Space Data®

Exhibit A

Incremental coverage above 85% Pops / 10% landmass costs approximately $1B for each 5% greater coverage of Pops, unless Wide Area Technology is Used

Standard FCC Build Out

D-Block Auction 73 Build Out

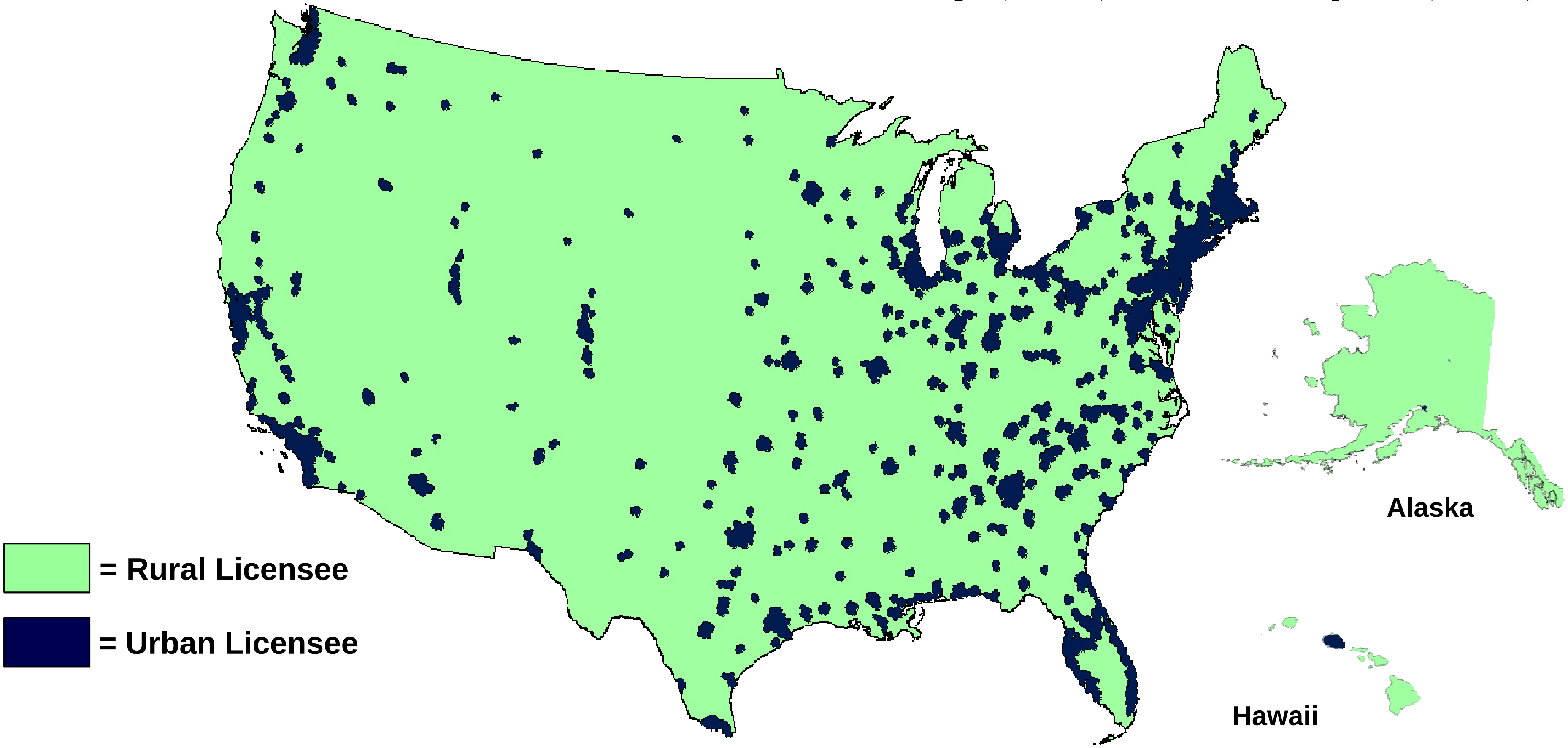
Population Coverage	Landmass Coverage	Required Towers	Incremental Towers	Incremental Cost at $0.25M/Tower ($ Million)	Cumulative Cost above Std. 75% Build Out ($ Million)	Avg. Pops per Tower	Backhaul Cost per Tower / mo.	Incremental Backhaul Cost ($M / yr)	Cum Backhaul Cost ($M / yr)	Cost Factor per Sub vs. 75% Buildout
70.0%	4.2%	13,464				14,536	$ 2,500	$ 404		1 X
75.0%	5.5%	14,563	1,099	$ 275		12,720	$ 2,500	$ 33		1 X
80.0%	7.5%	16,164	1,601	$ 400	$ 400	8,732	$ 3,000	$ 58	$ 58	2 X
85.0%	10.5%	18,615	2,451	$ 613	$ 1,013	5,703	$ 3,500	$ 103	$ 161	3 X
90.0%	15.4%	22,570	3,955	$ 989	$ 2,002	3,535	$ 4,000	$ 190	$ 350	5 X
95.0%	24.4%	26,174	3,604	$ 901	$ 2,903	3,879	$ 4,500	$ 195	$ 545	5 X
99.3%	45.3%	30,399	4,225	$ 1,056	$ 3,959	2,846	$ 4,500	$ 228	$ 773	6 X
99.9%	70.0%	35,385	4,986	$ 1,247	$ 5,205	336	$ 6,000	$ 359	$ 1,132	67 X
100.0%	100.0%	41,500	6,070	$ 1,518	$ 6,723	46	$ 6,000	$ 440	$ 1,572	490 X
100.0%	100.0%	22,570	+ 370 Wireless Platforms at 70,000 feet							1 X

