begin the next phase of testing in 2018 on 20 commercial aircraft of an unspecified type with an unannounced North American carrier they have signed a partnership with (Kjelgaard 2017).

Target Architecture

In the short term, AWN's target architecture is to get the mesh network up and running in the United States to prove its feasibility. The company must successfully complete the FAA certification testing for both Phase I and Phase 2. Additionally, AWN wants to have approximately 200 ground stations across the United States (Croft 2016). Of the approximately 7,000 aircraft in flight at any given time in the United States, AWN wants to have their equipment in at least 2,000 aircraft to have a fully redundant mesh network (AWN 2016; NATCA 2015).

AWN's long term target architecture is to provide worldwide connectivity through its mesh network. This will entail the need for ground stations and backhaul networks around the world. Eventually, the company would like to see the world's 27,000 active commercial aircraft with AWN's equipment as well as new aircraft pre-wired to work with their equipment (PRNewswire 2016).

Gap Analysis

In order to realize the target architecture from where the company currently stands in the base architecture, a gap analysis identified the following necessary capabilities, as shown also in the Appendix in Figure 3:

- The company must establish the viability of the technology through successful testing.
- The company must either expand on its current partnership with the ground station/backhaul provider or establish new partnerships.
- The company needs to sign deals to put equipment on commercial aircraft.

- The company must establish partnerships with aircraft manufacturers to have new aircraft pre-wired for AWN's equipment.
- The company must fill the gap in coverage caused by fewer aircraft flying at night and over water.

Technology

AWN must determine the design of the microwave relay station equipment it plans to put on aircraft and at ground stations to make its mesh network a reality. In order to do this, the company must consider the size and weight of the equipment as well as whether it will begin with commercial off the shelf hardware or build its own. It will also need to determine the frequency band the equipment will operate on. Finally, the company will have to consider the software needed to get the equipment operational, such as the routing scheme, necessary protocols, and self-healing algorithms for any breaks in the mesh network. These will be necessary not only for equipment that malfunctions on aircraft but also because radio signals in the microwave frequency can be susceptible to adverse weather conditions such as heavy rainfall.

Base Architecture

Currently, AWN is working from the United States patent issued to Joseph Lai in 2001 for "Broadband Wireless Communication Systems Provided by Commercial Airlines." The company purchased the patent in August of 2016. The patent discusses the invention of "small, lightweight low power, low cost microwave relay station equipment" to put on commercial aircraft in order to form a "chain of seamless airborne repeaters" to provide broadband wireless connectivity (United States Patent 2001). AWN signed on with Aero Certification and

Engineering LLC, a Federal Aviation Administration (FAA) Designated Engineering Representative and Designated Airworthiness Representative services company, to help the company with the FAA certification process to include reviewing and approving all testing procedures for environmental and flight safety concerns (SEC Filing 2017). The company has also secured the services of Concept Development Inc. (CDI), a leading aerospace engineering design and manufacturing firm, to help define the onboard system from the design to the manufacturing of it as well as to provide software development support (Accesswire 2016). On October 31, 2016, AWN applied for and then received on November 28, 2016 a supplemental type certificate (STC) for the installation of its microwave transceiver equipment on the Boeing 757-200 based on the condition that the equipment would not interfere with existing aircraft systems (Kjelgaard 2017).

Target Architecture

AWN envisions that the technology for the microwave relay station equipment will need to exploit the specific characteristics of the aeronautical mesh network the company wants to create between the commercial aircraft flying between 20,000 to 40,000 feet and the ground control stations filling gaps in coverage. This equipment needs to be ready for initial testing in March 2017 which was discussed in the Implementation section previously. The network needs to be self-healing. It will ensure continuous connections by reconfiguring itself around any nodes that break down or weather that interferes, for instance. The technology in the system needs to perform load balancing and be aware of congestion at any particular nodes in order to create the maximum amount of throughput while providing for quality of service. The equipment must also take into account signal propagation rules, transmission power, signal

fadeout, and line of sight considerations for the frequency band used. Based on a cruising altitude of 40,000 feet and the curvature of the earth, Marius de Mos, Vice President of Technical Affairs and Development for AWN, indicated the microwave signal could reach 240 miles in one direction from an aircraft (AWN 2016). AWN also plans to work on the certification process for additional STCs from the FAA. These will be for the world's more common commercial aircraft types in order to enable the company to put the equipment on aircraft worldwide such as the Boeing 737 and 787 and the Airbus A320/21 series (PRNewswire 2016a).

