Airborne Internet - Market & Opportunity

by

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ABSTRACT

The purpose of this thesis to evaluate the opportunity for service provider entry and of the airborne internet, to analyze the disruptive impact technology used by AirCell and AeroSat has had on the development of an airborne internet, and to identify various stake holders and their value propitiation.

The airborne internet has the potential to change the way we fly and spend time when sitting in the plane. In the last fifty years, there has not been much technological advancement in the air traffic control system. Airplane operation still depends on current ground control and radar systems that are very expensive and very difficult to scale. These technologies are also heavily dependant on humans. There have been many technological advancements out side of the aviation industry. Establishing an airborne internet is a tremendous opportunity for everyone. With the help of an airborne internet, each plane can transmit its identity, location, and also direct video footage that will help Homeland security fight against terrorism.

The airborne internet has the ability to connect airplanes not just via a computer on the ground (or via satellite) but directly with each other, relaying information from other planes in an Internet-like fashion. The airborne internet is strongly supported by the Pentagon, FAA and NASA.

The U.S. Air Force and FAA are working on defining the architecture of an airborne network and hope to begin actively developing and testing the network itself between 2008 and 2012. According to the FAA, in 2005 there were 10 million flights carrying a total of 660 million passengers in the United States. For the FAA there are a number of merits to working with an airborne internet service provider to continue tests and validate the technical and economic feasibility of an airborne internet. First, there appears to be a substantial market -- in the range of $1b -- for services that require internet connectivity on the air for the commercial airline, air cargo, business jet, and general aviation sector. Second, current alternatives such as satellite solutions and existing air-to-ground solutions fail to meet all the needs of the mass market. Satellite solutions provided by companies such as Inmarsat, Iridium, and Globalstar are priced at a premium and carry an expensive cost structure from the maintenance and investment in orbiting satellites.

Airborne Internet service can be offered through three different technologies first, a satellite solution offered by Boeing; second, air-to-ground systems provided by companies such as AirCell; and third, a network of airplane ground –to - air system like AeroSat, all of which are compatible with the planned FAA architecture. Boeing's model is prohibitively expensive; a business model for an airborne internet solution based on a South West Airlines type low cost approach may make an airborne internet more feasible The model would rely on low service fees to promote greater consumer usage, high capacity utilization of ground stations to promote margins, low aircraft equipment costs to help cash flows, and risk/reward sharing with airlines to promote aircraft operator adoption. Assuming that a service provider relied on revenue from non-FAA related services, it could still generate ample margins to support other general FAA applications behind the scenes. The FAA can demonstrate overall support for an airborne internet vision, help attract key players to the ecosystem needed to implement the system, promote usage, and drive required airline ROI. The FAA could also drive the implementation of industry standards required to eventually ensure globally consistent services.

However, even with these clear benefits, there are a few key risks that need to be considered and further evaluated. First, this analysis evaluated the economic feasibility of an airborne internet. It does not take into consideration testing or validating the potential network performance from AeroSat's innovative mesh approach in an actual pilot test. Second, more extensive demonstrations will be required to further validate performance and the related cost for the supporting infrastructure. Some key economics like the number of antennae required on aircraft as the network grows should be explored in greater detail after initial simulations. Finally, uncertainty over potential developments of spectrum-free solutions, evolutes of ultra-wideband with potentially disruptive cost structures, could slow the market from adopting a spectrum-based solution. Although this is unlikely given the FAA's current stance on the use of UWB, the issue is worth further research and conversations with the FAA.

Accordingly, continued testing, development, and analysis to test feasibility and clarify the key unknowns is recommended. There are a few areas that deserve special attention. First, the target customer composition required to drive the business model should be finalized. The reliability and performance of the mesh-approach is partly dependent on the density of air-traffic in relation to the location of installed ground stations. Second, spectrum requirement issues, including the cost of acquisition and regulatory compliance, need clarification as they strongly impact the business model. Third, the potential magnitude and variability of assumed revenue sources, as well as the timing of cash collections across key customer segments, should be explored. Both of these impact the assumed free-cash-flows generated by the potential business model. Finally the potential terms of airline risk/reward sharing contracts required to equip aircraft with different quantities and types of antennae, need further exploration. Air carriers seem to be moving away from models where they absorb all of the equipment/certification costs – the economic feasiblity of a potential service provider depend on the service provider's ability to offer airlines this service at a reasonably good rate.

ACKNOWLEDGEMENTS

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TABLE OF ABBREVIATIONS

2-D	Two Dimensional (latitude and longitude)
3-D	Three Dimensional (latitude, longitude and altitude)
4-D	Four Dimensional (latitude, longitude, altitude, and time)
ACAS	Aircraft Collision Avoidance System
ACC	Area Control Centre
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AEEC	Airlines Electronic Engineering Committee
AGDL	Air/Ground Data Link
A-EXEC	Automatic Execution Service
AIC	Aeronautical Information Circular
AIRSEP	Air-to-Air Self-Separation Service
AMAN	Arrival Manager
AMC	ATC Microphone Check
AMN	Airspace Management and Navigation
AM(S)S	Aeronautical Mobile (Route) Service
AMS(R)S	Aeronautical Mobile Satellite (Route) Service
ANSP	Air Navigation Service Provider
AO	Airline Operations
AOA	Autonomous Operations Area
AOC	Aeronautical Operational Control
AP	Action Plan
APP	Approach Control
APT	Airport
ARP	Address Resolution Protocol
ARMAND	Arrival Manager Information Delivery Service
AS	Airborne Surveillance
ASAS	Airborne Separation Assistance System
ASPA	Airborne Spacing
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATG	Air to ground
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSA	Airborne Traffic Situational Awareness
ATSU	ATS Unit
BGP	Border Gateway Protocol
bps	bits per second
Bps	Bytes per second
CAGR	Compound Annual Growth Rate
C&P	Crossing and Passing
CDM	Collaborative Decision-making
CDTI	Cockpit Display of Traffic Information

CFMU	Central Flow Management Unit
CNS	Communication, Navigation and Surveillance
D-ALERT	Data Link Alert
D-ATIS	Data Link ATIS
D-ATSU	Downstream ATSU
DHCP	Dynamic Host Configuration Protocol
DYNAV	Dynamic Route Availability
E2E	End to End
EASA	European Aviation Safety Agency
EMER	Emergency
ENR	En route
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FCI	Future Communications Infrastructure
FCS	Future Communications Study
FDPS	Flight Data Processing System
FIS	Flight Information Service
FLIPCY	Flight Plan Consistency
FTP	File Transfer Protocol
GA	General Aviation
GAT	General Air Traffic
GBAS	Ground-Based Augmentation System
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRECO	Graphical Enabler for Graphical Co-ordination
GS	Ground Surveillance
GTA	Ground to Air
HF	High Frequency
IATA	International Air Transport Association
ILS	Instrument Landing System
IP	Internet Protocol
ISP	Internet Service Provider
kbps	Kilobits per second
kHz	Kilohertz
KIAS	Knots Indicated Air Speed
kph	Kilometers per hour
LAN	Local Area Network
MAC	Media Access Control
MHz	Mega-Hertz
m/s2	Metres per second squared
ms	Milliseconds
n/a	Not available
NOC	Network Control Center
NGATS	Next Generation Air Transportation System
NIC	Network Interface Card
NOP	Network Operations Plan

NPV	Net present value
OSI	Open System Interconnection
OSPF	Open Shortest Path First
PC	Personal Computer
PSR	Primary Surveillance Radar
P2P	Peer-to-Peer
QoS	Quality of Service
RARP	Reverse Address Resolution Protocol
RCP	Required Communication Performance
RF	Radio Frequency
ROI	Return-on-Investment
rsvd	Reserved
RTA	Required Time of Arrival
RTD	Required Time of Departure
RTF	Radio Telephony
SRS	Standard Routing Scheme
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
SWIM	System Wide Information Management
TBD	To be determined
TCP	Transmission Control Protocol
VHF	Very High Frequency
WAN	Wide Are Network
WLAN	Wireless Local Area Network
WTP	willingness to pay

Introduction

The airborne internet has the potential of providing a number of benefits to the aviation industry as well as establishing a platform for new types of consumer airborne services. However, previous efforts to provide internet or data connection services on planes have not been particularly successful. After investing approximately $1 billion dollars in the effort, Boeing has been unable to create a sustainable model using leased satellite capacity[1]. To provide another grim example, after being in the business for a number of years, Verizon decided to shut down its data and voice service (Airfone)[2].

Do these failed past attempts tell us that there is not a way to commercially establish the envisioned service? Recent market activity seems to point to the contrary. AirCell and JetBlue have recently bid on Spectrum and have announced plans to provide an air-to-ground alternative for domestic internet service[3]. Their recent field trials have validated that their potential approach does work technically and that it would interest the consumer. Their solution not only provides broadband connection for users, but through in-cabin adaptors, can also provide data access to potential customers using handheld devices. However, given their heavy reliance on ground coverage of base stations, their specific approach might not contain all of the right components to be a long term solution since it can not provide access to remote locations nor flights that have routes over large bodies of water.

AeroSat has developed a novel approach to creating an air-to-ground airborne mesh network. Coupled with air-to-ground technology, their airborne mesh network solution allows for greater coverage per potential base station installed, thereby leveraging the existing backbone infrastructure of players such as Level 3 Communication. In addition, through peer-to-peer

[1] Andy Paztor and J. Lynn Lunsford, "Boeing Weighs Sale or Closure of Connexion Internet Venture", *The Wall Street Journal Online,* June 22, 2006, http://online.wsj.com/article/SB115094804596687272, accessed July 2006
[2] Pilcher, Jim, "Verizon drops its airphone business", *Daily Herald*, July 12, 2006
[3] Yu, Roger, "Providing in-Flight Wi-Fi still a struggle; AirCell, JetBlue step up as others take a step back", *USA Today*, June 29, 2006

relaying, their solution allows for air-to-ground connection for planes not directly linked to ground stations, such as those that are flying over the Pacific. Additionally, AirCell's differs from other players by creating an AirCell coverage area using AirCell Antenna and ground cells mobile switching center. This thesis will examine and evaluate the potential opportunity for an airborne internet service provider, analyze the disruptive technology used by AirCell and AeroSat, and identify the parties interested in the airborne internet. This thesis then evaluates the interests of participating parties and their value propitiation.

Technology

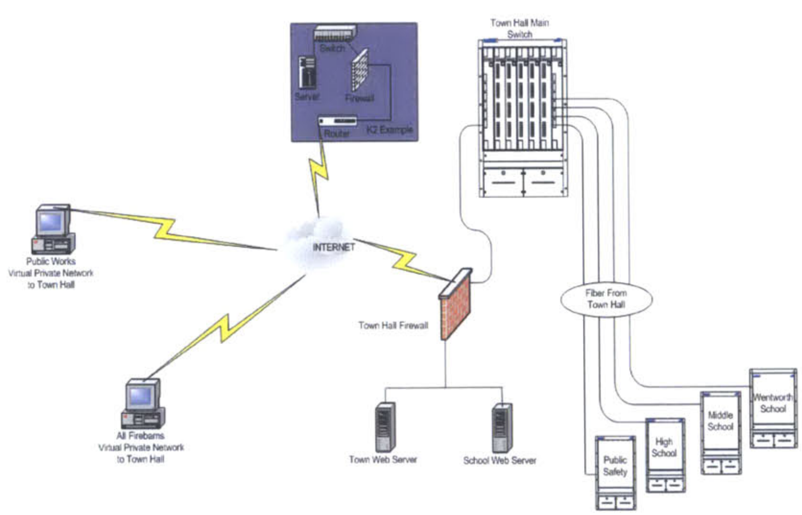
The airborne internet architecture using the same principles as a traditional network. To understand how the airborne internet works, one must first understand how a traditional LAN works.

In basic computer local area networks, each computer utilizes a network device, such as a network interface card (NIC), as its physical interface onto the network wire, or Local Area Network (LAN). This is part of first layer (physical layer) out of seven OSI layer.

The network wire (or cable) connects directly to the NIC in the back of the PC. At the next level higher, (data layer) network protocols are applied and bound to the NIC. The most commonly used is TCP/IP. IPX is another popular protocol, started by Novell. The Internet Protocol (IP) is a network-layer protocol that contains addressing information and some control information that enables packets to be routed. With the help of IP addresses the packet is routed to the destination address. The packet is also forwarded to the next hop using Mac addresses.

The IP component provides routing from the one network to other network and finally to the global Internet. TCP is responsible for verifying the correct delivery of data from the client to the destination server.

