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701 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
202 434 7300
202 434 7400 fax
www.mintz.com

Howard J. Symons

Direct dial 202 434 7305
HJSymons@mintz.com

July 13, 2004

SUBMITTED ELECTRONICALLY – VIA ECFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: WT Docket No. 03-103; Ex Parte Submission of The Boeing Company

Dear Ms. Dortch:

The Boeing Company ("Boeing") hereby submits the attached technical paper, "Boeing ATG Update Report" (the "Boeing Report") in the above referenced proceeding. Boeing has participated in this proceeding on behalf of its business unit, Connexion by Boeing[sm] ("CBB"), which provides mobile broadband service for the commercial aviation industry. In this proceeding, Boeing has urged the Commission to adopt rules that ensure open competition in broadband air-to-ground services in the United States.

The Boeing Report is designed to (1) generally reflect the company's latest thoughts regarding the FCC's Air-to-Ground ("ATG") proceeding; (2) further evaluate the proposals submitted by other parties in this proceeding regarding the use of the ATG spectrum; (3) respond to the inaccurate and outdated criticisms of Boeing's proposals made by Verizon Airfone and its contractor, Telcordia Technologies; and (4) respond to inquiries made by the FCC's staff regarding the cost and availability of antennas that would be used in Boeing's proposed system.

In particular, it is apparent that there are several approaches under which multiple providers can be authorized to provide ATG services at 800 MHz. Boeing therefore recommends that the FCC and all interested parties focus on the development of spectrum sharing rules that enable multiple parties to offer ATG service and allow implementation of a variety of technical solutions.

With respect to specific proposals submitted in this proceeding, the Boeing Report concludes that the Skyway Aircraft ("Skyway") plan is flawed because it promotes the same narrowband system that has proven unacceptable to date. The Space Data Corporation ("Space

Data") proposal relies on a premise – the use of passenger devices for off-board communications – that has already been rejected by the FCC. By contrast, AirCell's proposal, which permits the authorization of multiple providers, merits further consideration.

Verizon Airfone ("Airfone") continues to propose a band plan that would foreclose the opportunity to have competitive providers of ATG service. In addition, Airfone and its contractor, Telcordia, mischaracterize Boeing's position on several matters. Contrary to the Verizon assertion, Boeing does not propose that ATG service providers be required to use any particular implementation or technology. Instead, Boeing proposes that the FCC adopt sharing rules that establish inter-system interference limits that provide protection to all service providers and allow each to choose their own technology. Boeing has provided a reference system design to demonstrate that there is at least one implementation method that is both affordable and has the capacity to serve the expected market. Boeing's proposed design uses "plain old" segmented base station antennas, which are ubiquitous in the cellular phone industry, and a directional aeronautical antenna.

The Boeing Report also provides additional detail on the grid approach to base station separation, which could permit four ATG providers when used in conjunction with the directional antennas proposed by both Airfone and Boeing. Finally, in response to questions from the FCC's staff, the Boeing Report addresses the cost and feasibility of Boeing's proposed phased array antenna. The report notes that the switched beam phased array antenna proposed by Airfone is compatible with Boeing's multi-system sharing approach. The cost of using Boeing's proposed antenna system is approximately $50,000 per aircraft installation (in shipsets of 1000), which compares favorably to satellite based systems, where the cost is approximately $168,000 per aircraft. While Airfone has criticized the cost of Boeing's proposed aeronautical antenna, that antenna is nearly identical to the antenna that Airfone has proposed using and is testing under an experimental license issued by the FCC.

Please contact the undersigned if there are questions regarding the Boeing Report.

Cordially yours,

/s/ Howard J. Symons

Howard J. Symons

Attachment

Boeing ATG Update Report

7/13/04

Michael de La Chapelle
Boeing Technical Fellow

Jeff Cunningham
Senior Systems Engineer

Janet King
Senior Systems Engineer

Introduction and Summary

This report updates the Boeing Company's (Boeing) proposal for the licensing of Air-to-Ground (ATG) services in the 800 MHz spectrum in light of the additional information recently presented to the FCC by other parties. We also present our evaluation of other ATG proposals that have been submitted in this proceeding. Additionally, this report responds to questions posed by Telcordia Technologies, a consultant for Verizon Airfone (henceforth referred to as Airfone), regarding the cost and feasibility of Boeing's proposed aeronautical terminal.

We believe that the antenna issues raised by Airfone are moot because the switched beam directional antenna design proposed by Airfone is fully compatible with Boeing's spectrum sharing proposal, and we believe that either directional antenna design (Boeing's or Airfone's) will allow multiple service providers to share the ATG spectrum. Boeing also responds to inaccurate assertions from Airfone/Telcordia regarding the required size of the aeronautical antenna.

With respect to our own proposal, Boeing presents additional information on the required spacing between base stations that will achieve spatial discrimination sufficient to support four service providers. In particular, we discuss performance sensitivity to base station spacing and off-grid placement. The results indicate that the proposed concept is feasible over a very wide range of base station spacing and is tolerant to off-grid base station location.

At our last meeting with FCC staff, Boeing was asked about the size, weight and cost of Boeing's proposed aeronautical terminal. To achieve greatest fidelity, Boeing has created a preliminary design and obtained cost estimates from suppliers. The estimated aeronautical terminal price is $50,000, less expensive by a factor of three than the least expensive satcom terminal. More detail is provided in the discussion of Aeronautical Terminal Design.

Finally, we believe the Commission can and should adopt spectrum sharing rules that would permit the operation of multiple ATG providers, rather than prescribe the use of a particular technological solution. We outline the elements of sharing rules that would accommodate the dissimilar approaches proposed by AirCell and Boeing, and would be compatible with the directional antenna design proposed by Airfone.