Gap Analysis

In order to reach this target architecture from the company's current base architecture, a gap analysis identified the following necessary capabilities, as shown also in the Appendix in Figure 3:

- The company needs to determine the type of hardware for the microwave relay station equipment to include types of antennas.
- The company needs to determine the frequency spectrum allocation.
- The company must determine the software for the equipment to include routing scheme, protocols, and algorithms.
- The company will need to apply for STCs for additional common commercial aircraft.
- The company wants to be ready for Phase I testing by March 2017.

Data, Information, and Knowledge

In the architecture area of Data, Information, and Knowledge, AWN has two large issues to consider while moving the company from the planning and development stages into the operational stage. The first issue revolves around collecting useful data from the equipment the

company will be putting onboard aircraft and at ground stations. With the Internet of Things making machine to machine communication possible, AWN will be able to put sensors on all the equipment at the various air and ground nodes providing the company with an invaluable and immense amount of data. In addition to this, network traffic monitoring and analysis measurements can provide valuable insight to network traffic characteristics for capacity planning purposes. The second issue concerns the information technology (IT) delivery model structure of the company. AWN needs to establish an appropriate and cost-effective means of doing business. This involves decisions over hardware, software, and data storage requirements.

Issue 1 Equipment Data Collection: Base Architecture

Currently AWN is in the process of designing the microwave relay station equipment that will go onboard aircraft and at ground stations to establish its mesh broadband network. The equipment will include antennas, transmitters, receivers, and routers. All of this equipment provides opportunities for data collection with the addition of sensors to collect such information as location, altitude, velocity, acceleration, vibrations, and temperature. These sensors can give greater visibility into a device's condition as well as provide opportunities for remotely controlling that device. Additionally, routers in the network can collect information from packets traveling the network concerning delay, loss, and bandwidth—measurements that can provide network traffic characteristics to aid in capacity planning and traffic engineering for the network (Moon and Roscoe 2001).

Issue 1 Equipment Data Collection: Target Architecture

AWN wants to use the data collected via its broadband connectivity equipment and the sensors on that equipment, both in the air and at the ground stations, to better understand network usage and equipment requirements. The company will use both data gathered from routing equipment and data from sensors integrated into its microwave relay equipment. This information gathered from routing equipment will help the company in future capacity planning operations. Additionally, by incorporating sensors into the design of the equipment, AWN will be able to gather information about the condition of its equipment—specifically the airborne equipment that the company will not always have immediate access to. Because that equipment will be out of AWN employee sight for a majority of the time, it is crucial to include sensors that can evaluate the condition of the equipment. Sensors to indicate the location, altitude, velocity, acceleration, vibrations, and temperature of the equipment will give AWN the ability to make decisions regarding the needs of the equipment. The amount of data collected could be as much as terabytes per day (Moon and Roscoe 2001). This data will need to be captured, stored, and analyzed in real-time. AWN wants a data management and storage capability to support this target architecture.

Issue 1 Equipment Data Collection: Gap Analysis

In order to make this target architecture a reality when starting from the company's current base architecture, a gap analysis identified the following necessary capabilities, as shown also in the Appendix in Figure 3:

- The company must determine the best sensors to use to collect the right kind of data.

- The company must obtain big data software appropriate for the size, scope, and analysis of the collected data.

Issue 2 Delivery Model for IT Services: Base Architecture

AWN currently has a small footprint in terms of employees and operations. The company has a service agreement with IRTH Communications to provide general corporate communications and investor relations services such as public relations, Internet development, and other communication services (SEC Filing 2017). The website includes basic information about the planned mesh network and its advantages, about the management, partners, and investors of the company, and about the patented technology behind the mesh network concept. The contact information on the website takes interested parties to an IRTH Communications representative. There is no real IT department or infrastructure in place for IT services.

Issue 2 Delivery Model for IT Services: Target Architecture

As AWN moves into the testing and operational phases of its mesh network concept, the company wants to have a more efficient delivery model for IT services. AWN envisions a flexible, scalable, and reliable infrastructure to help the company save time and money in order to allow the small number of employees currently in the company to focus on operational issues. To run IT services, the company plans to hire at least one IT specialist in the initial stage of developing the IT infrastructure. Additionally, the top executives want the ability to work from anywhere as they travel to make new business deals. The target architecture must be highly available and secure without any large, upfront capital expenditures. In order to work

with its network management concerns, the platform should include a high-performance Data Warehouse management and storage optimization capability.

Issue 2 Delivery Model for IT Services: Gap Analysis

To get to the target architecture from the current base architecture, the gap analysis identified the following necessary capabilities in the IT delivery model, as shown also in the Appendix in Figure 3:

- The company wants the ability to work and collaborate from anywhere.
- The company needs a data warehouse storage and management product.
- The company wants a scalable, reliable, and secure infrastructure.
- The company needs to hire an IT specialist.
- The company wants few upfront capital expenditures.