Figure 1



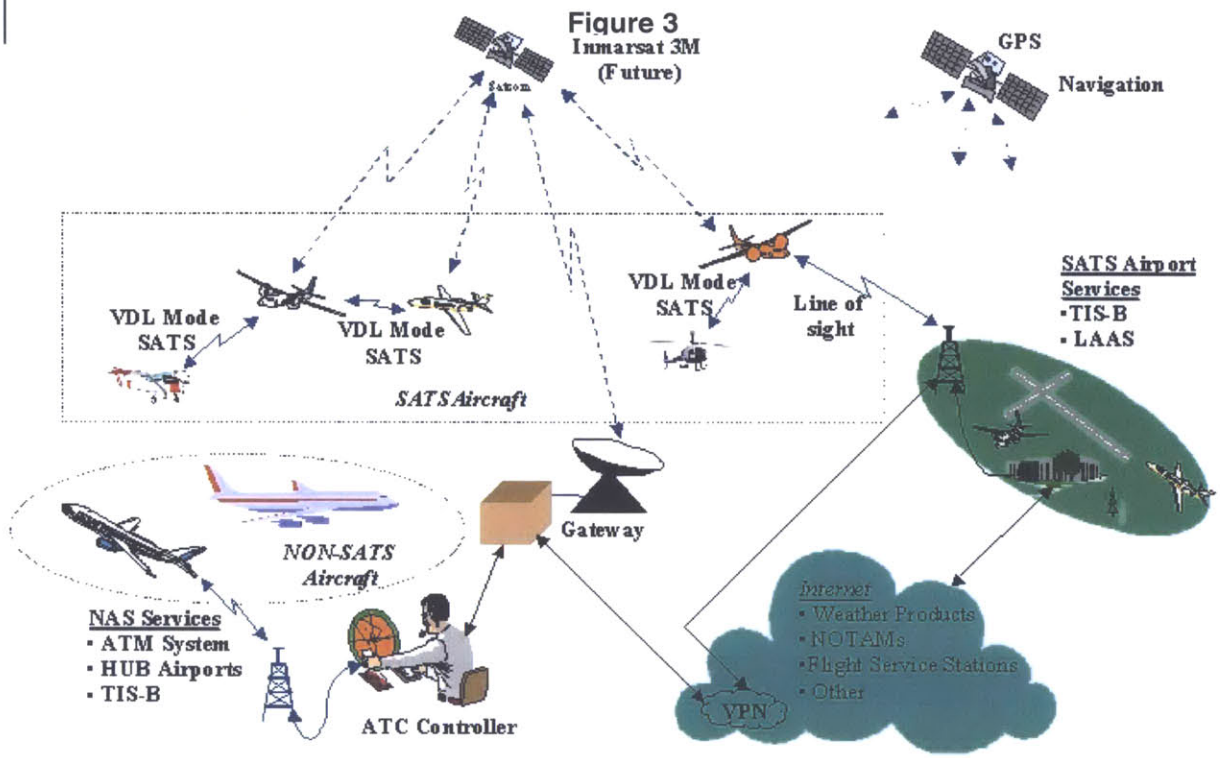
Each Network Interface Card has a unique MAC address that is applied during the manufacturing process, the first two hexadecimal digits indicate the manufacturer's name. TCP/IP assigns a unique number to every workstation (actually its NIC) in the world. There are two way to assign IP address, one is static and the second is dynamic and uses a DHCP server. Then network addressing depends on the network configuration. The IP address and the MAC are married together. We can get MAC address information through the IP using ARP protocol. This is similar to the way we can get IP address info using RARP protocol. This "IP number" is four bytes long and is expressed by converting each byte into a decimal number (0 to 255) and separating the bytes with a period. For example, the www.yahoo.com web site server is 66.94.234.13

The entire network (enterprise and ISP) has been built using commercially available TCP/IP router boxes. These boxes are located at different places including Internet Service Providers. Each router maintains its routing tables, that table has information about all different routes. The table translates the name into a destination IP address. This system is very similar to US post office delivery mechanism. The way the router operates is very similar to the way the US Post Office uses zip codes to route, sort, and deliver the mail to the destination address. Routers uses the IP address to find the destination address. The router must also determine where to send it next, or which "route" to use to ensure it arrives at its destination. Every time a packet arrives at an IP router, the router uses the routing table to make an individual decision about where to send the packet next.

Figure 2

The principle behind the airborne internet is to create a high-speed network backbone in the sky with a very reliable and robust network. Aircraft are mobile devices and because of that, routing information to them is very different than compared to traditional LANs and WANs. Connectivity is difficult to maintain because airplanes are not stationary. In order to maintain connectivity, mobile routing is required. The airborne internet model is built on the same concept as computer networks.

Figure 3

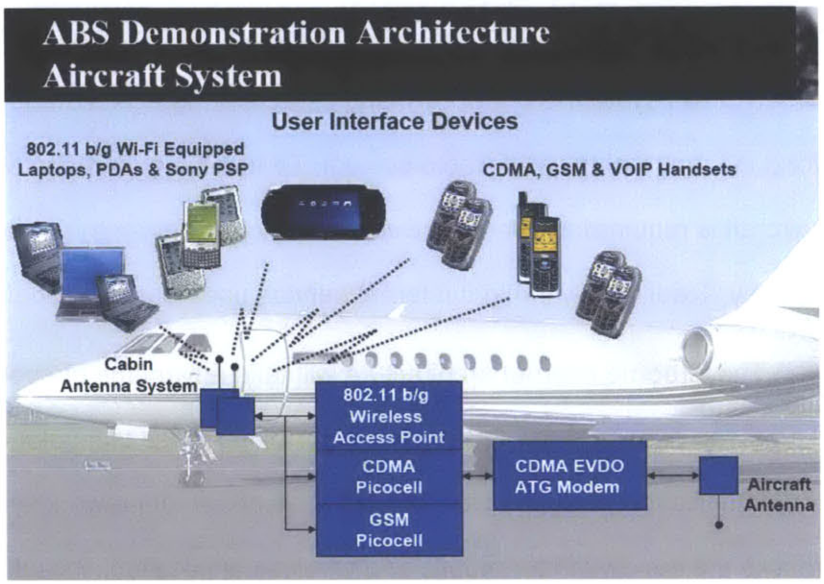


Airplanes using the airborne network must have IP network connectivity with another airplane or ground based IP network. This function can be accomplished by using a combination of Very High Frequency (VHF) radio and an alternate, backup communication method to make a redundancy network. A satellite communication system could be used by aircraft that fly in remote areas that are beyond the VHF coverage of the existing NAS infrastructure. The satellite communication system is currently being used for long flights (trans-oceanic flights) that are beyond the range of the VHF radio system. To use the airborne internet, the correct position of the aircraft is required. Current GPS technology can deliver this information reliably and accurately Traditionally in-flight internet service uses Satellite (Boeing) technology.

The airborne internet architecture will take advantage of open source, open standards and protocols like TCP /IP, OSPF, BGP etc. Using these technologies, the IT and telecommunications industry can develop a client-server network system architecture that increases the bandwidth for mobile and wireless applications including WLAN. In the airborne internet architecture, each aircraft is connected to the next aircraft to form a network similar to the peer-to-peer network we have in an IT/Telecommunication network. Peer-to-peer networks (P2P) do not require a central server. A peer-to-peer (or P2P) computer network is a network that relies primarily on the computing power and bandwidth of the participants in the network rather than concentrating it in a relatively low number of servers. The peer-to-peer network does not work as a client/server model but in this network each node works as a client and server with equal rights. This type of network is very different than the client-server model . In the client-server model, information flows from server to client. The server has all the information and resources, the client accesses this data from the server when needed. A File Transfer Protocol (FTP) server is a very good example of the client –server model. Bit Torrest is an excellent expmple of the peer-to-peer model.

In the airborne internet, every aircraft workstation acts as a router that also runs the Automatic Dependent Surveillance - Broadcast (ADS-B), and flight information services like broadcasting weather and e-mail applications. The airborne internet router is connected to the VDL Mode SATS radio and ground LAN .The Controller Pilot Data Link Communication (CPDLC) ground controller and the peer-to-peer workstations are connected to the ground LAN. Once connected to the LAN one can access to services like web enabled status that remotely monitors the status of the routers and the radios.

Figure 4

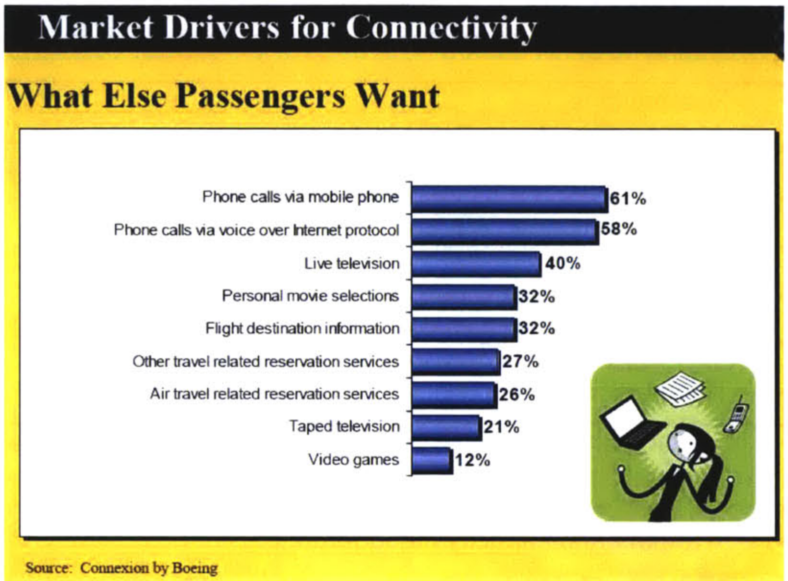


Market

The market opportunities created by an airborne internet are significant enough in size to warrant entry by a provider and support by the FAA, despite the past history of failure and existing competition. The overall opportunity is driven by three potential revenue markets created from an airborne internet network: consumer services, carrier services, FAA services. The consumer services market obtains revenue from fees paid by individuals looking for data access on planes. The potential revenue segments are: laptop users looking to do work on a plane, mobile users looking to connect while traveling, and fees generated from advanced in-cabin entertainment services.

There is also a strong potential of advertising revenue generated in this segment. However for the purpose of quantifying a conservative estimate, these sources of revenue were ignored in this study. The carrier operational services market obtains revenue from fees that carriers are willing to pay for connectivity because of the operational benefits. Some examples of potential benefits include: improved weather information, electronic flight-bag applications, receiving gate dispatch assignments, flight crew scheduling, and decreasing pilot idle time.

Figure 5



Finally, potential revenues from fees for FAA related services paid for by airlines (not paid for by the FAA but by aircraft operator) were considered. These include any fees related to integration to SWIM or any specialized homeland security functions. Table 1 summarizes the potential application by consumer, operating, and FAA services segments.

Table 1: Comprehensive list of applications by potential segment

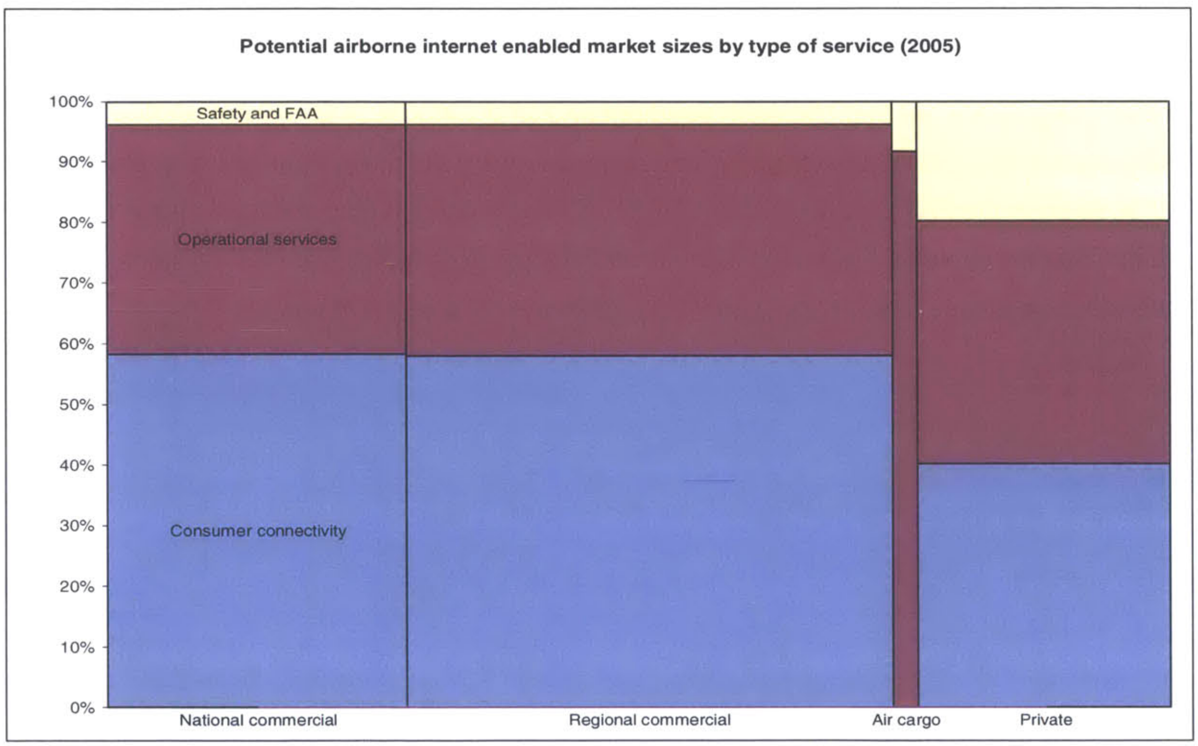
Segment	Applications
Consumer service applications	• In flight Internet access • On demand movies • In-flight entertainment • VPN access to corporate office • Real time stock quotes
Commercial airlines operational applications	• Fuel savings • Airport and facility directory • Enabling pilot dispatcher communication • Receiving gate information • Flight crew scheduling • VoIP communication • Telemedicine
Air-cargo operational applications	• Sending engine and aircraft monitoring information to the ground • Inventory and capacity management • Asset tracking
Private (business) jet applications	• VoIP services • Video-on-demand • Corporate email access • VPN access to corporate data • Real-time stock quote and news • Sending engine and aircraft monitoring information to the ground
FAA related applications	• Pre-departure clearance transmissions and oceanic position reports • Black-box transmission • Sending engine and aircraft monitoring information to the ground

Analysis determined that the potential domestic opportunity for an airborne internet market is in the range of $1 billion. Figure 5 illustrates the composition of market size by segment. We segmented the airline market into four groups: national commercial airlines, regional commercial airlines, air cargo carriers, and private planes. National commercial airlines are comprised of aircraft that fly long-haul national routes. Examples of national commercial airlines are carriers such as United, American Airlines, etc. Regional commercial airlines include aircraft that have more clustered operations. Examples of regional carriers include MaxJet, AmericaWest, etc. Air cargo aircraft includes planes of providers including FedEx and UPS.