Boeing's Position

Boeing believes that the traveling public would be best served by having broadband connectivity on commercial aircraft and private business jets to enable access to the Internet, TV viewing, and voice services. Boeing has made significant investments through its business unit, Connexion by Boeing (CBB), to make this happen. We are the first to offer truly broadband Internet service on commercial aircraft using a satellite based network, and we have contracts with several international airlines. Boeing also expects to offer broadband connectivity services to passengers on the U.S. domestic

fleet, and, as a service provider, desires to use the most cost-efficient technologies available. While satellites are the only means of providing service over oceans, and are the most cost efficient way to deliver certain types of services (such as TV), terrestrial systems may offer significant competitive advantages over satellite systems in delivering certain service offerings over land. Only a licensing scheme that accommodates multiple terrestrially-based providers will ensure the competitive availability of the full suite of broadband connectivity services within the continental United States.

To this end, Boeing recommends that the FCC and all interested parties focus on the creation of spectrum sharing rules that allow a wide variety of technical implementations while limiting the amount of interference into any one system from all other systems. Boeing believes that a major failure of the existing rules is that they are too closely tied to a particular implementation and do not give service providers the flexibility to expand into new services such as broadband.

The Big Picture

Using the legacy ATG technical solutions (omni aircraft and base station antennas, single polarization, etc.), there is insufficient capacity in the ATG band (2 MHz up and down) to offer broadband services to the entire commercial airline market in the U.S. (thousands of aircraft having over 100 seats each). Use of modern CDMA cellular communication standards (i.e. CDMA20001xevDO) enables broadband communication to the aircraft, but by itself does not sufficiently increase the capacity of the ATG band. To support the entire market, spectral efficiency in the ATG band must be increased. Boeing, AirCell and Airfone/Telcordia all recognize this, and all three have proposed approaches to increasing spectral efficiency. Table 1 summarizes these approaches.

	Spatial Diversity, Directional Aero Antenna	Spectral Diversity, Channel Staggering	Polarization Diversity, V and H	Cross Duplex Operation	Segmented Base Station Antennas
AirCell		x	x	x	x
Airfone	x				x
Boeing	x	x			x

Table 1. Summary of proposed methods for increasing the capacity (spectral efficiency) of the ATG band.

Both Boeing and Airfone have proposed using directional aeronautical antennas to reduce the interference produced by each aircraft by a factor of approximately 6, relative to omni antennas. AirCell has proposed using polarization diversity and cross duplex operation. Polarization diversity by itself nearly doubles the capacity of the spectrum. All three companies have also proposed using segmented base station antennas, which can also increase capacity by several times. All these approaches are compatible and can be combined to achieve a spectral efficiency 10-100 times greater than the legacy ATG technical solution. This improvement can be achieved with off-the-

shelf cellular technology, and even greater capacity is possible using the most advanced available cellular technologies (smart antennas, adaptive beam forming, etc.). Moreover, the same methods that increase spectral efficiency can also provide isolation between multiple systems.

Evaluation of Other Proposals

This section is a brief summary of Boeing's evaluation of other proposals for the ATG band on public record at the FCC.

Boeing disagrees with Skyway Aircraft, Inc.'s (Skyway) proposal that the existing ATG rules should remain unchanged. It is widely acknowledged that ATG services under the existing rules are limited to narrowband only, are expensive, and are largely unprofitable for the service providers. The current rules have satisfied neither the traveling public nor the service providers. Without more detail on their technical approach, including supporting analyses or measured data, we cannot accept Skyway's claim that broadband connectivity is possible using existing ATG rules.

Boeing also disagrees with the proposal from Space Data Corporation to use the ATG spectrum for stratospheric communication. The ATG band is allocated for communication between aircraft and ground, not for communication between aircraft and stratospheric platforms (balloons, etc.). Furthermore, the Space Data proposal may be unsafe (high RF radiation levels from passenger wireless devices), unreliable (shielding of aircraft fuselage can prevent long distance off board communication), impractical (unrealistic to expect that passenger wireless devices would be modified to operate in the ATG band) and unaffordable (stratospheric platforms are far more expensive to operate than terrestrial infrastructure).

AirCell, Inc. has presented a proposal with supporting analyses for an implementation that allows four service providers to share the ATG band. AirCell's proposal to use both vertical and horizontal polarizations effectively doubles the capacity of the spectrum, and the feasibility of this approach has been demonstrated with AirCell's current service. The controversial aspect of AirCell's proposal is the use of "cross duplex" operation to achieve isolation between service providers. Boeing initially was concerned about aircraft-to-aircraft interference using this approach, but AirCell's latest FCC submissions present credible analytical results demonstrating satisfactory performance. Furthermore, aircraft-to-aircraft interference can be controlled through spectrum sharing rules.

The Commission should note that both Boeing and AirCell have proposed technical approaches to ATG spectrum sharing that are feasible to implement, can service the anticipated domestic U.S. market and support multiple systems (or service providers). With this evidence that there are feasible technical approaches to sharing, the FCC should focus on the formulation of spectrum sharing rules rather than specifying a particular ATG technology. The final section of this report outlines a set of simple and fair principles that can form the foundation of such rules.

Boeing's Response to Airfone

The Telcordia Technologies report filed on behalf of Airfone on June 3, 2004 is critical of Boeing's proposal with regard to the size, weight, power, cost and availability of the proposed directional antenna. This is ironic since Airfone has proposed using a similar directional aeronautical antenna for their next generation aeronautical services and they have been issued an experimental license from the FCC (File Number 0186-EX-PL-2003, Granted 9/2/03) for such an antenna. Airfone's experimental license application lists a beamwidth of 65°, nearly the same as the 60° beamwidth proposed by Boeing. While the analog beam forming approach proposed by Airfone and described in the Telcordia report may be less expensive than the digital beam forming method proposed by Boeing, digital beam forming provides significant performance advantages. We believe that it is unimportant what method is used to steer the antenna beam - switching between multiple beams (Airfone) or steering a single beam (Boeing). Either method is suitable and service providers should be free to choose.