Business Process

AWN understands that a vital element of their company needs to be ease of customer experience—both for the customers themselves and for the representatives helping those customers. Thus the company is looking for a strategy to manage its customer relationships and interactions that allows for seamless connections and streamlined processes with a one-stop format. With this strategy, management wants to develop a business process that allows customers the ability to have self-service access to their accounts via the Internet so they can complete transactions whenever and wherever they want. A customer self-service portal holds incredible business value by cutting customer service costs and increasing productivity through the ease of the business process.

Base Architecture

AWN's website is currently set up to introduce potential clients to the concept of an airborne mesh network. Aside from basic information about the company's vision, management, and technology, there is only a simple option set up to contact the company for more information. Currently, that link directs interested people to an IRTH Communications representative via an email address. There is no infrastructure on the website for customers to log in, manage their services, or communicate concerns with a representative. Because the company is still in the product development stage, management has not developed this business process yet.

Target Architecture

The target architecture should realize the vision of customer relationship management (CRM) with a single shared view of the customer base, compiling information on customers from multiple channels. These channels could include the company's website, telephone contact, live chat, direct mailings, marketing materials used to promote the product, and even social media. The CRM application can centrally manage customer data in such a way that makes it easier for AWN staff to coordinate the sale of services, service process fulfillment, billing, and customer support requests. The architecture should include a customizable dashboard that will include not only the customer's history with the company, but also monitor the status of orders, and track any customer service issues with the necessary follow up communications. The software should include features which automate repetitive tasks to streamline customer service representative duties as well as prevent duplicate efforts.

In combination with its CRM software, AWN wants to have an easy-to-use customer self-service portal. A self-service portal is a capability that offers customers the ability to do a variety of self-help functions accessible through the company's website. This portal will enable customers to securely create a username and password, update account information, manage their services, and pay their bills. The architecture of the portal will also include functions that allow for an immediate chat session during business hours with a representative or enable the customer to email their customer service representative for later attention. Another side capability of the self-service portal will be to provide collaborative spaces for customer to customer relationship building. This format allows customers to potentially resolve issues more quickly without the necessity of contacting a customer service representative. Additionally, AWN wants customers to be able to access the web portal from any device from desktop computers to tablets and mobile phones. Finally, because AWN wants to maintain its small organizational footprint, the solution for this architecture issue should be one that involves ease of set up and maintenance. See Figure 4 in the Appendix for a model of this business process.

Gap Analysis

In order to get to the target architecture from the current base architecture, the gap analysis identified the following necessary capabilities, as shown also in the Appendix in Figure 3:

- The company needs to acquire the appropriate CRM software.
- The CRM application needs to include self-service portal capabilities.

- The company wants customers to have the ability to use the software solution from any device.

Recommended Solutions

Implementation Solution

In order to realize its vision of the Infinitus Superhighway™, providing worldwide broadband connectivity through a mesh network of commercial aircraft and ground stations, AWN needs to accomplish several things. First, AWN needs to ensure the technology works. Phase 1 testing with three aircraft is scheduled for March 2017 while Phase 2 tests with approximately 20 aircraft are scheduled for early 2018. Once this is accomplished, AWN can continue to use its partnership with ALC to market its product to international airlines as well as to aircraft manufacturers like Boeing and Airbus to pre-wire aircraft for their equipment.

For the ground stations and backhaul networks, it will be most cost-effective for AWN to establish partnerships with established telecommunications providers rather than building this portion of the mesh network from the ground up. AWN should capitalize on its existing partnership with Electric Lightwave Holding to expand its ground network. Zayo Group Holdings Inc. recently purchased Electric Lightwave (Zayo 2017). Zayo is a global communications infrastructure services provider with a 114,500-mile network throughout North America and Europe. The company has an all-fiber backbone with connectivity to the wireless towers that AWN needs to complete the ground portion of its mesh network. In moving beyond North America and Europe, AWN could consider a partnership with CenturyLink, a global communications company with a 300,000-route-mile international transport network extending from the United States and Europe into Asia and down to Australia (CenturyLink 2017).

To fill gaps in the mesh network coverage that could arise due to less air travel at night as well as over the world's oceans, AWN will need to look into other carriers for its broadband equipment. For instance, the company could ensure an extended coverage area by putting the microwave relay station equipment on cruise ships, oil rigs, tankers, and cargo aircraft. Carnival Cruise Line and Royal Caribbean International are the two largest companies in terms of number of cruise ships, but AWN will also need to consider other cruise lines like Norwegian in order to get into international waters further afield than the United States, the Caribbean, and Europe. In terms of getting equipment on oil rigs, AWN would be best served by looking into Baker Hughes and Schlumberger as these companies are two of the biggest in the business. Baker Hughes has 933 international oil rigs, 741 oil rigs in United States waters, and 352 oil rigs in Canadian waters (Baker Hughes 2017). Schlumberger has a presence in over 85 countries (Technavio 2014). As for cargo aircraft, AWN needs to consider partnering with UPS and FedEx. Both companies fly to over 220 countries with hundreds of aircraft that would increase not only the range of AWN's mesh network but the time coverage since many of these cargo flights are overnight (FedEx 2017; UPS 2017). Together, all of these companies could minimize any gaps in coverage and help to extend AWN's planned mesh network.