Finally the private plane market includes both business jet and smaller general aviation aircraft. Note that in this diagram the $1 billion market size is represented by the sum of the product the quantity of aircraft in each segment and total willingness to pay for connectivity (using number of flights). Our segment approximates were me using domestic aircraft fleet figures listed in the FAA Aviation Report 2005[4]. This is a conservative estimate of the number of aircraft as the report did not include international operators flying over U.S. territory. Appendix 2 highlights aircraft figures used to make market size estimates.

[4] Federal Aviation Administration, "FAA Aerospace Forecasts: Fiscal Years 2006-2017", U.S. Department of Transportation Office of Policy and Plans, accessed July 2006

Figure 6: Diagram of Potential Market Size by Segment



For consumer willingness to pay a 16% usage per flight given $5 usage was assumed[5]. The $50 fee per flight figure for both commercial segments and air cargo is based upon current market comparables and customer contacts.

In the private jet market, the $10 willingness to pay for consumer internet services and operating service was based on a per flight basis benchmarking to current prices for satellite services[6]. The $5 figure for fees generated for FAA services for all three segments is based on potential cost of using current alternatives for predicted usage. These estimates are comparable with Frost & Sullivan's estimate of $3 billion worldwide by 2010[7]. Figure 8 highlights Frost's yearly projections.

Figure 7

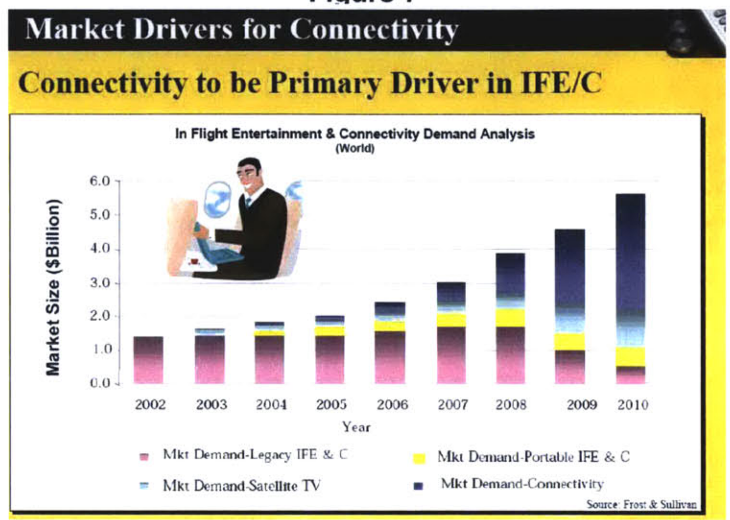
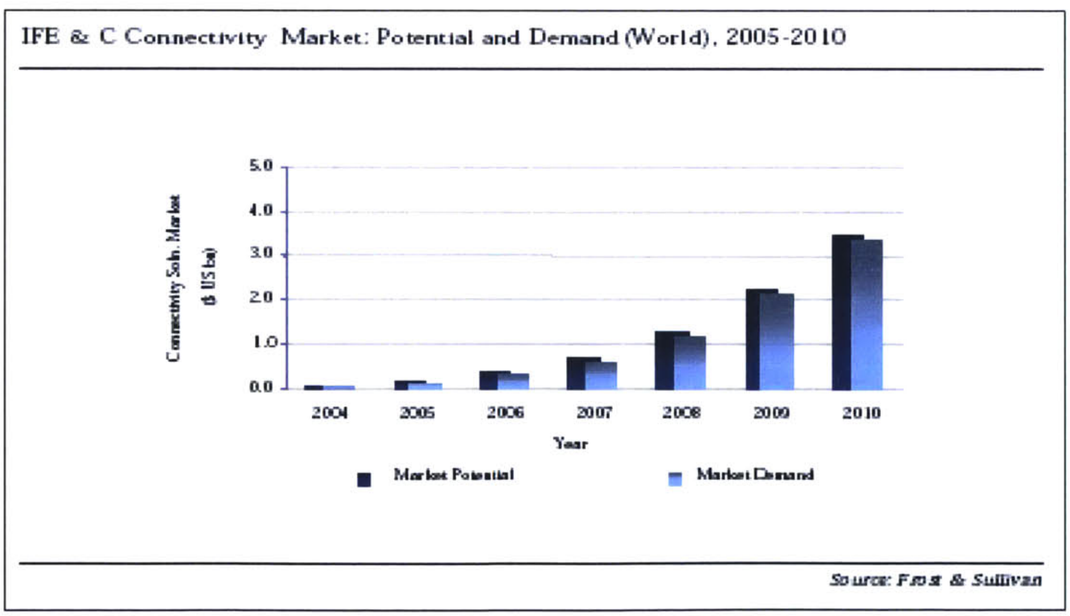


Figure 8: Frost & Sullivan Chart On Potential Growth Of Internet Connectivity Segment



[5] Henry H. Harteveldt, "Business Traveler Behavior And Attitudes", The Forrester Report (June 2006), Forrester Research Inc, accessed July 2006

[6] Blumenstein, Jack, "Broadband to the Seat: Decoding it All", Powerpoint Presentation, April 2005, AirCell

[7] "World MSS Voice and Data Services Markets", Frost and Sullivan: F841-66 (2006), Frost & Sullivan, accessed July 2006

Airborne Internet testing

From the FAA test, Airborne Internet has demonstrated following capabilities:

(*Following text taken directly from FAA website* http://www.airborneinternet.com/AI4.htm)

- Demonstrate aircraft-to-aircraft communications. A broadcast capability can be achieved using Automatic Dependent Surveillance – Broadcast (ADS-B) and Trajectory Change Point (TCP). ADS-B is a system by which each aircraft's surveillance transponder is used to broadcast to the other aircraft in the vicinity its position data. ADS-B has also been used to provide the same information to the ground air traffic control system. By using ADS-B, a pilot is provided with the information needed to understand his own "situational awareness" by viewing his own aircraft in the context of those surrounding him. Ships and boats have had similar "situational awareness" by using shipboard radar in which they can view other vessels (and objects) around them.

- Ground broadcast Surveillance information service. Traffic Information Services – Broadcast (TIS-B) can be used for this purpose. TIS-B is a system by which air traffic control information available to the air traffic controller is also provided to the aircraft.

- Maneuver and Control can be demonstrated using Controller Pilot Data Link Communications (CPDLC). This is a system in which ground controllers can issue commands to aircraft using text messaging instead of VHF voice radio. In return, the aircraft can acknowledge on the same text messaging link. The system is being implemented in the NAS today. The purpose of CPDLC is to reduce the usage of the already over subscribed aviation VHF voice radio frequencies. In its simplest form, think of it is an elaborate "Instant Messaging" system.

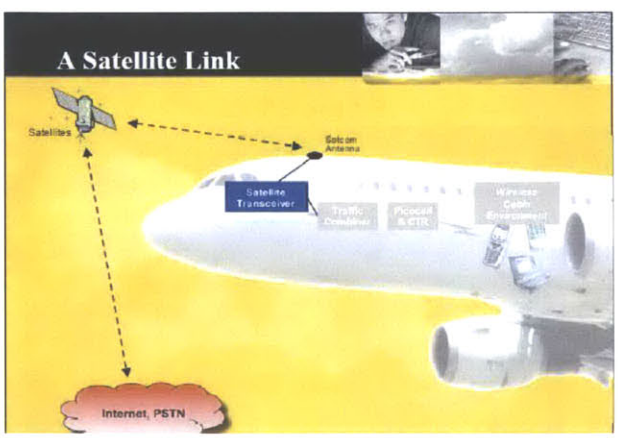
- Applicability of external Internet for Flight Information Services – Broadcast (FIS-B) kind of services, such as weather broadcast to aircraft from the ground. E-mail is another important service that can be provided. FIS-B can be used to provide near real time weather information to SATS pilots. One of the uses for VDL Mode SATS is a continuous broadcast by a ground station of local weather conditions or enroute weather.

- Prove the technology of VHF Digital Link Mode SATS, which uses Self-organizing Time Division Multiple Access (STDMA) as its media access mechanism. VDL Mode SATS permits data communication without the necessity of having a ground station to support the protocol.

- Peer-to-peer activity between two or more air nodes, and between air and ground nodes. Peer-to-peer communication enables real time collaboration between equal entities by sharing resources and information.

Boeing Technology-

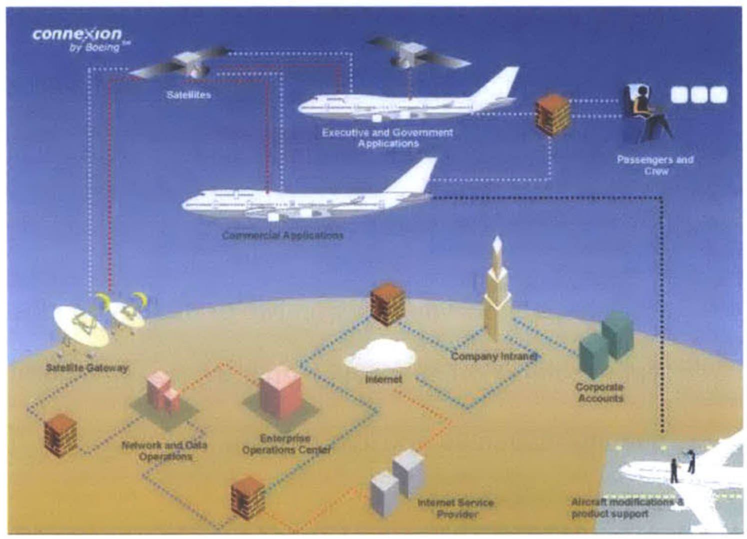
Figure 9



Boeing's airborne internet service "Connexion by Boeing" provides passengers a broadband internet connection through satellite technology. With Boeing's service , users have an option to connect to the internet through wire (Ethernet cable) or through wireless LAN on the aircraft. Transmission speeds was depend on various conditions, but maximum capacity was 20 MBPS download to the aircraft and 1 MBPS upload. Passengers are able to connect to the service from laptop or handheld computers over 802.11b Wi-Fi access points installed in the aircraft. Those access points provide raw data rates of 11 MBPS. The estimated hardware installation costs per aircraft for "Connexion" are in the range of US $ 300,000-500,000.

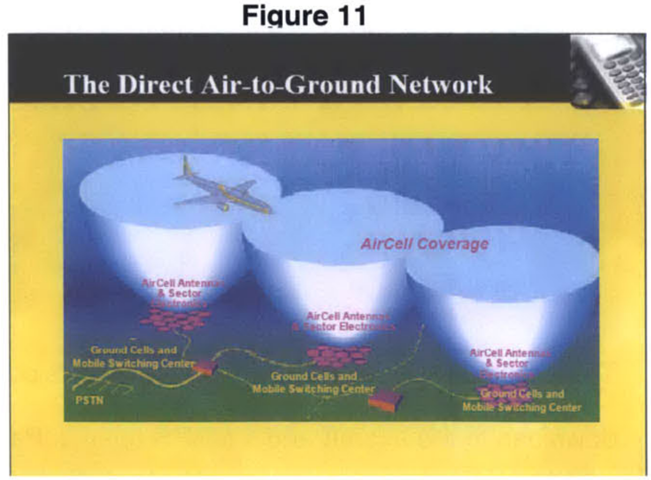
Boeing's business model targets corporate customers directly, as well the corporate jet market. Boeing Co. set the pricing for its airline passenger high-speed Internet service at $29.95 for unlimited use on long-duration I flights of /6 hours or more and $19.95 for flights lasting between 3 - 6 hours. Boeing was also offers a metered pricing option starting at $9.95 for 30 minutes and 20 cents a minute thereafter.