Ideal

A, B and E Block Auction 73 Build Out

Exhibit B

- Urban license contains areas within 10 km of Urbanized Area as defined by Census Bureau
  - 48-state Urbanized Areas total 191,332,248 Pops (68.4%) and 185,889 sq. km. (2.3%)
  - Areas within 10 km of Urbanized Area: 213,334,173 Pops (76.3%) and 805,629 sq. km. (10.0%)*



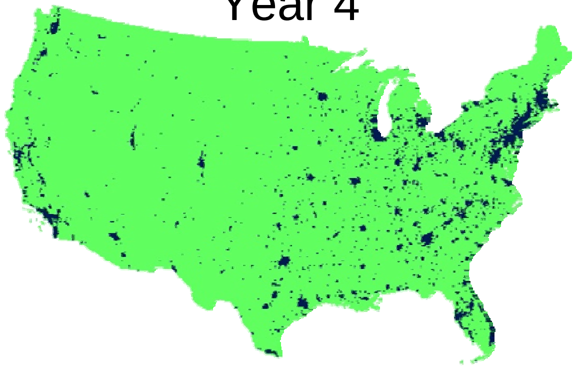
** Based on Continental US Landmass*

Space Data®

Exhibit C

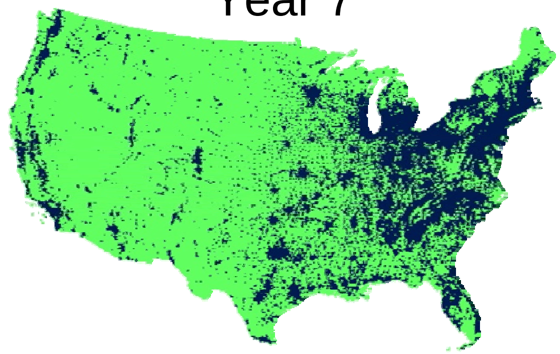
Coverage Provided By One Nationwide D Block License