Technology Solution

AWN has a short timeline to testing their microwave relay station equipment. Using commercial off the shelf (COTS) equipment offers the company advantages such as a shorter development time, reduced costs, and access to state of the art technology at competitive prices (Julian, Lucy, and Farr 2011). AWN may face certain challenges with the compatibility of different products, but there are many choices available on the market. Many COTS products

that have been in use for some time have already been tested and used extensively enough to have proven their value as well as solved any versatility issues.

AWN's microwave relay station equipment will most likely need to operate in the Ku band (AWN 2016). This portion of the frequency spectrum, from 12-18 GHz, is primarily used for satellite communications. This relatively high frequency has a shorter wavelength than lower frequencies used in communications thereby allowing for smaller antennas. However, heavy rain fall can degrade signal strength in this range. Additionally, microwave signals operate on line of sight. AWN will need to ensure enough aircraft have their equipment operational to provide a fully meshed network with plenty of redundancies. Because commercial aircraft fly lower than Low Earth Orbit satellites, there is greater potential for reuse of the spectrum with minimal interference issues. AWN executives will need to coordinate with the FAA and the FCC to determine the frequency spectrum to use.

AWN will want to use highly directional antennas potentially in the form of electronically steerable antennas. Highly directional antennas transmit more power in the direction of the receiver which increases the signal strength. Medina et al. (2012, 1232) describe how highly directional smart antennas give the capability to quickly change the direction in which they transmit and receive while "optimiz[ing] the signal-to-interference ratio at the receiver." Chang and Hu (2012, 2233) describe a "smart antenna" as an antenna array that has a complex signal processing algorithm and that allows for adjustments to beam pattern to emphasize signals of interest while minimizing interfering signals. The high level of directivity allows for a high amount of spatial isolation between links. This results in a greater amount of spatial reuse, and thus channel capacity, in the network. IMST, a communications company

based in Germany but with offices in the United States, offers a phased array architecture for the Ku band with partially mechanical and electronically steerable systems (IMST n.d.).

Cain, Billhartz, and Foore (2003, 643) note that the communication between numerous aircraft and ground nodes with directional antennas to support "highly variable traffic exchanges" in a dynamic network requires a link scheduler consisting of algorithms, protocols, and software that "adaptively schedule" the connections among the antennas. Medina et al. (2012, 14) introduce the Geographic Load Share Routing scheme which can react quickly to variations in traffic demand and link capacity to fully utilize the throughput in an air-to-ground mesh network by using the following strategies:

- A forwarding strategy: uses "position and buffer size information local to the forwarding node"
- A handover strategy: enables the network to control which aircraft are associated with which ground station based on geographic proximity and congestion at the ground station

Using this routing scheme in combination with the highly directional antennas allowing for greater spatial reuse allows the network to achieve a much greater throughput.

Data, Information, and Knowledge Issue 1 Solution

Using large data sets to discover previously unknown correlations and patterns in business information is known as big data analytics. Getting the right information from a large number of sources and analyzing it quickly can be vital to businesses trying to obtain a competitive edge. Thus it is incredibly important to use the right tools to analyze the data in order to find the business value quickly and accurately. AWN will be pooling data from sensors

on its microwave base station relay equipment. Additionally, through using network traffic monitoring and analysis (NTMA) equipment, the company could be gathering several terabytes of data a day that could provide valuable insights to network usage (Moon and Roscoe 2001).

The data gathered from network monitoring is not only large in amount, but it comes in the form of high speed streams that contain many different types of measurements from different kinds of logging systems. For network monitoring applications that collect what Bär et al. (2014, 165) term "rolling data analysis," or situations where results are "periodically and incrementally updated," the authors recommend DBStream. DBStream is an easy to use Data Stream Warehouse designed specifically for, although not limited to, storing, processing, and analyzing data streams coming from NTMA applications. NoSQL systems like Hadoop and MapReduce are also frameworks meant to process and store large amounts of data. However, these systems focus on processing data in large batches rather than the continuous streaming approach offered by DBStream. Baer et al. (2016, 16) detail how their experiments using DBStream with different NTMA applications gained them "useful insights on how to improve the system to offer increased performance and higher flexibility."