Figure 10



In the fall of 2006 Boeing, discontinued its Airborne Internet service because this service was not profitable. Boeing's service failed because infrastructure was too costly and there was no partnership with another stakeholder. Boeing assumed all the risk for this service. They should have shared the cost and risk with airlines carriers.

Figure 11

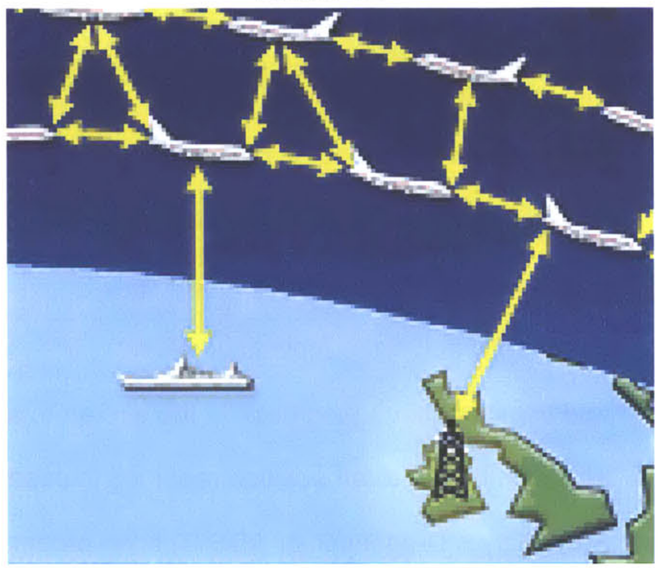


AirCell Technology -

The AirCell airborne internet is approach is very different then the traditional approach offered by Boeing. AirCell's model is dramatically less complex, less expensive, and more flexible than Boeing's solution. AirCell is going to create coverage area through out North America with the help of AirCell antenna and ground cells.

AeroSat Network Technology

Figure 12



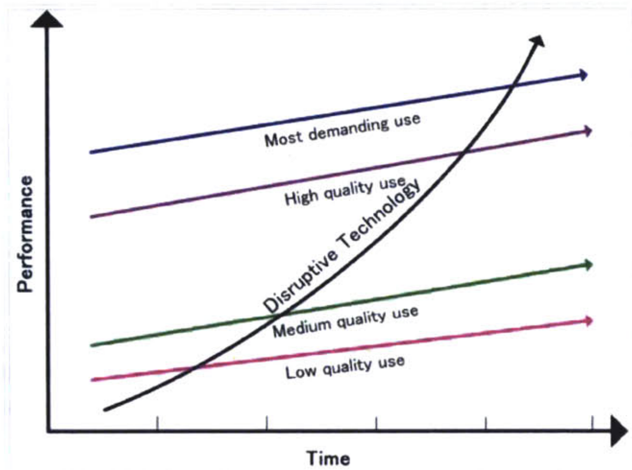
According to AeroSat, it's technology is 1000 times faster then traditional 64 K satellite network. AeroSat's network cost is much less than Boeing's service. AeroSat's airborne network, forms a network of planes at flight level by passing the signal from one aircraft to other aircraft and then down to a ground station (see figure 11).

AeroSat is offering 45MMBPS speed to aircraft in flight without using satellites or ground networks. This technology enables the transmission of data at a very low cost to airline operations, air traffic management, maintenance, safety and security, and in-flight entertainment. Nine ground stations will be required around the Atlantic perimeter that will support the network. Similar only seven aircraft will be required to create a link that extends signals all the way across the Atlantic. Cruise ships or other ships at sea can also be part of this network by connecting with an aircraft that is within line of sight and then connecting to the rest of the network through the ground station.

Disruptive Technology

It seems that AeroSat and AirCell are disruptive technology. Both companies offer similar services with a low price, high speed, and better technology. According to Christensen description (see figure 13), all disruptive technology should be lower performance but in this case, lower performance is not an issue. AirCell and AroSat's performance is much better then the current technology.

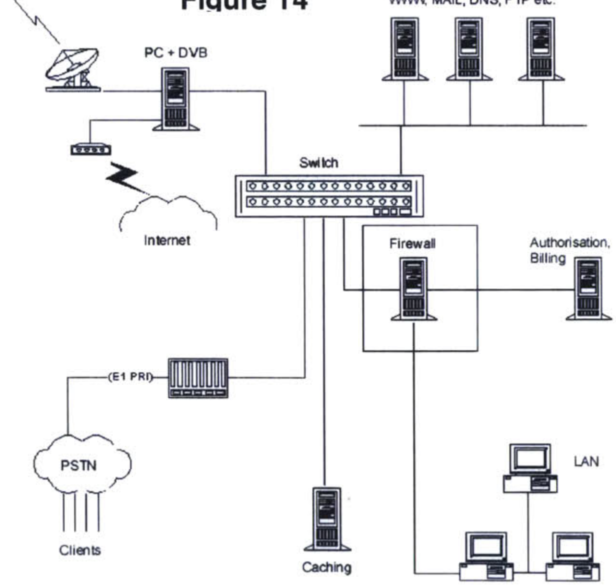
Figure 13



How low-end disruption occurs over time.

By combining the GPS provided position information of any moving aircraft (or other vehicle) with reliable mobile network connectivity, the aircraft's position could be constantly reported to the ground network for processing. Further, this data could be intelligently parsed to provide position and tracking information back to the aircraft to alert the flight crew of other aircraft movement in its proximity. Air-to-air position reporting is possible (such as Automatic Dependent Surveillance-Broadcast, or ADS-B) if the proper radio method is used. It is possible that enough aircraft could utilize the airborne internet architecture to create a virtual network in the sky. At any given moment, there are between 4500 and 6000 aircraft in flight over the United States. Air transport aircraft could not only use airborne internet for their own purposes, but they could also provide a network router function that could sell excess bandwidth to other bandwidth-demanding aircraft. This network in the sky not only

Figure 14

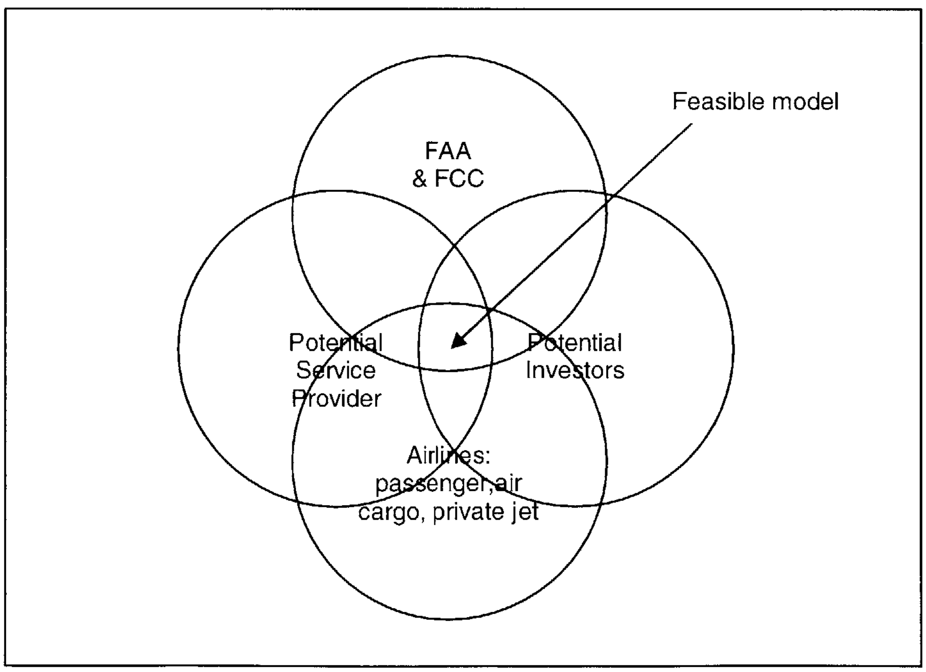


reduces equipage and saves system costs, but it could also create a revenue stream for air carriers that does not currently exist.

Stakeholder analysis

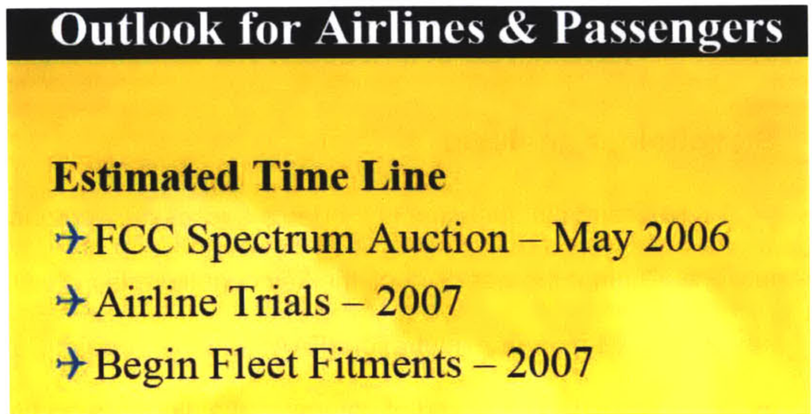
To achieve a sustainable model, a successful approach to establishing an airborne network will meet the needs of all the key constituents including: regulatory agencies such as the Federal Aviation Administration (FAA) and the Federal Communications Commission (FCC); the airline industry comprised of commercial airlines, cargo providers, business jets, and general aviation; the potential service provider; and any potential private investors. As Figure 15 illustrates, the most feasible model to bring this service to the market lies at the intersection of the interests of four primary parties (Section A).

Figure 15: Party Map



Interests of the FAA and FCC

Figure 16



The FAA and FCC's overall interests are to enable new public services and to use public resources in a way that benefits the general population. The FAA wants to work toward the improvement of aviation and to demonstrate international leadership. The FCC needs to make sure that any allocated airborne spectrum is used effectively.

Specifically, the FAA seeks to develop an airborne internet network to advance the systems and methods of air-traffic control. In order to do this, the FAA is promoting the SWIM program (next generation system). SWIM's fundamental goal is providing continuous connectivity. The general goal is to reduce the complexity of managing aviation and to promote the growth of the aviation industry. In addition, the FAA is interested in promoting products and services that are likely to make the consumer flying experience safer and more pleasant helping the economic viability of all players involved, such as national and regional airlines. Table 2 highlights the potential FAA related applications and the network requirements to deliver these applications.

Table 2: List of potential FAA related applications and required network features

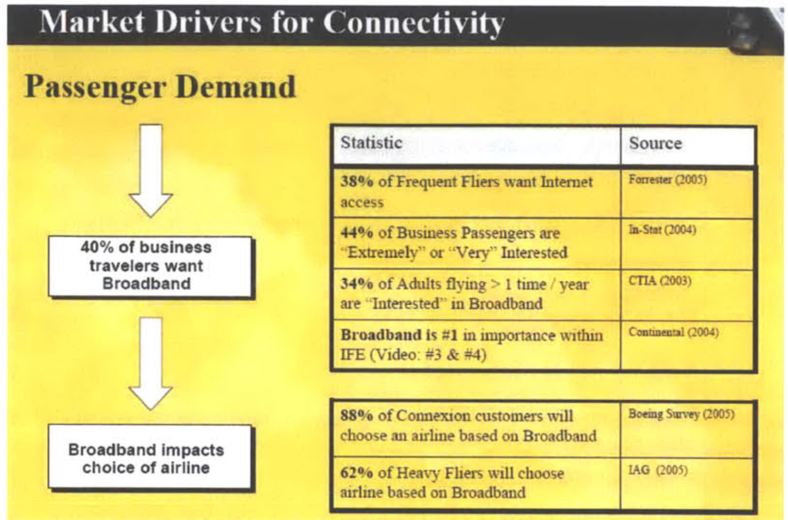
Sending engine and aircraft monitoring information to the ground	→ Enabled through low-cost and total coverage
Airport/Facility Directory	→ Enabled through low-cost
Enabling pilot-dispatcher communications	→ Enabled through high bandwidth, low cost, and total coverage
Receiving gate assignments	→ Enabled through low cost
Flight crew scheduling	→ Enabled through low cost
Pre-departure clearance transmissions	→ Enabled through low cost
Oceanic position reports	→ Enabled through low cost and total coverage
Electronic flight bag applications such as conflict detection and avoidance	→ Enabled through low cost
Telemedicine	→ Enabled through high bandwidth, low cost, and total coverage
Special homeland security functions	→ Enabled through high bandwidth, low cost, total coverage
Receiving in-flight weather reports	→ Enabled through low cost and total coverage
Controller Pilot Data Link (CPLDC) regularly downloading of the aircraft s 'black box' data	→ Enabled through low cost and total coverage
Priority TCP/IP message delivery	→ Enabled through low cost and total coverage
Voice over IP (which then could be used as voice in the Oceanic or Gulf of Mexico airspace),	→ Enabled through high bandwidth, low cost, and total coverage

The FAA's immediate focus is adopting technologies that are help alleviate the current "pains" of aviation, including safety and monitoring. Given that a potential airborne internet technology meets these requirements, the FAA is likely to support a plan for rapid adoption. In addition, it is likely that the FAA will not want major responsibility of operating and maintaining the airborne internet infrastructure in the long-run, and that it will prefer to support private providers that can be a long-term partners in the airborne internet's R&D efforts. For further details on the FAA's interest, please see Appendix 1.