The June 3 Telcordia / Airfone report inaccurately describes Boeing's position on several important issues. It appears that Boeing's April 29 submission to the FCC was ignored in the June 3 Telcordia / Airfone report. Telcordia inaccurately portrays Boeing's concept as requiring "adaptive antennas on all aircraft and base stations" (sentence 1 page 54). In fact, Boeing went to great pains in our April 29 presentation to make the point that "plain old" segmented base station antennas are sufficient for our proposed implementation. We even went so far as to provide manufacturer's data on a suitable base station antenna product and presented simulation results showing that this products works.

The Telcordia / Airfone statement was also erroneous with regard to the aeronautical antenna. Our April 29 presentation stated that adaptive beam forming was optional but not necessary. Our simulations did not assume the use of adaptive beam forming and we never said that it was necessary; we have only stated that it could be used to further enhance performance.

Most importantly, the Telcordia/ Airfone report implies that Boeing is proposing to require service providers to use this antenna. In fact, Boeing has proposed that service providers be free to choose their own system implementations, as long as they abide by the spectrum sharing rules. The only purpose in discussing implementation issues is to demonstrate that there is at least one technical solution to achieving the necessary spectral capacity and to support multiple service providers. Both Boeing and AirCell have done this; now we suggest that Airfone focus on establishing sharing rules necessary to support multiple providers as both Boeing and AirCell have demonstrated is possible.

Another example of Airfone / Telcordia ignoring Boeing's April 29 submission to the FCC occurs on page 56. Telcordia attempts to show that a ridiculously large antenna (36,100 elements, 100 feet in length) array would be required to reject the interfering

BTS while serving the desired BTS in the “worst case situation” depicted in Figure 44 of their report. In fact, Boeing went to great pains to demonstrate during our April 29 presentation to the FCC that the scenario of Figure 44 never occurs. We even created a video simulation which was put in the public record to prove this fact.

The video showed an aircraft flying across the U.S. from Reagan National Airport (Washington, D.C.) to SeaTac Airport (Seattle, WA). A regular grid of base stations from 4 service providers was laid down over North America and the aircraft was programmed to connect to the nearest base station from one service provider. The “near-far” problem, in which an interfering base station is in the main beam of the aeronautical antenna at a range closer than the serving base station, was shown to never occur. In fact, it is very simple to show by inspection that the situation depicted in Figure 44 never occurs given a regular base station grid.

The worst case condition occurs when an aircraft flies directly over another system’s base station. With the regular grid of 4 service providers shown in Figure 1, the interfering base stations are located at a point that is exactly equidistant from 2 serving base stations where a hand-off would occur assuming the simplest algorithm in which an aircraft is served by the closest base station. A “snap-shot” of the geometry for this worst case condition is shown in Figure 2. The aircraft antenna is pointed to the horizon to communicate with the distant serving base station while the interfering base station is directly below the aircraft.

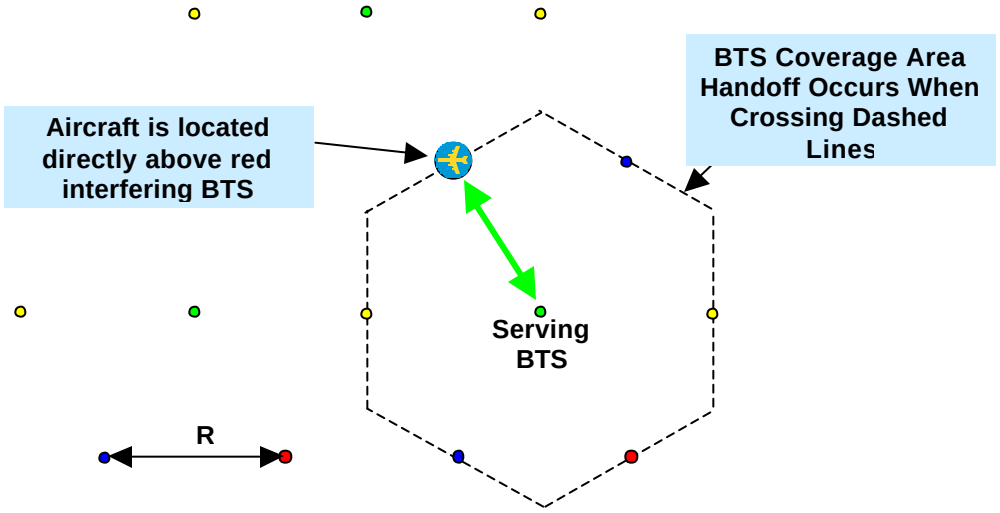


Figure 1. Top view of the worst case condition when aircraft flies directly over the base station of another system.

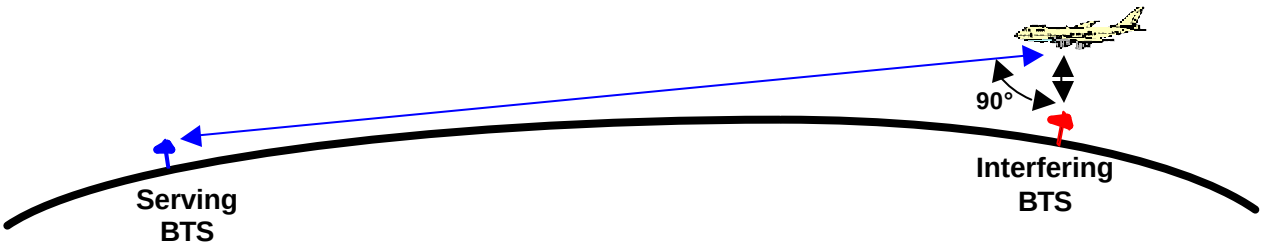


Figure 2. Side view of the worst case condition in which aircraft is communicating with distant base station while receiving interference from the base station of another system directly below the aircraft.