DBStream is an excellent solution for AWN because the software can also monitor machine to machine (M2M) communications from sensors on the equipment AWN will be using. Baer et al. (2016) discuss a project with the M2M Traffic Classification, or MTRAC, application in conjunction with DBStream to discover M2M devices and apply machine learning algorithms to gain valuable information from sensors. For instance, AWN will be able to use sensors to determine if equipment needs maintenance, possibly even predicting failures before they occur to allow for preventative action.

Data, Information, and Knowledge Issue 2 Solution

Cloud computing offers AWN an efficient business solution with minimal upfront capital expenditures. It is an IT delivery model that enables convenient, flexible, and scalable network access to a shared pool of computer resources. As needs change, cloud computing offers the ability to reconfigure resources with minimal management effort from AWN's employees. Of the three main cloud computing options—a public cloud, a private cloud, and a hybrid option (mix of public and private)—the public cloud is the best solution for AWN.

With a public cloud infrastructure, an organization sells cloud services to the general public or to companies who pay on a per-usage basis. A public cloud offers AWN the following advantages: data availability, on demand scalability, the technical expertise of the cloud provider's IT staff, and an easy and relatively less expensive startup process. However, as one of the biggest issues with public cloud computing is the security, AWN will need to negotiate service agreements for specific security and privacy concerns (Goyal 2014). A private cloud option gives an organization greater control over its resources thus allowing for better control over security options. However, the private cloud option does not meet AWN's needs due to the high upfront cost of purchasing equipment, software, and staff to support it. A hybrid cloud also does not meet AWN's target architecture because of the need for a private cloud on premise even though it does offer the reduced cost and scalability benefits through the public cloud portion of the deployment model.

Of the public cloud providers, Synergy Research Group (2016) noted that Amazon Web Services (AWS) had the highest market share in January of 2016 at 31% as well as the fastest growth rate in terms of "raw dollars" over rivals Microsoft and Google. Additionally, AWS is the

only public cloud provider of Synergy's top five (AWS, Microsoft, IBM, Google, and Salesforce) to offer the open source relational database PostgreSQL (AWS 2017). This is important for AWN because DBStream, the solution discussed for the company's data warehouse needs, is built on the PostgreSQL database (Bär et al. 2014). Finally, AWS meets AWN's other cloud deployment needs with a range of competitively priced product solutions. AWS also offers various support plans depending on the needs of the company at any given time.

Business Process Solution

Because AWN wants a CRM solution that is easy to set up and maintain, choosing a cloud option is their best alternative. The industry has consistently rated Salesforce.com as having the best CRM software year after year (Salesforce.com n.d.). The CRM solution offered by Salesforce is in-line with the infrastructure that AWN desires in both its customer solution and its IT delivery model solution discussed in the Data, Information, and Knowledge section. Salesforce offers a quick deployment capability, automatic software updates, cost-effectiveness, scalability, and the ability to work from any device. Salesforce also offers an artificial intelligence (AI) capability built into the core of its CRM platform which enables employees to build and use apps that "get smarter with every interaction" (Salesforce.com 2016). The AI capability pools information from the CRM database, email, calendars, social media, and other sources to deliver predictions, recommendations, and also to automate tasks. AWN will also be able to customize the functions in the CRM software to ensure that it meets the exact needs of the company. Although the Data, Information, and Knowledge Issue 2 Solution recommended AWS for the rest of AWN's IT delivery model needs, AWS does not offer any product solutions which meet the needs of AWN's desired CRM service.

Conclusion

AWN is on the cusp of offering a breakthrough product that could potentially change the way the world experiences broadband connectivity. As a startup not quite ready to offer that product yet, the company needs to iron out some basic infrastructure needs of its day-to-day operations in order to ensure its success. This paper has identified five major architecture issues associated with the successful launch of AWN's Infinitus Superhighway™. The issues involved the implementation of the company's mesh network, the technology of its microwave relay station equipment, the ability to collect data both from and about the equipment, the delivery of the company's IT services, and the business processes involved in the way forward with a CRM solution. See Figure 5, an Events Matrix, in the Appendix for an overview of the big picture events discussed in the paper, the processes triggered, and the business results. By adhering to the recommendations in the solutions section of this paper and the work packages in the Architecture Roadmap, AWN has a solid way forward to achieve its vision of creating an "airborne digital superhighway providing worldwide broadband connectivity using commercial aircraft" (AWN 2017). In proceeding with the next steps in developing the company, AWN executives need to ensure they create a solid foundation with an IT infrastructure that can pave the way for achieving all the company's strategic goals. In only a few years, this company may be part of the solution that truly brings the Internet to every corner of the world. In the meantime, the company's leadership needs to ensure testing goes smoothly, that they deal with equipment hardware and software issues, and that they make crucial partnerships that will pave the way forward for the business.