Interests of airline industry

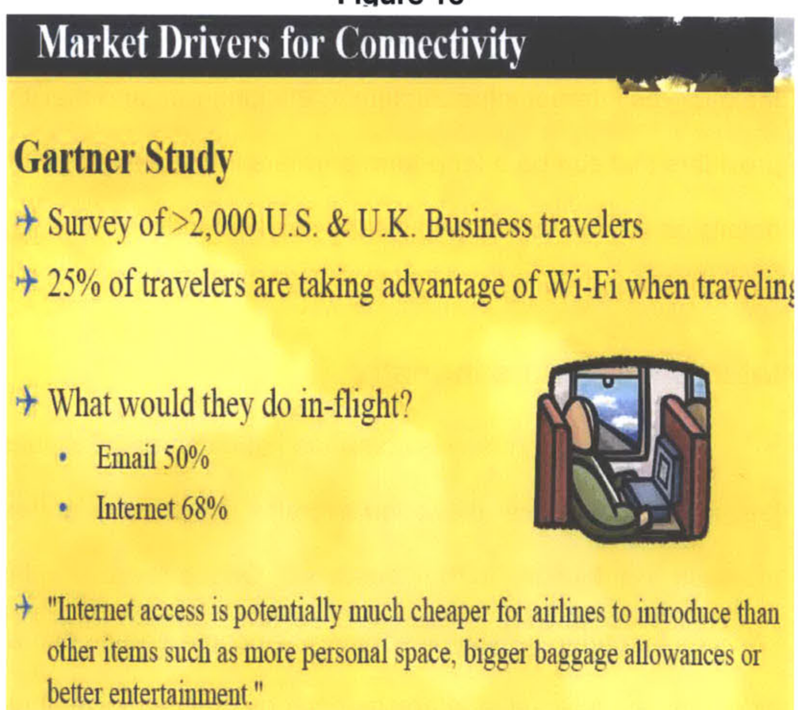
The airline industry is comprised of commercial airlines, air cargo providers, business jets, and smaller general aviation aircraft. The primary interest of commercial airlines is to increase contributions to their business. On the revenue side, they are likely to be interested in services that bring additional sources of income and/or increase customer loyalty. On the cost side, they are interested in any technology that can lower their operating costs. In addition, they are likely to be attracted to the idea of a service that helps them differentiate themselves from the competition.

Figure 17



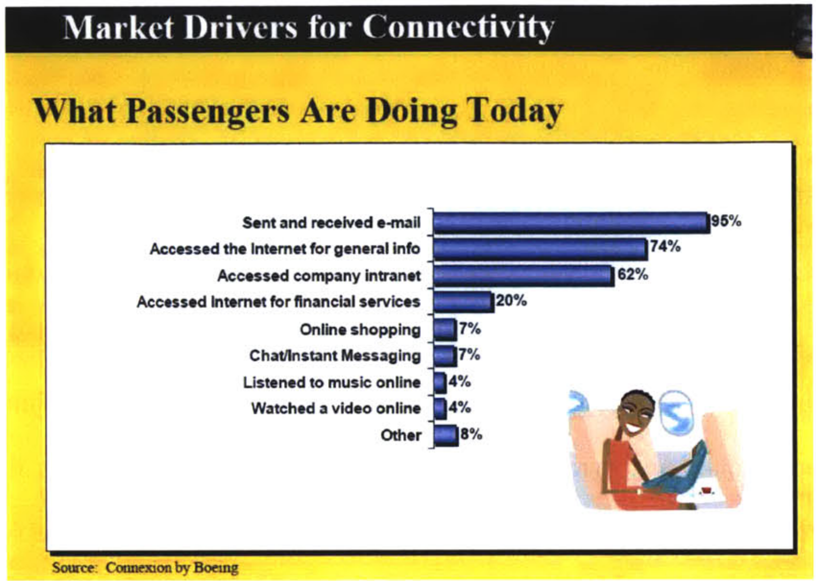
For the commercial airline segment, it is important to note that the historical context has made it critical for any potential service to have a clear return-on-investment (ROI) for airlines. Particularly after the Boeing experience, airlines are likely to be hesitant to install equipment without a clear ROI. In fact, for the early adopters, subsidizing equipment purchases is likely to be a requirement. Otherwise, airlines expect a clear "sharing of risk and sharing of reward." In turn, to assure alignment of these parties, all of the other parties involved have to realize that focusing on meeting aircraft operator ROI is critical for the project's success.

Figure 18



In terms of the remaining segments, air cargo providers are interested in services that are likely to bring them operational improvements. Applications that can leverage connectivity to increase how they utilize their capacity or generally bring efficiencies to their business are likely to be attractive. The business jets segment is unique in that it is likely to have a higher willingness to pay for connectivity because of their interest in using more advanced applications (such as video conferencing and VoIP). Finally, the general aviation segment comprised of smaller planes and maintained by independent owners, is likely to be interested in connectivity services, however with less emphasis in luxury applications and greater sensitivity to price.

Figure 19



Interests of service provider

The interest of a potential airborne internet network provider is to create a sustainable business. This includes achieving a model that allows the provider to raise the required financing, gain support from regulatory agencies to assure compliance to market requirements and integrate into public aviation services, and economics in business to meet the needs of their customers (parties in the airline industry). The ability to raise required financing depends on having demonstrated technology and an accurate sense of the key risks in the effort as well as a clear idea of how to achieve success. To have the support of regulatory agencies, the technology of the service provider must have the ability to comply with market regulations as well as effectively integrate with any public aviation service. Finally, to meet the needs of its customers on a long-term basis, there must be a business model that generates enough free-cash-flows to provide a return to investors, while also funding for maintenance and future infrastructure requirements.

Interests of potential investors

Finally, potential investors want to invest in an opportunity that will yield returns commensurate with the risks of the project. There are three key factors that affect the potential return for investor: capital invested, growth, and exit value. First, capital invested needs to be controlled and minimized. For an airborne internet effort, it is important for private capital to be invested at the appropriate time so that it goes into market deployment of the solution when the technology has been validated. Second, potential growth of the service needs to be rapid. This helps increase the chances of sustainability of the venture by giving the airborne internet a strong foothold in the market. Finally, exit valuation and options must be attractive. It is critical that a private investor have ways to receive back their initial investment plus the premium for taking the risk to invest in future efforts.

The intersection

With an understanding of the diverging interests of all the parties involved, it is clear that executing a plan that meets all parties demands will be challenging. The approach that is likely to be most successful and avoid the failures of the past is one where the above parties can easily be attracted to the effort. The effort has to meet the public vision, the needs of the FAA and FCC, the aircraft operator's ROI requirements, the potential service provider's required economics, and investor's IRR goals. The FAA business case that follows focuses on a service provider plan that lies at this intersection.

The Alternatives

A second critical reason for the FAA's involvement is that current alternatives are ineffective: they are expensive, have poor coverage, and are slow. Table 3 summarizes the current market offerings for airborne connectivity (please note that values were omitted from the table if they were not found). The offerings can be grouped into two segments: satellite service providers and air-to-ground providers. Satellite service providers include companies such as Iridium, Globalstar, Inmarsat, Row 44, Telenor, SES, and ARINC. The air-to-ground provider is AirCell. These player's offerings differ in performance, because of both the technology and the spectrum they use (see Appendix 3 for spectrum definitions). Appendix 4 contains more detailed analysis by competitor.

Table 3: Summary of competitive offerings

	Iridium	Globalstar	Inmarsat	Row 44	Telenor	SES	ARINC	AirCell
Frequency	S	S	L	Ku	S	Ku	Ku	S
Speed	2.4 kb/sec	8 kb/sec	14 kb/sec	30 Mb/sec	2.4 kb/sec	1024 kb/sec	3 Mb/sec	1 Mb/sec
Price	$1/min	$0.14-1.5/min	$6.56/min	-	$9.49/min	-	-	$1.60/min
# installed	7500	-	-	Flight Trials Q1 2007	-	-	-	Flight Trials in 2007
Type	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	ATG
Advantages	- global coverage - larger share of existing air market - remote applications (private air	- global coverage offering service in remote area	- global coverage - diverse revenue stream - fiscally strong - most reliable network in world	- low cost, offering variety of services, tied with HughesNet broadband service	global coverage -largest market share for remote applications	- Service provider in Europe, Middle East, and Africa	- Service provider primarily for gov't and DOD	-Low cost - First to market with spectrum
Disadvantages	To expand they are	Service through	Reliance on	Reliance on ground	To expand they are	Very slow	Operates only in	Reliance on ground

	dependent on satellites, reliant on handheld device	hand held service	satellite, require handheld equipment, more expensive	stations, smaller player, redundancy	likely dependent on satellite, air is likely private jet, very slow	speeds	North America	stations, spectrum limitations, redundancy issues
Primary segments	Ground, air, sea	Ground, air, sea	Ground, air, sea	Ground, air, sea	Ground, air, sea	Ground	Ground, Air	Air

The satellite service providers are the incumbents in the industry. These players generally have a strong foothold in the land and sea markets. Their primary customers include individuals who need the ability to gain internet connection in remote areas or in extreme contexts such as maritime transport. Although the providers have the ability to provide access anywhere in the world given their extensive number of orbiting satellites, the costs of maintaining and deploying this infrastructure is also their weakness. As can be observed in the table above, these carriers have prices significantly higher than standard telecommunication rates. Additionally, most of the solutions (except for ARINC) are slow, making applications enabled from broadband services nearly impossible. Although many of these companies are investing in technologies to upgrade to higher service rates, we think that these services will never be able to provide economics of air-to-ground solutions given the high capital expenditure requirements from buying, launching, and maintaining satellites. In fact, the satellite providers seem to have lost interest in the airborne segment and are paying closer attention to land, sea, and military opportunities[8].

The current AirCell air-to-ground solution also has its limitations. Although it provides much higher transmission speeds, its coverage cannot be compared to that of satellite services as it is limited by the availability of a ground station directly in the line-of-sight of a flying aircraft.

[8] Home, Marvin. Interview by Anand Bhadouria Thursday, August 10, 2006

Additionally, this technology may have some redundancy issues given a localized outage (ex: electricity outage in region). A local outage could potentially disable multiple ground-stations that were in place for redundancy purposes.

Overall, the low adoption of alternatives could also indicate that these alternatives do not completely meet all core customer requirements. The current $70M market for airborne connectivity could significantly understate market opportunity for a new service[9]. The reason for this lack of adoption could be that customers across different segments are sensitive to four attributes when considering adopting an airborne connectivity solution: service price, installation costs, performance, and coverage. Service price influences the potential consumer's usage and the respective ROI per flight. As the Boeing effort demonstrates, the economics of a premium priced internet service do not make sense for commercial airlines. Installation costs increase the out-of-pocket expenses for airlines and raise the revenue requirements for airlines to achieve their ROI. These costs are especially important for commercial and general aviation segments[10]. Performance of the service limits the types of applications that can be provided (ex: video conferencing is not possible without high-bandwidth and low cost usage). Finally, coverage effects a potential provider's ability to switch a given aircraft's flying route. Table 4 summarizes the assumptions for potential differences in key requirements across various customer segments.

[9] Frost and Sullivan: F841-66 (2006)

Table 4: Customer requirements by segment

	Service price	Installation costs	Performance	Coverage
National commercial	High	High	Medium (depends on application)	High (should match airline flexibility)
Regional commercial	High	High	Medium (depends on application)	Low
Air cargo	Medium	High	Low	Medium
Private	Low	Low	High	High

AeroSat's Solution

An FAA-tested solution could potentially better meet key next generation FAA systems and broader market requirements. Pending further validation and testing, AeroSat's solution could provide the needed performance. AeroSat's solution deserves attention since it potentially meets customer needs with the right mix of low costs, high speed, broad coverage, scalability, and redundancy. AeroSat's superior cost position originates from the economics of its mesh architecture. Compared to traditional air-to-ground solutions, ground-stations enabled with AeroSat can achieve better utilization. The reasons for this are that through the peer-to-peer network capabilities, the effective coverage of a ground station will be extended. With a clear understanding of the competitive cost advantages, AeroSat might also be able to develop lighter and cheaper antennae. A second advantage is the greater bandwidth AeroSat can provide versus alternatives. Through the use of the Ku band, connection speeds up to 45 Mbps may be achieved. Finally, compared with traditional air-to-ground solutions, AeroSat can provide greater coverage. By extending network coverage and allowing it to potentially adapt to air-traffic patterns, connections can be extended over areas such as oceans. This also potentially provides better redundancy, since the communications link to one plane can potentially originate from ground stations that are very far apart.

However, there are a few requirements for this performance to be truly superior on a cost adjusted basis. First, it is assumed that the aircraft antennae can truly be designed to cost, and if not less costly, will be comparable to those of current alternatives. Second, it is assumed that network performance through this architecture is acceptable, providing the appropriate bandwidth, reliability, and latency. Finally, it is assumed that building redundancy into system will not require overly complex systems. At this point in time, these are assumptions that must be true for the performance benefits of AeroSat to be realized. Only through further testing and piloting of the approach will the final metrics be truly determined.