Year 4



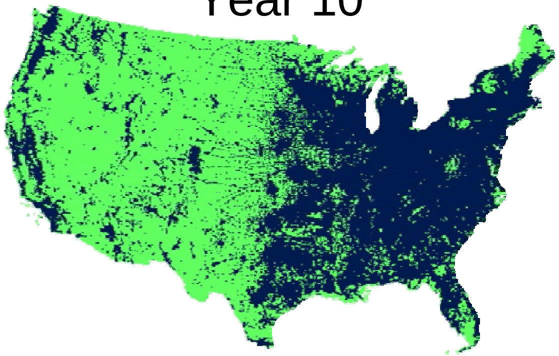
75% Pops

Year 7



95% Pops

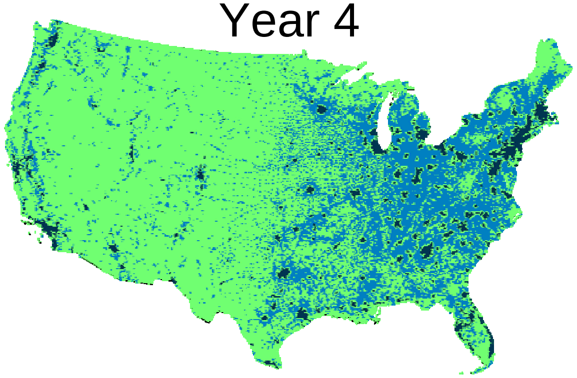
Year 10



99.3% Pops

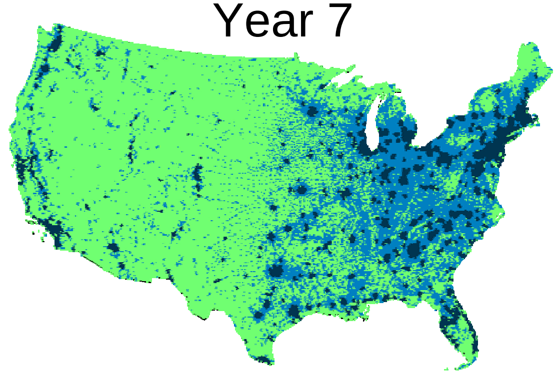
Coverage Provided By One Urban and One Rural License

Year 4



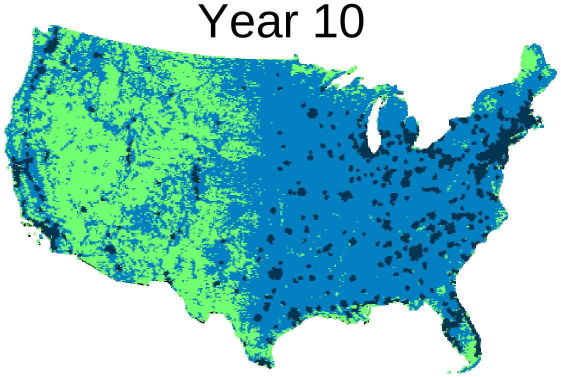
Urban: 75% Pops &
Rural: 35% Land

Year 7



Urban: 95% Pops &
Rural: no 7-yr. milestone

Year 10



Urban: 99.3% Pops &
Rural: 70% Land

* Based on 10 x 10 km resolution analysis

APPENDIX 1

Analysis of Potential Interference from "SkySite" High-Altitude Platform Stations in a 700 MHz Shared Wireless Broadband Network.

Prepared for

Space Data Corp.

by

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President, Drucker Associates

June 9, 2008

Drucker Associates
Consulting Engineers
Radio Telecommunications
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Analysis of Potential Interference from "SkySite" High-Altitude Platform Stations in a 700 MHz Shared Wireless Broadband Network.

June 9, 2008

INTRODUCTION

In the recent FCC auction of 700 MHz licenses, the D-block was intended to be auctioned as a nationwide license with the expectation that the winning bidder would collaborate with the Public Safety Spectrum Trust (PSST) to deploy and operate a Shared Wireless Broadband Network (SWBN) using both the D-block channel spectrum and the adjacent spectrum previously allocated to the PSST for broadband networks. Unfortunately, the D-block auction failed to elicit a bid at or above the predetermined minimum.

The FCC is now considering alternatives for re-auctioning the D-block. It has been suggested that one reason for failure of the earlier auction was the very high cost of conventionally meeting coverage requirements for the SWBN in rural areas, as defined in the document *Public Safety Spectrum Trust – Public/Private Partnership – Bidder Information Document* Version 2.0, dated Nov. 30, 2007 (hereinafter referred to as "the BID"). Space Data Corporation has offered a novel proposal that would partition the nationwide D-block into two licenses, one for urban and suburban areas and the other for rural areas. Space Data has also suggested that the cost of achieving specified completeness of rural SWBN coverage could be dramatically reduced using a "hybrid" network with coverage provided by both conventional terrestrial base stations (BTSs) and a system of high altitude balloon platforms called "SkySites."