High Level Architecture Roadmap

Phase I Testing Work Package due March 2017

- The objective is to complete Phase I testing of the microwave relay station equipment both on the aircraft and on the ground.
- This work package is dependent upon finalizing the design of both the hardware and software included in the equipment.
- The measure of effectiveness will be passing the FAA certification process.
- The business value of this stage will be proving the operational concept of the product in order to market it more effectively to airlines and aircraft manufacturers.

IT Infrastructure Work Package due May 2017

- The objective is to set up a cloud computing IT infrastructure for AWN employees.
- This work package will require hiring an IT employee to manage the cloud setup with the contracted company.
- The measure of effectiveness will be during employee use of the new cloud applications both at the home office and during business travel.
- The business value of this stage will be aligning the IT infrastructure with AWN's business strategy to make both more effective.

CRM Work Package due July 2017

- The objective of this work package is to set up a cloud CRM solution that includes a customer self-service portal.
- This work package is dependent upon aligning the CRM solution with the current cloud infrastructure of the company.

- The measure of effectiveness will be ease of access for both AWN employees and customers to the portal.
- The business value of this stage will be in streamlining customer concerns, making these business processes more effective and efficient.

Mesh Network Partnerships Work Package due November 2017

- The objective of this work package is to secure ground node partnerships for the rest of the United States as well as cruise ship and oil rig coverage partnerships.
- This package is dependent upon determining mutually beneficial arrangements with numerous other companies.
- The measure of effectiveness will be ensuring the goal of 200 ground stations is completed as well as over water coverage departing the United States from both coasts.
- The business value of this stage is that the AWN mesh network will cover the entire United States when marketing this concept to airlines and aircraft manufacturers.

Phase 2 Testing Work Package due March 2018

- The objective is to complete Phase 2 testing of the microwave relay station equipment both on the aircraft and on the ground with a larger number of aircraft. Testing will also include M2M sensors on the equipment.
- This work package is dependent upon getting additional STCs approved through the FAA. It is also dependent upon finalizing the software issues with the sensors, the networking equipment, and collecting the data for analyzing through the cloud based data warehouse solution.

- The measure of effectiveness will be passing the FAA certification process and ensuring the sensors and equipment work smoothly with the cloud software.
- The business value of this stage will be proving the operational concept of the product on a larger scale in order to market it more effectively to airlines and aircraft manufacturers.

Appendix

Actor / Role Matrix

R = Responsible for carrying out the role A = Accountable for actors carrying out the role C = Consulted in carrying out the role I = Informed in carrying out the role	Office of CEO CEO	Business Development and Compliance Vice President	Industry Relations Vice President	Technical Affairs and Development Vice President	Human Relations	Information Technology	External Partnerships
Base Architecture							
Negotiating Relationships with Key Companies	R	I	A	I	I		I
Managing Compliance Issues with FAA, FCC, etc	I	R		C			A
Managing Technical Design Specifications	I	C		R			A
Establishing Marketing Strategy and Networking Contacts	I		R		I		A
Target Architecture							
Coordinating Equipment Testing Process	I	R	I	A		C	I
Managing Software Development Support and Upgrades	I	I		R		C	A
Managing M2M Sensor Process		I		C		R	A
Coordinating with Cloud Provider					I	R	

* As of November 30, 2016, AWN had only 6 employees (SEC Filing 2017).

Figure 1. Actor / Role Matrix for Airborne Wireless Networks.