Figure 2 shows that the worst case angular separation between serving base station (on the horizon) and interfering base station (directly below the aircraft) is about 90 degrees instead of the 5 degrees claimed by Airfone / Telcordia (p. 57 of 6/3/04 report). Figure 3 shows that the 7-element phased array antenna proposed by Boeing has a 60 deg beam width that can easily discriminate between the serving and interfering base stations. In comparison, Telcordia/Airfone makes the unsupported claim that a 36,000 element array is required for the worst case geometry (p. 57 of 6/3/04 report). In fact, Figure 3 shows that there is a deep null directly below the aircraft because the vertical monopole elements have no gain in this direction. The rejection of the interference is shown to be greater than 30 dB for this scenario. Furthermore, Figure 4 shows that the interfering BTS has a deep null in its gain pattern looking straight up. The combination of the spatial isolation provided by the aeronautical antenna and the BTS antenna can provide greater than 60 dB isolation.

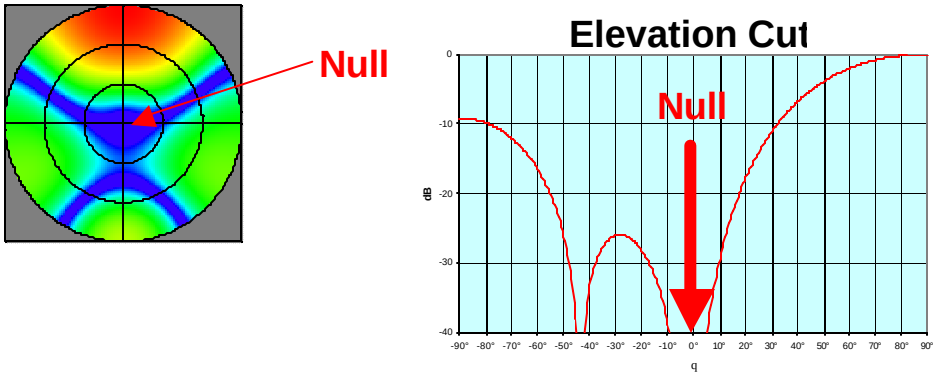


Figure 3. Demonstrates that the interfering BTS is located in the null of the aeronautical antenna gain pattern when the antenna is scanned towards the horizon to communicate with a distant base station in the “worst case” scenario.

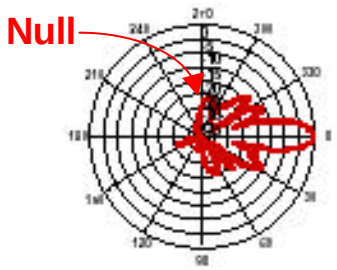


Figure 4. An additional 30 dB of interference rejection is achieved in the "worst case" scenario because the interfering BTS has a null looking straight up.

Base Station Separation Distance

Boeing's proposal provides spatial isolation between base stations that is independent of separation distance, R, between base stations (see Figure 1) when base stations are placed on a regular grid. In others words, the geometry does not change with scaling, as long as the base stations are on a regular grid and aircraft communicate with the nearest base station. So what is the optimum separation distance? Here is a list of technical considerations for base station separation:

(1) Intra-system base station separation should allow aircraft flying at 10,000 feet altitude and higher to always communicate with a base station that is located within the radio horizon distance. Furthermore, base stations should be moved in from the "smooth earth" radio horizon to provide margin for rough terrain. This places a limit on the maximum BTS separation distance.
(2) Reducing the separation distance between base stations causes more and more interfering base stations to appear within the radio horizon of the aircraft, as shown in Figure 5. As stated previously, these interfering base stations are located at a distance greater than the serving base station, but they still cause interference. This discourages the selection of closely spaced BTS.
(3) As base stations are moved closer together, overlaps are created in their radio horizon coverage areas (see Figure 6). Aircraft flying in these regions of overlapped coverage can intelligently choose which base station to use. Coverage overlap enables load balancing between base stations, a very useful method for increasing network capacity.
(4) The closer the base station spacing, the less the base station and aircraft transmit power required to close the forward and return links, and the less interference generated.
(5) The number of base stations to cover a given area increases as the spacing is reduced. Obviously, there is economic incentive to minimize the quantity of base stations.