Financials

A third reason for FAA involvement is that a feasible financial model exists to attract investment. Figure 19 demonstrates a sample business model with attractive financials. This scenario is feasible in that it allows airlines to achieve their desired ROI and allows an investor a favorable IRR. Note that some of the primary assumptions in the model include: $50k airline subsidy, 43% revenue shared to airlines, consumer elasticity of $5 equals 16% usage, average passenger load of 100, average aircraft flights per year of 800, operating fee revenue of $50 per flight, antennae cost $125k, and a ground station cost of $200k. Additionally, terminal growth rates have a strong effect on the sensitivity, with the following relationships observed: 1% yields a 1% IRR, 5% growth yields an 8% IRR, a 10% growth yields a 24% IRR, and a 14% growth yields a 69% IRR.

Figure 20: Example of a feasible financial model for airborne internet

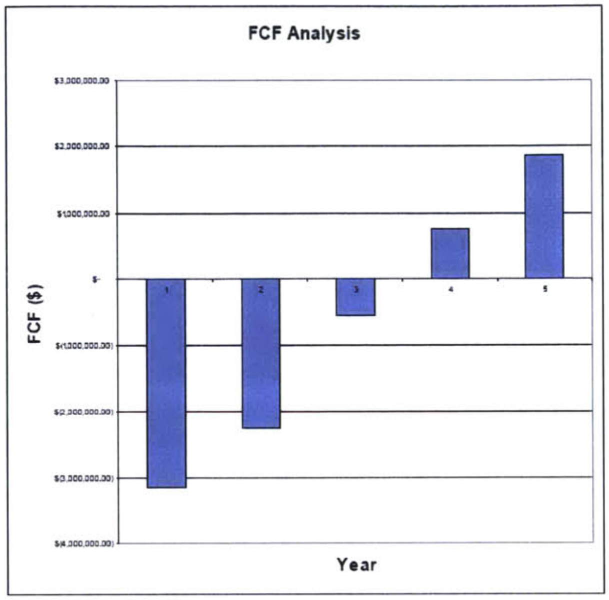
- Key assumptions:*
  - Adoption: 2% of market in year 5

Aircraft	10	40	70	100	130

  - Regional ground station rollout

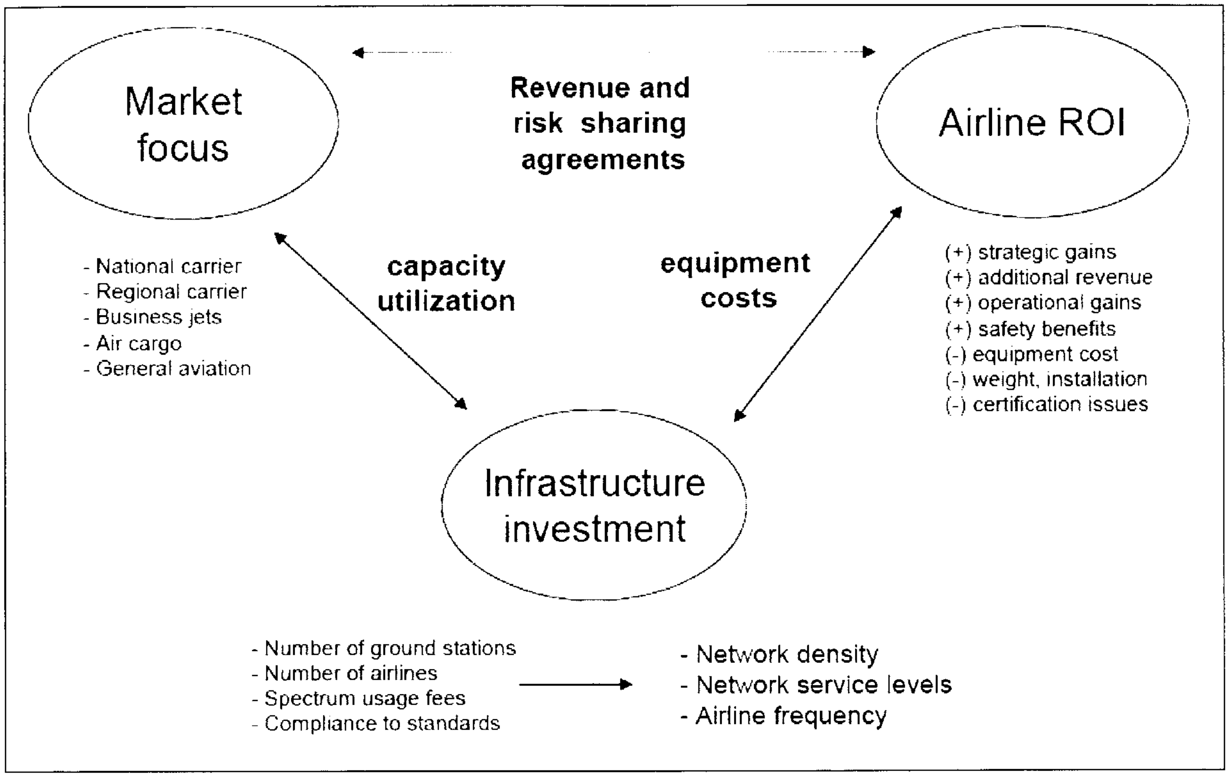
Ground stations	2	3	4	5	6

  - T3 capacity matching demand
- Preliminary estimate of returns:
  - NPV: $32 mm
  - Funding requirement: $7.5 mm
  - IRR for investor: 37%
  - Terminal value: $83 mm



The above is a sample scenario, but more generally, a successful business hinges on three key factors illustrated in Figure 20. These key factors are selected market focus, achieving airline ROI, and infrastructure investments. Changes in each of these drivers will effect decisions in the other. For example dependent on specific market focus, a specific ground infrastructure investment will be required and specific revenue sharing agreements will need to be instituted to achieve specific target airline ROI profile. A change in the initial ground infrastructure deployment will affect both the interest of an initial market segment as well as the equipment requirements or aircraft (affecting the airline ROI). Finally, sensitivities to ROI of different airline customers are likely to shift the specific target market segment decisions moving forward and the resulting ground infrastructure investments. Please note however that to truly determine the appropriate metrics inherent in a successful project and to improve likelihood of success, further testing and piloting of the technology is required.

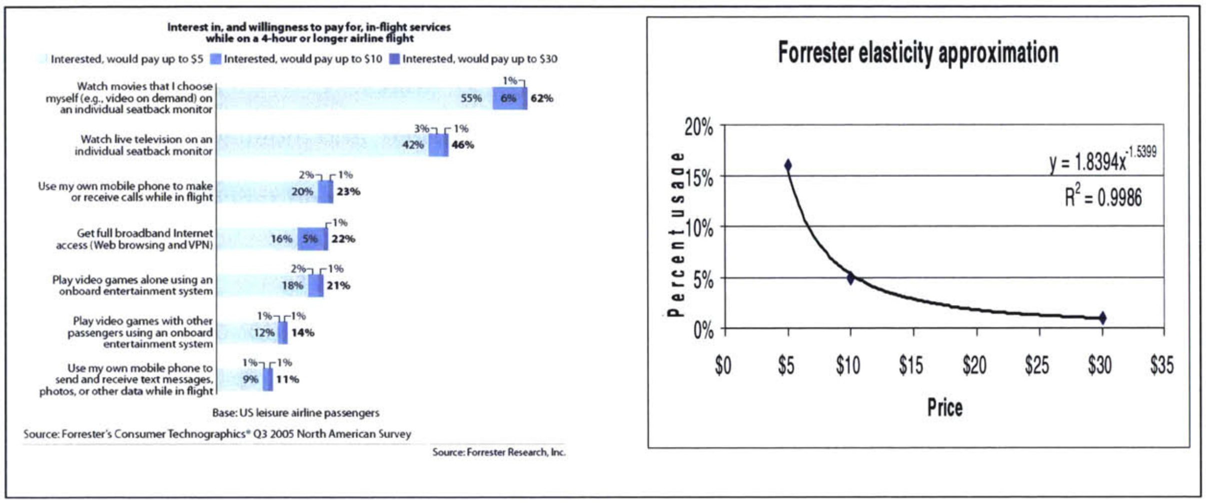
Figure 21: Major factors affecting airborne internet provider business model



The first driver is the specific market focus: national commercial, regional commercial, air cargo, or private. The revenue profile of the service changes depending on the specific choice. Based upon the assumption that it is likely that the profitability of bandwidth fees in ($/mpbs) will vary, the carriers wiliness-to-pay per flight will change, and the ability for the specific segment to absorb required FAA subscription fees will differ. For example, the commercial consumer elasticity between national and regional flights will vary partly based on demographic differences. The operational fees will differ based on the gains available in each segment – air cargo providers have different needs then the commercial segment. Finally, the private jet segment will potentially require higher network performance and utilize a greater portion of capacity from its applications.

It is worth mentioning that this analysis uses an average consumer elasticity based on Forrester research (see Figure 21). In reality, this elasticity is likely to differ between customer segments and is likely to influence potential deployment of the service. The assumption of single elasticity does not capture the reality of segment pricing variations. A more detailed understanding of price elasticity variations by segment can further help refine the assumptions made in this financial model.

Figure 22: Elasticity estimate from Forrester research



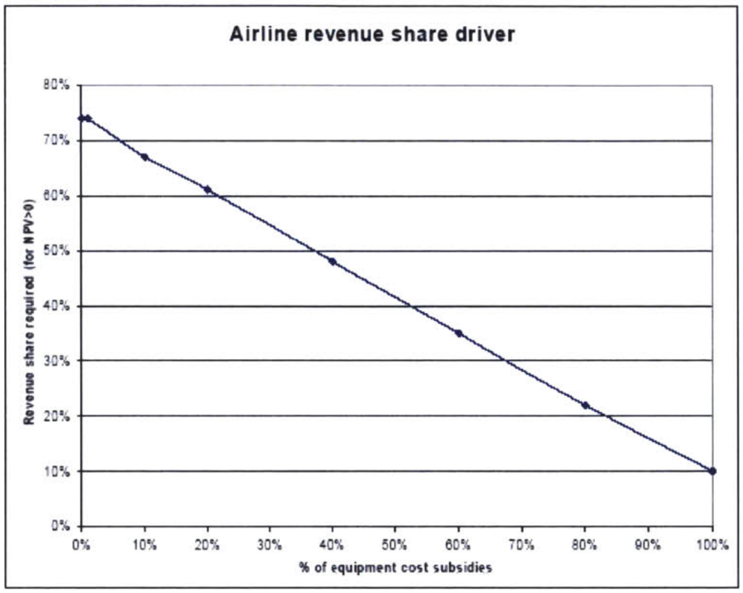
The second driver is the airline ROI. To justify any investment in any avionics equipment, aircraft operators across all segments (commercial, air cargo, and private jet) require a return on their investment. The return on investment by the airline is driven by the share of initial costs and depends on returns that they generate from the initial cash outlay. However, given the past failures it is likely that airlines are even more apprehensive about bearing the risk of paying for all equipment costs. In turn, the actual contractual agreements that specify the cost and revenue sharing required by participating aircraft operators are likely to differ. The differences will be a result of varying risk profiles and alternative views on potential benefits of airborne connectivity. The details of the contractual agreements driving the aircraft operator's ROI will affect both the revenue of the internet service provider and cash flows of the business.

For a potential participating aircraft, the costs of participating with an airborne internet network provider include purchase of expensive equipment, installation costs, certification costs, potential aircraft downtime, and any unforeseen risks from installation of this equipment. Certification costs are likely to be an issue for early. The higher the potential costs are, the greater the return of the project has to be (on a risk adjusted basis) to convince airlines to adopt the technology.

The potential benefits for participating, or the return on the investment, include additional revenues from connectivity, any revenue share from advertising fees, cost savings from operational benefits, advantage of differentiation in the marketplace, and meeting the FAA's interests. Each potential customer segment is likely to place different importance on each of these revenue drivers based upon the needs of their business. For example, air-cargo airlines will care much less about consumer services fees than commercial airlines (for obvious reasons). Additionally, depending on the strategic position of the airline operator within their industry (market leader, new entrant, etc), the operator is likely to value the short-term competitive benefits differently (ex: attracting customers from their main competitor by being the first with broadband access).

Regardless of their views on costs and revenue generating opportunities, the decision and resulting contractual agreements with airlines will affect the revenue that the service provider collects. Regarding risk, the aircraft operator's initial position will determine who will bear the burden of initial equipment costs. Regardless, the more that the initial service provider pays for aircraft equipment installation, the less revenue they are likely to share. Figure 22 quantifies this relationship in detail for a potential agreement with a commercial airline. For this analysis it was assumed that a commercial airline will accept a 0 NPV project just for consumer revenue sharing services given additional competitive benefits and potential operational cost savings. One important point to consider is that a greater portion of subscription fees are required for every dollar that an airline spends versus every dollar that a service provider spends – this is due to potentially different cost of capital of airlines versus service providers.