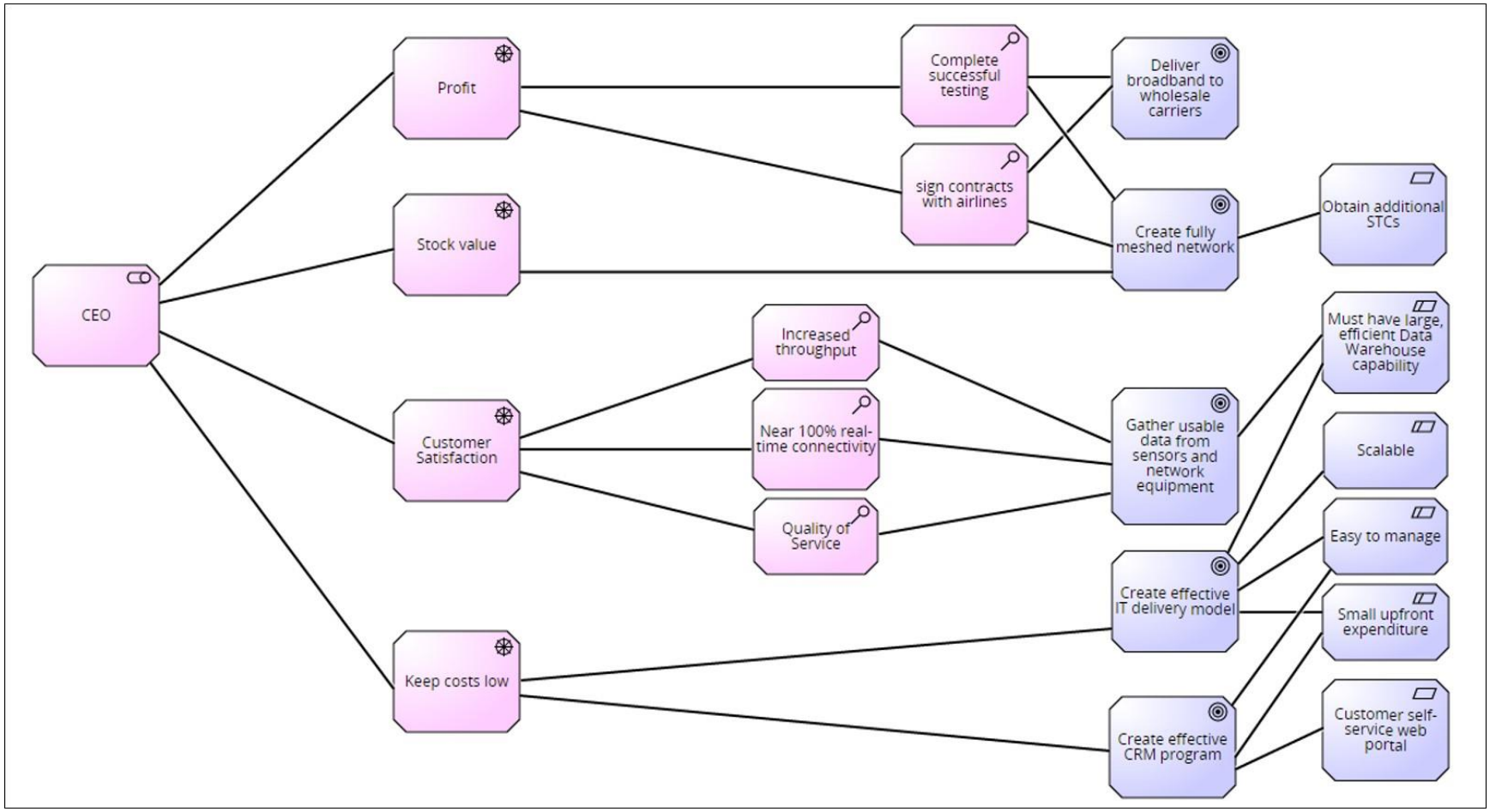

Figure 2. Goal Diagram for Airborne Wireless Networks.

Baseline Architecture	Target Architecture																		
	Implementation Issue									Technology Issue		DIK[1] Issue #1		DIK[1] Issue #2		Business Process Issue		Eliminated
	Ground Link Partnership	Extended Ground Link Partnerships	Marketing Agent for Airlines	Procure Patent	Contracts with Airlines	Phase I Testing	Outsourced Engineering Support	Aircraft Manufacturer Partnerships	Connectivity Gaps at Night/ Over Water	Hardware and Software for Relay Station Equipment	Additional STCs[2]	Sensors	Big Data Analytic Software	IT Delivery Model	Hire IT Specialist	CRM Software	Customer Self-service Portal	
Ground Link Partnership	Inc[3]																	
Marketing Agent for Airlines			Inc[3]															
Procure Patent				Inc[3]														
Outsourced Engineering Support							Inc[3]											
New		Gap: To be entered into			Gap: To be entered into	Gap: To be completed		Gap: To be entered into	Gap: To be filled with cruise ships, oil rigs	Gap: To be configured	Gap: To be applied for	Gap: To be determined and installed	Gap: To be determined and installed	Gap: To be determined	Gap: Position to be filled	Gap: To be determined	Gap: To be determined	

1) DIK = Data, Information, and Knowledge
2) STC = Supplemental Type Certification
3) Inc = Included

Figure 3. Gap Analysis Grid for Airborne Wireless Networks.