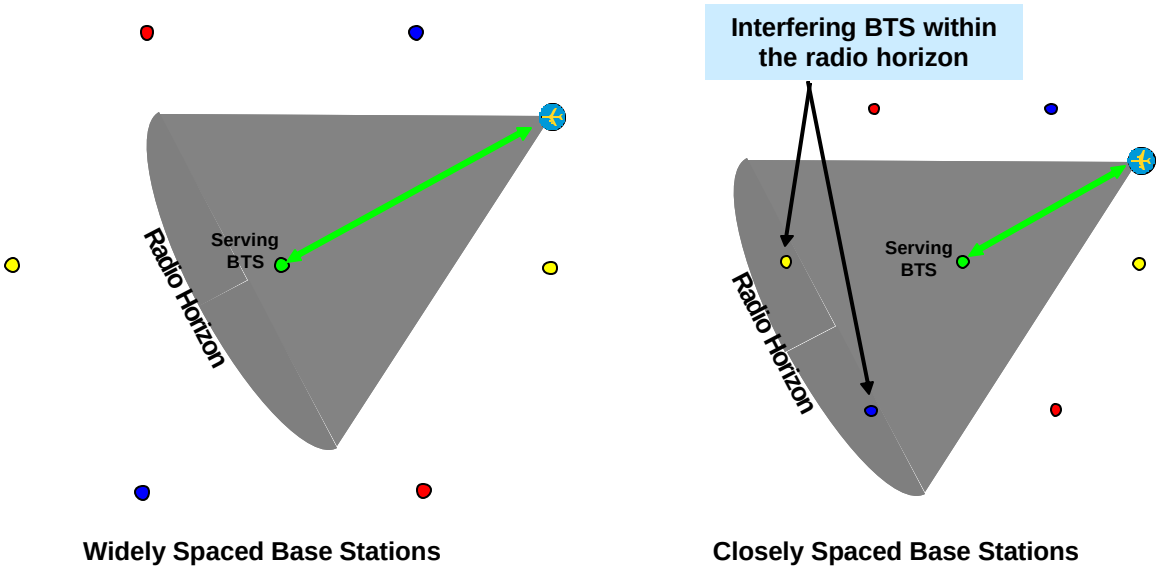


Figure 5. As the base station separation is reduced, greater numbers of interfering base stations can appear within the radio horizon of the aircraft.

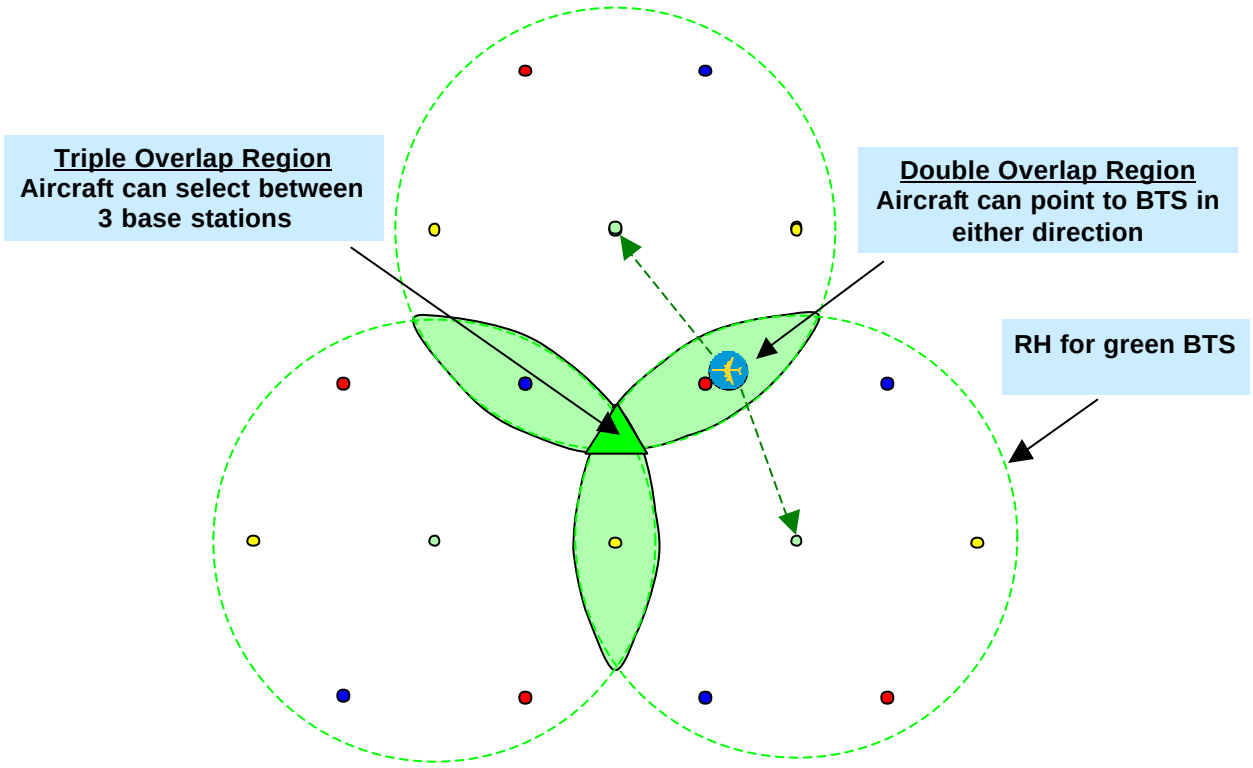


Figure 6. Base station coverage overlap resulting from closely spaced base stations. Aircraft can choose between base stations in the overlap region.

Boeing has developed a model to measure network capacity as a function of base station separation. Simulations were performed using a load balancing algorithm that

makes smart decisions when assigning aircraft to base stations to take advantage of (3). What we discovered is that the network capacity of each service provider, and hence the overall capacity of the spectrum, increases by 2x as base station separation is reduced from R_{max} to $R_{max}/2$, where R_{max} is the maximum possible separation distance with no overlap in the radio horizon coverage (about 131 miles). Note that the number of base stations increases by 4x when the separation is reduced by 2x.

In summary, the approach recommended by Boeing can accommodate a wide range of base station spacing, with capacity increasing as spacing is reduced, at the cost of additional base stations.

Off-Grid Base Station Placement

Practical considerations prevent BTS from being placed on a perfectly regular grid. In fact, it is highly desirable to give service providers flexibility in base station siting to account for terrain (shadowing), availability of host towers, accessibility, power and fiber access, etc. In our April 29 presentation, we advocated letting service providers choose their BTS locations subject to BTS offset rules. Others have expressed concern about this approach, because it might permit the first service provider that licenses base stations to secure use of the best locations, and relegate the last service provider to secure the worst sites. Because of this concern, Boeing now advocates an approach under which the FCC would assign the locations of base stations for all service providers using a regular grid. Service providers would be given a radius of distance around the assigned location in which to locate their base stations, as shown in Figure 7.