Figure 23: Revenue and risk sharing relationship for a potential commercial airline



The third factor driving a successful business model for an airborne internet network provider is the development of an infrastructure that matches the segments needs and also maximizes the use of capital invested. The decision about the initial infrastructure developed is potentially driven by the risk profile of both investors and management team, and will dictate the initial decision between employing a regional or national strategy. However, this will strongly affect both the initial and phased investment in fixed, semi-variable, and variable costs.

The fixed costs for the business are the ground stations and infrastructure investments required to connect ground stations to backbone. Any potential spectrum purchase fees might also be a fixed cost if a fixed fee is paid to use the spectrum for a specific number of years. The semi-variable costs include additional expenses to run a connection service provider such as a

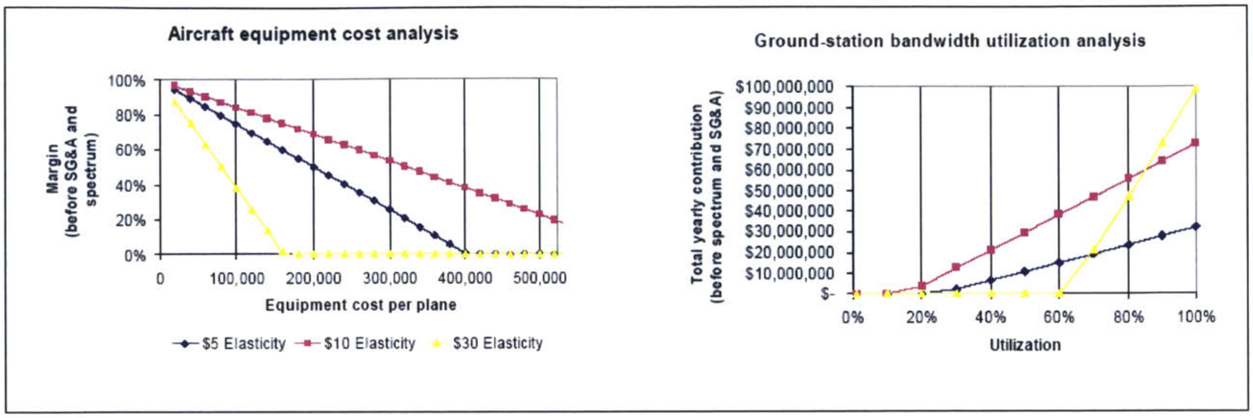
NOC (network operating center), ground station maintenance costs, costs for antennae subsidy to aircraft operators, and any general administrative expenses. Finally, the variable expenses are monthly fees for leased bandwidth for backbone operators. Table 5 summarizes the costs and assumptions made for this feasiblity model.

Table 5: Example of infrastructure cost assumptions

Type of costs	Details	Estimate
Fixed costs	- Spectrum fee - Ground stations - Interconnection to backbone	- 1.6 Mil (annually) - 250 K/ per ground station - 24 K
Semi-variable costs	- Ground station maintenance - Antennae cost (full subsidy) - SG&A (includes network operating center costs)	-25 K -105 K -?
Variable costs	- Leased bandwidth	-3 K/ per T3 line

The second infrastructure component that drives a successful business model is the management of investments to achieve maximum utilization. It is important to consider what issues help drive the generation of margins. High ground station utilization and low equipment costs are critical. Figure 22 describes this analysis. Note that this analysis is for pre-revenue share agreements and assumes 100 person planes, with a 10-year life, and consumer connectivity fees per user on a per flight basis. The margin analysis (left chart) presents the potential margins generated on a per ground basis, while the utilization analysis (right chart) presents margin generated for a potential network in aggregate.

Figure 24: Investment management (margin & utilization) analysis



The first component is equipment cost. Outside of the revenue share component, the variable cost of providing equipment is sensitive to consumer usage. Again, higher prices for the consumer imply less usage per flight, which leads to lower revenues per plane over the lifetime of the service. This creates a lower pricing threshold for antennae costs – antennae cost have to be less than this price to generate the required margins. The second component is ground station utilization. As the right graph illustrates, the ability for the entire service to generate margins relies on the use of available capacity for ground station investments. The ability for a ground station to generate free cash flows (before any spectrum or SG&A expenses) was examined. Assuming different consumer usage revealed that as consumer pricing goes higher, and usage per flight decreases, a higher utilization threshold is required for each ground station since each airplane has fewer active connections. Both graphs indicate that a lower cost service improves the likelihood of achieving utilization per flight resulting in greater probability of positive margin generation.

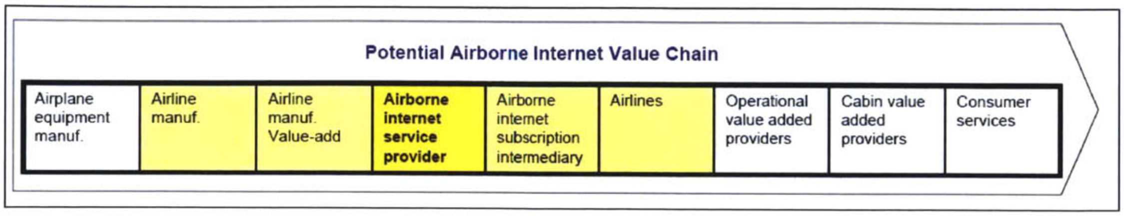
Overall the infrastructure deployment factor is a critical decision in the business model since it affects the free cash flows generated in the business. Any infrastructure deployment plans need to match the needs of the target segment, and must consider the specific ROI contracts for aircraft operators. Managing aircraft equipment cost and maximizing capacity seem to be key for sound financials. On a historical note, it is interesting to consider that Boeing's approach relied on expensive equipment for aircraft and one time massive infrastructure deployment. Neither of these decisions helped the business generate sufficient cash flows.

To reiterate, feasible financial models exist for a potential airborne internet network provider. Broadly, the successful model selected had an appropriate combination of the target market segment, contractual ROI agreement with aircraft providers, and infrastructure deployment strategy. However, as Appendix 5 illustrates, there are other potential scenarios for business that need to be considered. Success will be achieved by pursuing and executing on an approach that effectively meets the needs of stakeholders and matches market environment at the time of deployment.

Ecosystem

To be successful, airborne internet needs an ecosystem; the FAA's work with AeroSat can help develop such an ecosystem. The ideal ecosystem to promote adoption would be one that is comprised of members across the value chain. Given the different characteristics and market power of the different members, the FAA can play a very influential role. Working with AeroSat to validate a potential approach to low-cost mass market airborne internet service, the FAA can begin to develop relationships with companies that need to be part of the ecosystem. Figure 10 demonstrates a potential ecosystem composition.

Figure 25: Potential ecosystem composition of airborne internet value chain



By clearly promoting an ecosystem, the connectivity proposition becomes more of a turnkey solution for airlines. For example, a close relationship with consumer service providers and in-cabin flight solution providers can drive adoption of consumer usage. As discussed above, consumer usage is a success driver because it increases the feasibility of achieving airline ROI goals. As another example, potential collaboration with airplane manufacturers can reduce airline installation and equipment cost, further promoting the adoption of the service.

One point of distinction is that ideal ecosystem is likely to vary by customer segments. For example, the goal of the commercial airline ecosystem should be to increase consumer usage. An ecosystem tailored for the air cargo segment should help providers realize operational improvements (ex: asset tracking and capacity management software providers). Finally, the private jet segment ecosystem should include private jet leasing suppliers to reduce the direct selling expenses involved in penetrating this market.

Finally, there is one more member in the potential airborne internet value chain that deserves attention. There is room for an “airborne internet subscription intermediary” in the value chain. This member will have the critical role of helping execute revenue sharing agreements between the airborne internet service provider and the airlines. Initially revenue sharing is likely to occur only with subscription fees. As the market develops it is likely that additional sources of revenue, such as advertising, can be shared across the value chain. Through the airborne internet subscription, intermediary airlines can have more options to achieve their target ROI, increasing the overall feasibility of the effort. This intermediary can potentially be a new entrant, or its role might be fulfilled by existing service providers who have the billing and tracking capabilities that this agent requires.

Standards

Finally, continued FAA-AeroSat collaboration will help validate the specific technology and enable evaluation and the role of standards. By working to pilot the technology, the FAA can help better understand the requirements that will help them achieve their SWIM vision, while still considering the current regulatory constraints and regulations around the use of spectrum. Overall, the FAA can better understand the necessary specifications for a potential standard.

The exact position of FAA on standards is yet to be decided, but testing and assessing the AeroSat solution can give some guidance to the market. If a standardized path is selected, potential benefits include accelerating adoption and influencing the implementation. Given the historical context of providing airborne internet, using standards to assure consistency and openness of solutions, the FAA can help ease airline fears of purchasing obsolete equipment. FAA can also help achieve the critical mass in the early stages to improve the feasibility of the service. Additionally, by guiding and influencing the product development, the FAA can help assure that the needs of aviation industry and consumer are considered in early design stages. As the FAA considers its role in standardization, it is important that it examine the potential disadvantages including reducing the rate of innovation for new technologies by supporting a specific approach and potentially influencing market adoption of a specific initial solution.

Returning to the specifics on the FAA and AeroSat collaboration, the overall arguments seem to be positive. First, with continued pilot tests one can help evaluate the merits of the spectrum-based approach and planned integration to SWIM. Second, the FAA can better explore its requirement as potentially pivotal user of the system. Third, the FAA can better understand the needs of airlines and consumers, risks, and issues of most importance before making commitments to any long-term path. Finally, by testing the ideal spectrum-free approach, more information can be gained when considering standardization decisions related to spectrum-flexible (ultra-wideband) approaches.

Key Risks

It is important to consider the key risks for solution ecosystem partners, investors, and the FAA. First, AeroSat has not secured spectrum usage and details on actual costs are still unclear. Ideally, if AeroSat was able to secure spectrum usage at an extremely attractive rate business feasibility would be more resilient to potential obstacles. For this analysis, a spectrum rate of $1.6mm per year was assumed.

The second major risk is achieving the required network performance in the target budget. As this discussion has highlighted, only through more testing and piloting of the system will the true performance of the costs be better understood. Once this is known, then the required infrastructure investment can be more accurately determined.

Third, there are risks related to the rate of acquisition of participating airlines. A successful model assumes a customer acquisition rate (in terms of number of participating commercial aircraft) above 100% compound annual growth rate. Given the complex certification processes and installation costs, it is critical that airline customers make fleet level commitments to install this equipment. These types of decisions take time and therefore the 100% CAGR requires close attention and is a key risk to success. However, given that even this aggressive growth rate represents approximately only a 2% penetration of the commercial market (as calculated using number of aircraft), the effort may not be impossible.

Fourth, there are risks revolving around achieving necessary consumer usage at the estimated price sensitivities. As discussed, it was assumed that Forrester's approximation would generally describe entire market behavior, but in reality the elasticity may be better or worse. As Boeing's effort demonstrated, a high-priced offering does not promote mass adoption; therefore it is critical to consider potential price sensitivity differences across different customer segments. Failing to achieve the necessary consumer usage will dramatically affect the ability for airlines to achieve their required ROI.

Finally, the other major risks include unforeseen changes that effect aviation and air travel as well as the potential emergence of spectrum free alternatives. Unforeseen changes in aviation, such as laptop restrictions due to security concerns, will greatly affect usage. Any policies that are justifiably adopted to reduce travel risk given threats from terrorism will impact the financials of the service provider. The potential emergence of spectrum-free alternatives (which rely on ultra-wideband type technologies) are worth noticing as they can potentially disrupt the provider's economics. In the spectrum-based world, those who have invested heavily in spectrum expect to recuperate their investment from fees that their service generates. Spectrum-free approaches will force providers to potentially provide new customers with a spectrum-free solution, while continuing to serve existing customers with spectrum-based approach to help them avoid high switching costs. Spectrum-free approaches might also potentially make it easier for potential entrants to enter the market.

Key Factors for Success

Given these risks, the model that can potentially succeed will rely on: a sustainable advantage from lower costs, a regional to national development strategy that relies on network growth, growth potential and terminal growth rate in year 5, clear understanding of strategic issues, smart decisions about initial target customer segment, competitive strategy issues (build vs. buy preferences for incumbents), positioning around open industry standard & licensing of core IP, a phased financing strategy, effective marketing, sales, and channel strategy, the ability to adjust to technology shifts, spearheading the development of the right ecosystem, and prioritizing FAA needs effectively integrating them to the service. Table 6 summarizes some of the key strategic decisions that need to be made and related comments.