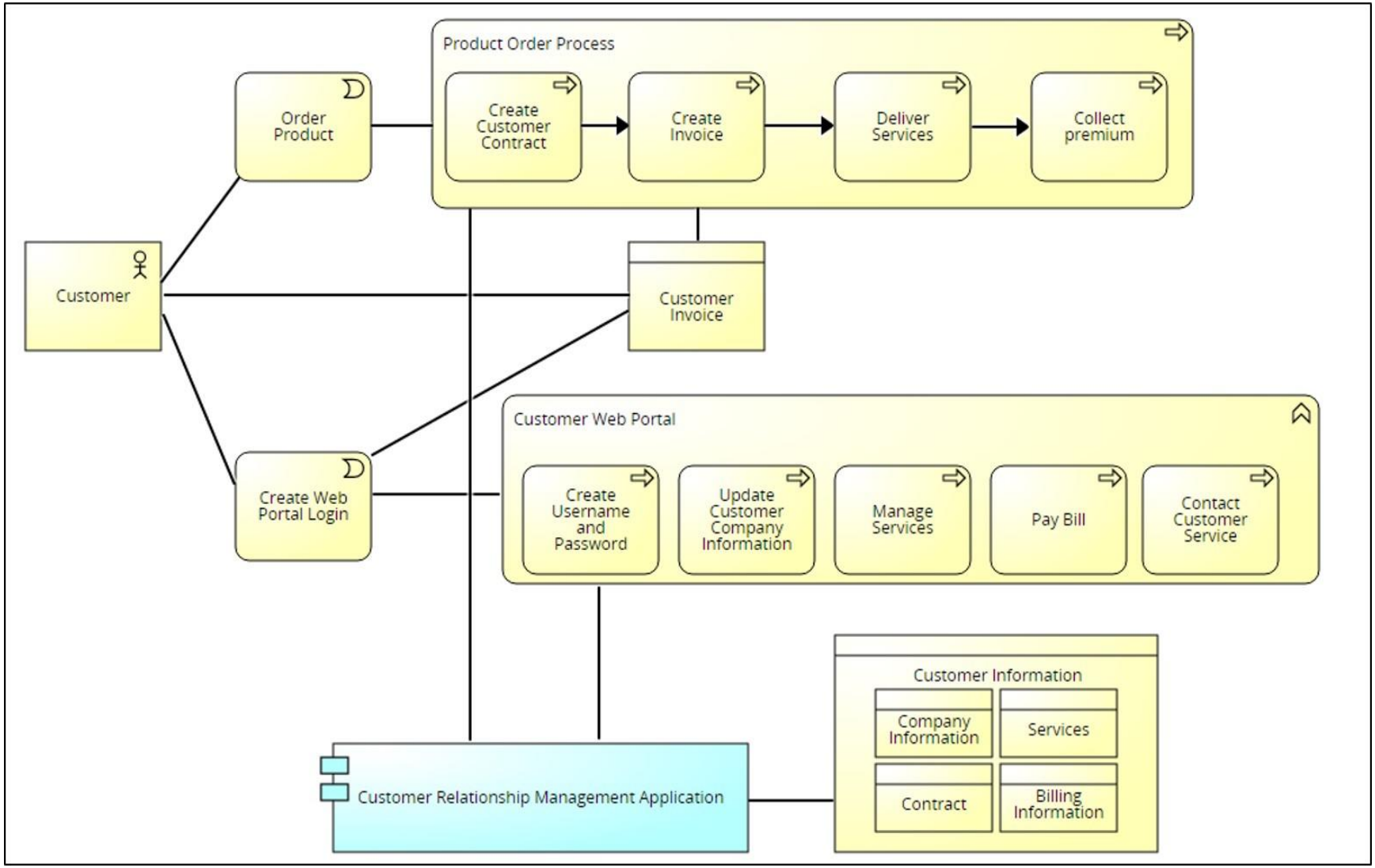

Figure 4. Customer Relationship Management Business Process for Airborne Wireless Networks.

Events Matrix		
EVENT	**PROCESS TRIGGERED**	**BUSINESS RESULT(S)**
Implement mesh network	• Increase focused marketability of product • Deliver wholesale broadband service	• Increased sales • Increased profitability
Add partnerships for ground nodes, airlines, cruise ships, oil rigs, etc.	• Increase production, distribution, set up of equipment	• Greater redundancy in mesh network • Better product offering
Add more Supplemental Type Certificates	• Market product to new aircraft	• Greater redundancy in air portion of network • Better product offering
Gather data from sensors and network equipment	• Data Warehouse analytics software processes information	• Maintenance determined/scheduled • Network optimized
Notified of need to update / upgrade equipment	• Technicians service equipment	• Better quality of service offered by product
Customers use self-service web portal	• Service request process initiated • Customer pays bill online	• Service delivered • Bill is paid
Bill generation	• CRM service automatically populates bill to portal	• Customer can electronically pay bill
Customer initiates request for service through web portal	• Service contract generated	• Increase in sales / profits

Figure 5. Events Matrix for Airborne Wireless Networks.

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