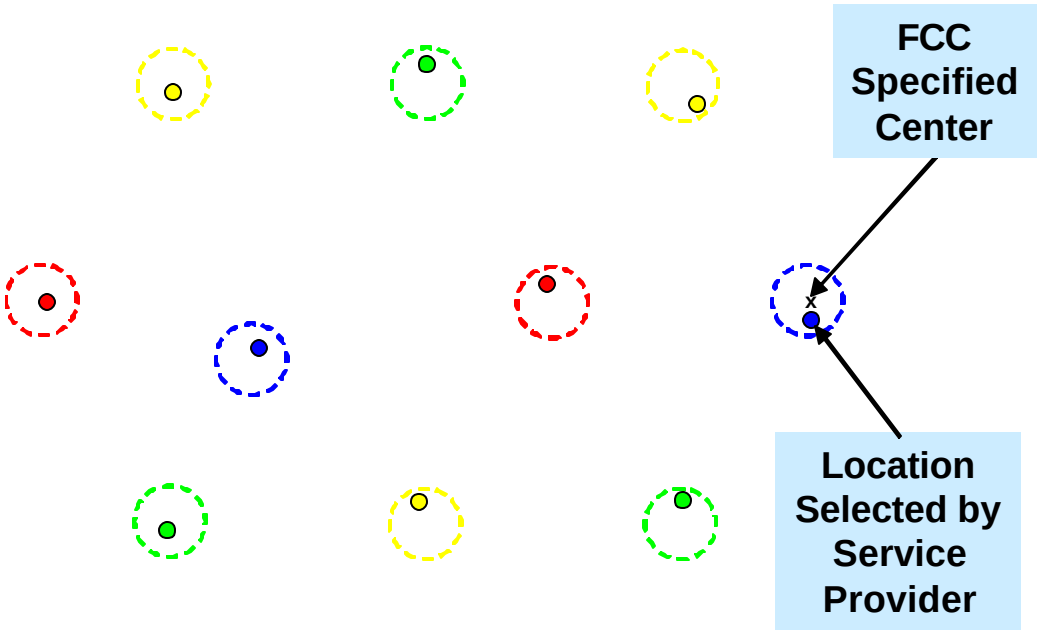


Figure 7 (Previous page) Off-grid BTS placement. FCC assigns BTS location centers and service providers select their BTS location within some distance of assigned centers.

The use of a regular grid would allow the licensing of up to four independent ATG providers. We performed many simulations to determine sensitivity to off grid base station locations. We used an algorithm that randomly selects base stations locations within a given radius of on-grid base station centers. We observed negligible reduction in capacity to service providers when the radius was increased up to 20 miles at a nominal inter-system BTS separation of 85 miles.

Connecting to the nearest base station does not work for off-grid BTS placement, because a close interfering base station can appear in the antenna main beam (the near-far problem). As noted in Figure 5, however, the aircraft has a choice of which base station to use, so if the red interfering base station is displaced (placed off grid) within the overlap region then the aircraft can always choose a serving base station that allows it to point away from the interfering base station. As long as there is overlap in coverage, the near-far problem never occurs, even if the base stations are placed off grid.

Aeronautical Antenna – Size, Weight, Power, Cost and Feasibility

The Commission's staff requested that Boeing estimate the cost and feasibility of our proposed phased array antenna. This data is not being provided to promote a particular antenna implementation, for we have already clearly stated that multiple implementations are possible including Airfone's proposed switched beam design. Boeing's proposal does not require any particular antenna implementation, but in this report we provide a demonstration of the feasibility of a particular antenna implementation using an electronically scanned phased array. Other antennas may be simpler and less expensive.

Aeronautical Terminal Design

A block diagram of the aeronautical terminal is shown in Figure 8. The principal components of the ATG terminal are the blade antenna elements, receiver front ends (LNA, down converters), transmitter front ends (HPA, up-converter), analog-to-digital converters (ADCs), digital-to-analog converters (DACs), digital signal processor (DSP) beam former, CDMA2000 protocol engine and Pentium controller. The entire ATG terminal (minus the blade antennas) is packaged on five compact-PCI boards that can fit within a standard ARINC chassis of 6MCU size.