Table 6: Summary of key strategic decisions

Decision	Comments
Target customer segmentation and prioritization	-Determine based upon contribution to overall network performance - Shift as network effect starts and network grows
Business/partnership model	- Partnership model with airlines - Potential need for alignment with incumbent MSS provider - Potential need to license mesh capabilities and partner with ATG provider
Standards strategy	- Work with industry to define standard that leverages core IP - Work with FAA to become a provider of potential standard
Product development strategy	- Focus on delivering fast network performance
Phased financing strategy that matches growth	- Hedge risks and control cash-flows
Marketing, sales, and channel strategy that scales gradually	- Market to segments required to drive demand - Distribute to segments required to maximize utilization - Spearhead ecosystem to promote use of overall network

General conclusions

Overall, an opportunity may exist for Aircell and Aerosat to provide a new airborne internet solution that has a sustainable business model. However, further business analysis and technical demonstration work is required. Although the simulation in December will be useful in providing some additional insight, it will not provide all the information – further testing, research, and analysis is required. Issues to explore include: additional technical feasibility demonstrations, identifying key customer segments required for performance, finalizing financial requirements for the business once network performance is understood, understanding the technological advantages of the current approach, and understanding the potential to develop standards and implication to UWB.

The model that meets all stakeholder interests involves a low cost proposition that drives the economics, good capacity utilization of ground station investments to promote margins, airline reward/risk sharing to promote adoption, and phased financing and effective collection for alignment with investor goals. The FAA's involvement with a potential provider is generally positive in that it helps to create a solution that benefits all constituents in the aviation industry. Support from the FAA can help promote more rapid adoption by easing certification costs and promoting a faster uptake by airlines. Additionally, it can indirectly establish the right market environment to facilitate the deployment of the service.

APPENDIX 1: MEETING FAA INTERESTS

The airborne internet is very important for the FAA since it has the potential to provide significant cost savings for both the FAA and aircraft operators. Leveraging an airborne internet network, the FAA might be able to consolidate many functions into one common data channel. Although there are a number of other applications, for the FAA, the primary applications for airborne internet network include tracking aircraft for air traffic control system SWIM, and ADSB.

The principle behind the airborne internet is to establish a robust, reliable, and highly available digital data channel for aircraft. The establishment of a general purpose, multi-application, digital data channel connection to aircraft is similar to the establishment of a local area network connection to a desktop computer that then expands to a wide area network. As more aircraft join the network, potentially a larger network can be established. However, there are differences between the desktop/local area analogy and airborne deployment. Aircraft are mobile objects that are moving at a speed of 500 mph. An aircraft requires mobile routing to maintain the constant data channel connectivity when the aircraft moves across regions. With enough aircraft using an airborne internet, there is the potential to create a network in the sky. At any given moment, there are anywhere between 4500 to 6000 aircraft flying over the United States. Using the thousands of “en-route” aircraft, it is possible to create a communications “mesh” that would increase bandwidth dramatically and potentially reduce the costs for data transfer. Implications would be not only to reduce equipment and system costs, but also to potentially create a new revenue stream for air carriers.

The idea of an airborne internet is to have all aircraft share broadband data amongst themselves and with a ground infrastructure. For the FAA, this would allow them to push new applications such as:

- Improved flight deck functionality using the Collaborative Information Environment (CIE) to transform the flight deck from a relatively static information user to a dynamic node on an information network.
- Flight deck applications could be commanded and controlled by the flight crew s voice rather than mouse, keypad and pointing devices
- Using TCP/IP and XMLWeb Services, the Airborne Internet CIE will provide the foundation upon which numerous new applications can be used by the people in aircraft
- Airborne Internet CIE applications could include the System Wide Information Management (SWIM)
- Controller Pilot Data Link (CPLDC) regularly downloading of the aircraft s 'black box' data, priority TCP/IP message delivery
- Voice over IP (which then could be used as voice in the Oceanic or Gulf of Mexico airspace),
- Enhanced weather information,
- Airport/Facility Directory
- Telemedicine
- Homeland security functions
- Electronic flight bag applications such as conflict detection and avoidance
- Receiving in-flight weather reports, sending engine and aircraft monitoring information to the ground,
- Enabling pilot-dispatcher communications, receiving gate assignments
- Flight crew scheduling, pre-departure clearance transmissions and oceanic position reports

The airborne internet will be a key element for the planned improvements in the National Airspace System (NAS). The current NAS systems are mostly hard-wired using point-to-point configurations and they do not share information with each other. It has individual data management processes which make it expensive and inefficient. More importantly, it is not readily available to all “stack” holders. To address this issue the FAA has initiated the SWIM Program, or System Wide Information Management. SWIM will develop and implement policies, standards, infrastructure, and tools that permit NAS-wide information sharing. With the implementation of SWIM, the FAA might be able to move to a network enabled, or network centric, operation. Network enabled operations would link individual systems together and allow them to operate. It would provide the ability to securely access the right information, in the right format, at the right time, and at the right location. Ultimately, integration with the systems and sensors from other agencies would allow the FAA to share information with homeland security, national defense, and other governmental purposes. SWIM will be an IP-based system that would deliver game-changing cost benefits. By applying a modern information management approach, SWIM could bring value to FAA legacy systems and also create a platform to add future systems.

APPENDIX 2: AIRCRAFT QUANTITY USED TO DRIVE SEGMENT SIZE ESTIMATES

	2005	Estimated 2014	CAGR
National commercial	3953	5481	3%
Regional commercial	2862	3851	3%
Air cargo	1021	1345	2%
Private	214,591	252,775	1%

APPENDIX 3: FREQUENCY DEFINITIONS

- L band:
  - Frequency range between 390MHz and 1.55GHz
  - Used for satellite communications and for terrestrial communications between satellite equipment.
- S band:
  - Frequency range from approximately 1.55 to 5.2GHz
  - Used for Digital Audio Radio Satellite (DARS) satellite radio systems and by some weather and communications satellites.
- The Ku band:
  - Uplink uses frequencies from 14 to 14.5GHz and the downlink uses frequencies between 11.7 and 12.7GHz.
  - Air-to-ground solution

APPENDIX 4: COMPETITOR SWOT ANALYSIS

AirCell

Product
• Satellite transceivers • Air-to-Ground Broadband -3.1 / 1.8 Mbps per Sector(150-500 U.S. Sectors) • Satellite Broadband – 25-35 Mbps per Transponder (Ku), 64-432 kbps per Channel (L-Band) • The patent also supports multiple communication protocols, such as CDMA (Code Division Multiple Access), GSM (now Global System for Mobile communications), and so forth. • Voice and Data Service:

Strengths	Weaknesses	Opportunities	Threats
• low cost • first to market • own spectrum • land coverage area	• reliance ground station • spectrum limitation • smaller player • redundancy	• domestic airline market	• new entrants (low cost, better technology) • don't go over water (geographic dependency)

Boeing (potential acquirer)

Product Offering
• The infrastructure uses a phased array antenna or a mechanically steered Ku-band antenna on the aircraft, leased satellite transponders, and ground stations • Very expensive (The current prices are $9.99 for one hour of access, $14.95 for two hours of

access, $17.95 for 3 hours of access and $26.95 for flat-rate)

Strengths	Weaknesses	Opportunities	Threats
• global coverage • proven technology • relationships	• high costs • no diverse revenue stream • no support from FAA • fiscally strong	• be sold for cheap • reduce costs	• low cost (newer technology)

Immarsat

Product offering			
• Three levels of terminals, Aero-L (Low Gain Antenna) primarily for packet data including ACARS and ADS, • Aero-H (High Gain Antenna) for medium quality voice and fax/data at up to 9600 bit/s. • Aero-I (Intermediate Gain Antenna) for low quality voice and fax/data at up to 2400 bit/s. Global beam coverage. Each satellite is equipped with a single global beam that covers up to one-third of the Earth's surface, apart from the poles.			
Strengths	Weaknesses	Opportunities	Threats
• global coverage • diverse revenue stream (marine and land), cross-subsidize • fiscally strong • most reliable	• reliance satellite • require handheld equipment • more expensive • core business not air	• air is potentially big market • defense market • hybrid system	• alternative architectures • distracted

satellite network in the world • larger share of			

Iridium

Product Offering			
• Direct Internet Data Service provides connectivity from a PC, through Iridium phone. • Speed 2.4 Kbps, cross-linked satellites, Meshed network, 66 satellites, satellite lifetime 7-9 years, telephone MHZ band, intersatellite links (GHZ band), ground segment (GHZ Ka band) • Offering service in oceans, air, earth through satellite by meshed network			
Strengths	**Weaknesses**	**Opportunities**	**Threats**
• global coverage • larger share of existing air market • remote applications (private air)	• to expand they are satellite dependent • air is likely private jet and DOD • not cheap, satellite reliant (commercial segment) • reliant on handheld device		• low cost alternatives in land market

Thuraya

Product offering
• Using GSM phone through Satellites • Up to 9600 Bps per channel

• 145 countries coverge

Strengths	Weaknesses	Opportunities	Threats
• remote land is strength (small handheld) • low profile antennae size	• limited focus on air market (if anything private jet) • ability to work in bad weather • smaller competitior	• telematics may be an opportunity	• losing maritime battle • low cost land based solutions attacking many segments

Globcomm

Product offering			
• Service through hand held service			
Strengths	**Weaknesses**	**Opportunities**	**Threats**
• satellite dependent	• telephone focused (reliant on specific handset) • focus is not air passenger market • ability to work in bad weather	• expanding capacity • partnering with telematics providers	• low cost land networks • may look for alternative markets

Verizon Airfone

Product
• Satellite transceivers

• Airfone Service offers voice, data & fax calling to and from the aircraft. • Verizon's ground station network allows calls to be placed to anywhere in the world while flying over the contiguous U.S., southern regions of Canada, Mexico and within 200 miles of the U.S. coastline • Verizon offers mainly voice service but you can use for Internet using there phone infrastructure. • Connection fees $3.99 , after that per minute $4.99 • 9.6kbps data transfer • Verizon has determined to exit the air-to-ground business by December 4, 2006.

Strengths	Weaknesses	Opportunities	Threats
- high cost - first to market - land coverage area	reliance ground station - Huge network - redundancy	- domestic airline market	- new entrants (low cost, better technology) - don't go over water (geographic dependency)

Row 44

Product
• Row 44 is working in conjunction with Hughes and their HughesNet® broadband satellite service • Low profile, lightweight, self-contained radome-based system • Broadband Data: 30 Mbps peak to the plane • Streaming Entertainment: 45 Mbps to the plane (>100 television channels)

- Self-contained system requires only power from the aircraft
- The system can be installed in just two overnights
- Voice and Data Service
- Broadband: Internet/Email via WiFi and/or wired IFE system
- Satellite Service: Ku-band service with separate links for data and streaming entertainment using the same antenna.
- Supported Airframes: RJs, single-aisle aircraft, wide-body aircraft

Strengths	Weaknesses	Opportunities	Threats
low cost - offering variety of services - land & sea coverage area	- reliance ground station - smaller player - redundancy	- domestic airline market -global opportunity - Availability Flight Trials: 1st Quarter 2007 General Availability: 3rd Quarter 2007	- new entrants (low cost, better technology)

Telenor Satellite Services

Product			
• Satellite transceivers • Dial-Up Data Service at rates up to 2.4 kbps • Voice and Data Service:			
Strengths	**Weaknesses**	**Opportunities**	**Threats**
- global coverage	- to expand they are	- domestic airline	- new entrants (low

- larger share of existing air market - remote applications (private air)	satellite dependent - air is likely private jet and DOD - not cheap, satellite reliant (commercial segment) - reliant on handheld device -veryslow	market -global market -Air -Sea	cost, better technology)

Starling Advanced Communications – Equipment provider

Product			
• Satellite transceivers • Air-to-Ground Broadband - Tx Bit Rate 512 Kbps Rx Bit Rate 4-7 Mbps • Satellite Broadband – low profile Ku band antenna • Internet access, VPN, PDA, VoIP, mobile phone, e-mail and video conferencing to online gaming			
Strengths	**Weaknesses**	**Opportunities**	**Threats**
-Full testing and regulatory approvals are expected by mid-2006.	- Antenna based - smaller player - redundancy -slow speed	- domestic airline market -global market	- new entrants (low cost, better technology)

APPENDIX 5: FINANCIAL MODEL SCENARIO ANALYSIS

	Low cost regional	Mid priced regional	High priced regional	Low cost national
Price to consumer [1]	$5	$10	$25	$5
Airline revenue share [2]	40%	57%	94%	40%
Customer acquisition CAGR (max planes)	109% (190)	172% (550)	169% (640)	144% (280)
Service provider valuation	$39.6 mm	$41.9 mm	$42.1 mm	$75.2 mm
Funding requirement [3]	$5.7 mm	$7.0mm	$7.0 mm	$20.6 mm
IRR [4]	20%	20%	0%	20%
IRR with carrier fees [5]	37%	56%	20%	61%
Notes	• Relatively good profile for potential investor • Lowest revenue share	• Customer acquisition rate rapidly increases • Capital employed for	• Plausible model only with carrier fees • Model doubled selling costs	• Assumed double selling costs • Assume 4% increase in terminal

	to airlines	model falls	• Lowest capital employed	growth rate assumption from network effects

[1] Elasticity determined from Forrester 2005 Research Study Data;

[2] Revenue share to airline assumes satisfaction at 0 NPV project from consumer revenue sharing given additional potential benefits;

[3] Funding requirements determined from FCF projections;

[4] IRR includes $10 mm development fee addition to calculated funding requirement assumption;

[5] Carrier fees assumed at $25 per flight and spectrum cost assumed at $1.6 mm per year

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