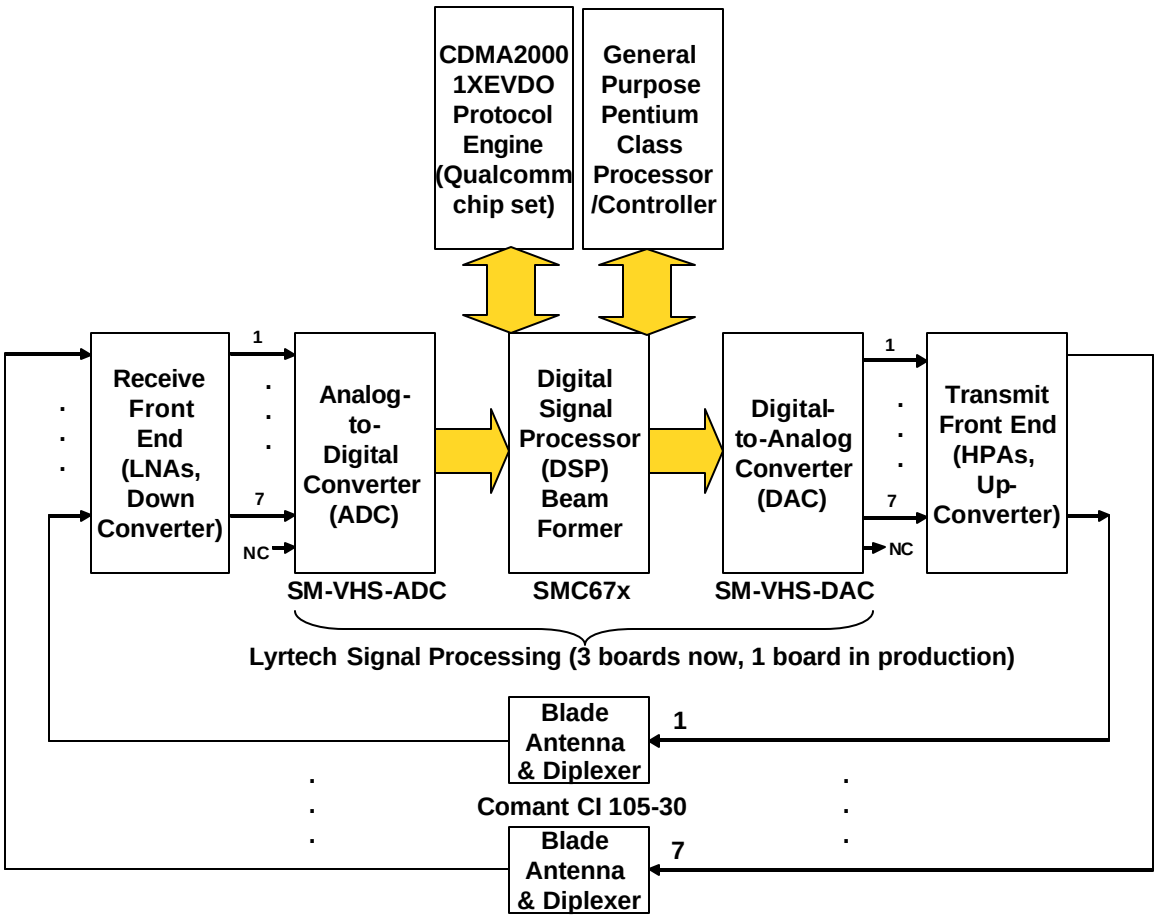
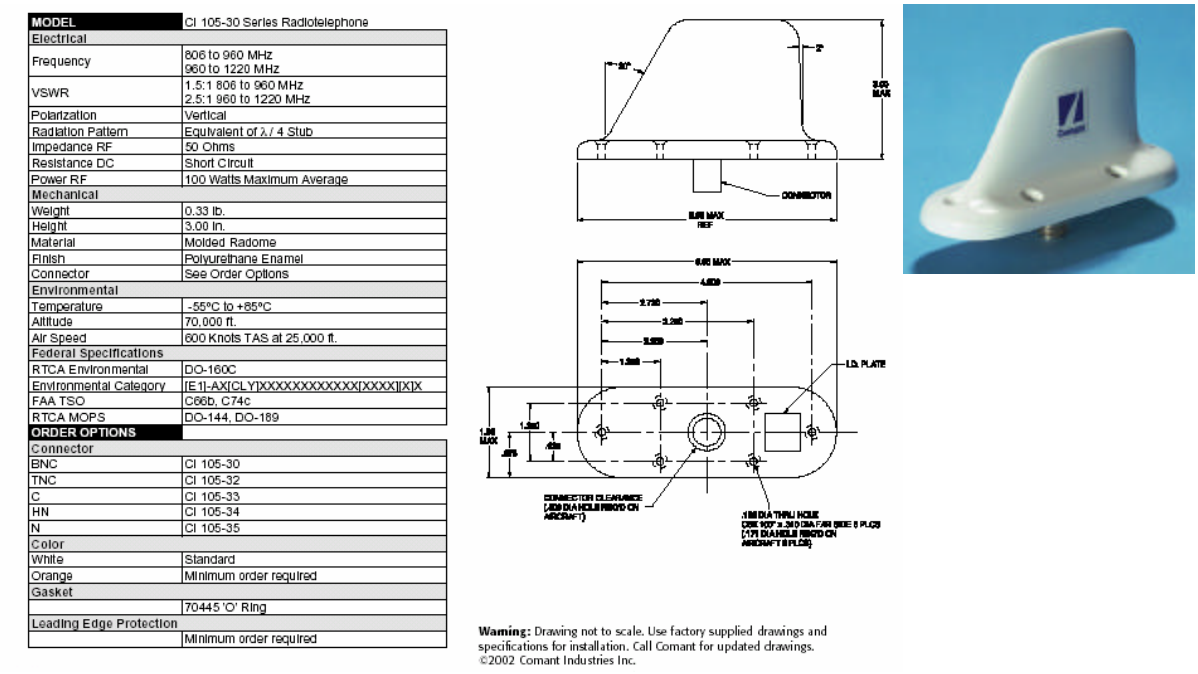


Figure 8. Block diagram of aeronautical terminal. System is comprised of six c-PCI boards and seven blade antennas. Manufacturer part numbers are shown.
Antennas

The design employs standard blade antennas that have been used on aircraft for decades. The product selected for this design is made by Comant (www.comant.com) part number CI 105-30 which is a vertically polarized monopole certified for aeronautical use. The retail price is approximately $150 each (small quantities) and 7 are required for each aircraft. Specifications for the Comant blade antenna are provided in Figure 9.



MODEL	CI 105-30 Series Radiotelephone
Electrical	
Frequency	806 to 960 MHz 960 to 1220 MHz
VSWR	1.5:1 806 to 960 MHz 2.5:1 960 to 1220 MHz
Polarization	Vertical
Radiation Pattern	Equivalent of λ / 4 Stub
Impedance RF	50 Ohms
Resistance DC	Short Circuit
Power RF	100 Watts Maximum Average
Mechanical	
Weight	0.33 lb.
Height	3.00 in.
Material	Molded Radome
Finish	Polyurethane Enamel
Connector	See Order Options
Environmental	
Temperature	-55°C to +85°C
Altitude	70,000 ft.
Air Speed	600 Knots TAS at 25,000 ft.
Federal Specifications	
RTCA Environmental	DO-160C
Environmental Category	[E1]-AX[CLY]XXXXXXXXXXXX[XXXX][X]X
FAA TSO	C66b, C74c
RTCA MOPS	DO-144, DO-189
ORDER OPTIONS	
Connector	
BNC	CI 105-30
TNC	CI 105-32
C	CI 105-33
HN	CI 105-34
N	CI 105-35
Color	
White	Standard
Orange	Minimum order required
Gasket	
	70445 'O' Ring
Leading Edge Protection	
	Minimum order required

Figure 9. Commercial "off-the-shelf" blade antenna.

Note that Boeing no longer recommends the conjoined blade antenna design shown in our April 29 presentation. Aerodynamic drag increases when airflow accelerates between the long conjoined blades. Boeing now recommends that individual blades be mounted directly on to the aluminum aircraft skin. This is also the lowest cost approach since individual blade antennas are available as off-the-shelf items from several manufacturers (no development cost). Also note that the blade antennas are considerably smaller (3" high) and lighter (0.33 lbs each) than estimated in Boeing's April 29 presentation to the FCC.

Signal Processing

The core of the aeronautical terminal is the digital signal processing (DSP) that forms and points the antenna beam. Boeing has received a proposal from Lyrtech Inc. (www.lyrtech.com) of Quebec City, Quebec, Canada to perform the ADC, DAC and DSP functionality (reference: "A 900 MHz Array Antenna System Based on the SMS-VHS-ADC Member of the SignalMaster Family", 6/30/04). Their existing products implement these functions on 3 separate c-PCI boards, but with additional development investment they estimate that these functions can be implemented on a single c-PCI board with daughter board. Lyrtech's budgetary price estimate for the single production board is $12K in quantity of 1000 units.

Note that Figure 8 shows the existing 3-board configuration using separate boards for the SM-VHS-ADC and SM-VHS-DAC with one port terminated on each board for the proposed 7-element array (the existing boards accommodate up to 8 antenna elements).

Front End Electronics

The front end electronics are implemented on two c-PCI boards, one for transmit and one for receive, each board contains 7 transmit/receive chains. Lyrtech proposes to partner with Comlab (www.comlab.com) to develop this product. They have provided a cost estimate of $1,000 in quantities of 1000.

Overall Size, Weight and Cost Estimates

The electronic hardware described above, along with a power supply, can be packaged in a standard aeronautical electronics chassis of size 6MCU (approx. 7.6" x 7.6" x 15") with an estimated weight of less than 20 lbs. Antennas and cables will add another 20 lbs. The price for an entire aircraft installation kit (6MCU electronic chassis, blade antennas, cables, etc.) is estimated to be about $50,000 in quantity of 1000 shipsets. This compares very favorably with satcom systems which start at approximately $168K (http://www.flightdailynews.com/farnborough2002/07_22/avionics/swift64.shtm). In addition, the proposed ATG terminal has significantly lower size and weight compared to satcom.

Comments on Airfone Aeronautical Antenna

Notably, Airfone has acknowledged that its broadband ATG service would require the development of a new aircraft antenna. *See* Airfone Ex Parte Submission in WT Docket No. 03-103 (Apr. 12, 2004) at 6. The switched beam phased array antenna proposed by Airfone/Telcordia is compatible with Boeing's multi-system sharing proposal. The Airfone antenna can provide the necessary spatial isolation between base stations of different systems. Airfone's proposed antenna may be less expensive than Boeing's because of Airfone's proposed use of an analog RF Butler Matrix to form multiple simultaneous beams. Boeing nonetheless believes that use of digital signal processing to form the antenna beam provides the following performance advantages:

(1) Reduced pointing loss because the antenna can accurately center its beam on the target base station.
(2) The ability to place deep nulls on the interfering base stations. This can reduce interference by >10 dB.

In summary, either antenna will work. While the switched beam phased array antenna may be less expensive, the DSP based design provides better performance. The choice is left to the service provider.

Principles for Developing Sharing Rules

Rather than limit ATG systems to a single technology, Boeing believes that the adoption of spectrum sharing rules would allow multiple service providers to use the ATG

spectrum and give each provider the flexibility to develop its own system. Sharing rules would be based on RF interference limits rather than particular system requirements, ensuring that all systems are treated equally and no provider has an advantage.

A sharing approach would accomplish the following objectives:

- Support four service providers (systems)
- Support implementations proposed by AirCell (polarization diversity and cross duplex) and Airfone/Boeing (spatial diversity)
- Continuous coverage above 10,000 feet.

Sharing rules would also be:

- Simple
- Easy to verify
- Able to accommodate incumbent system, including some reuse of existing infrastructure
- Allow airport operation (below 10,000 feet)

Sharing rules would address five areas:

(1) Channelization/Polarization/Duplex –Channel polarization and duplex assignments for systems.
(2) Base Station Location – Base stations are assigned to specific locations to provide necessary spatial isolation.
(3) BTS Interference – Rules specify maximum aggregate interference from one system into another system's base station.
(4) Aircraft interference – Rules specifying the maximum interference emitted from base stations into aircraft.
(5) Policing - Rules that specify that service providers must police their own interference levels and keep records of aircraft positions, EIRP levels, etc. that the FCC may audit should their be an interference complaint.

CONCLUSION

The ATG proceeding presents the Commission with an opportunity to allow airborne communications to take a tremendous leap forward. Several proposals are now before the Commission which would allow it to adopt new rules while still maintaining its goal of providing a competitive and robust market for ATG services. In this filing Boeing has outlined its technical bases for asserting that multiple providers can offer competitive and economic service in the ATG spectrum. By adopting rules based on the principles outlined above, the Commission can resolve the outstanding issues in its current ATG proceeding in a fair and rational manner. Boeing stands ready to work with the Commission and other interested parties to accomplish this goal