A hallmark of SkySite operation is that each high altitude platform can provide coverage over a very large area. Of course, that coverage necessitates that forward (downlink) channel signals transmitted from SkySites propagate over a correspondingly large area. In order to assure essentially ubiquitous coverage in the remote rural areas, signals from SkySites will inevitably be present in areas where SWBN coverage is provided on the same channel band by terrestrial BTSs, including urban and suburban regions and rural areas where user densities are sufficient to make service from terrestrial BTSs practical. Indeed, this presence of SkySite downlink signals in areas where service is normally provided by terrestrial BTSs may be advantageous in that it allows SkySites to provide emergency coverage (albeit with vastly reduced capacity) in the event of terrestrial BTS outages.

The likely presence of downlink signals from SkySites gives rise to concerns as to whether these signals will materially interfere with service provided by co-band SWBN terrestrial BTSs. This document is intended to address these concerns through analysis of the “hybrid” network as proposed by Space Data with respect to operational requirements as specified in the BID.

DESCRIPTION OF SKYSITE OPERATION

For purposes of this document, it is assumed that each individual SkySite will operate at an altitude of 20 km above mean sea level (MSL). SkySites will be launched from locations, and at frequencies, such that each SkySite will provide coverage on the ground over a radius of 120 km. (Obviously, because of varying winds and other factors, the actual service area provided by a specific SkySite may, at any given time, be reduced.) SkySites will be deactivated during ascent and descent.

In addition to the system definitions described above, the analysis presented herein is based upon the following assumptions:

- The terrain being served by both terrestrial and SkySite systems is essentially flat and at sea level.

- By programmed preference, mobile stations (MSs) will not be served by SkySites in locations where SWBN service can be provided with acceptable quality by one or more terrestrial BTSs.

- Because of on-board power constraints, and in order to minimize interference with terrestrial BTS operations, SkySites will transmit forward channel signals at the lowest possible power level consistent with maintaining desired coverage while achieving throughput performance as specified in the BID for rural areas.

It is anticipated that SkySites will operate with three equal-sized sectors defined by directional antennas. SkySites will be rotationally stabilized so that azimuth characteristics of the sectors will remain constant (although location relative to the ground will change as the SkySite drifts with prevailing winds).

Figure 1 shows the relationship between an operational SkySite and the coverage to be provided by one of its sectors.

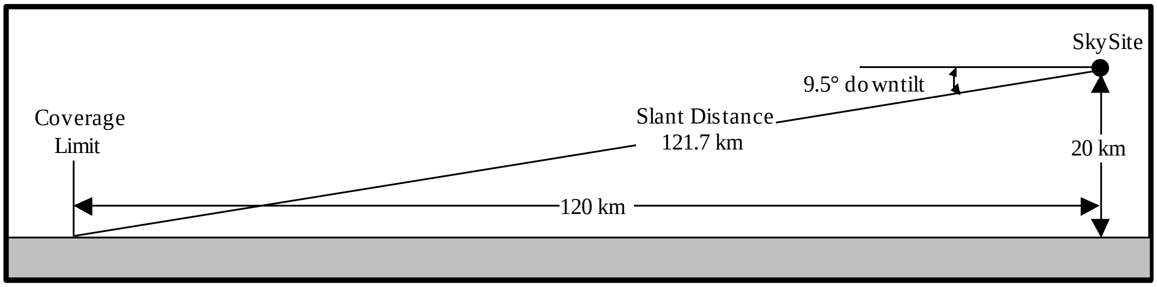

Figure 1: SkySite Sector Coverage

From Figure 1 it is seen that the SkySite sector antennas will be optimally downtilted by 9.5 °. At locations closer than the maximum range of 120 km the free-space path loss will be correspondingly reduced. Optimally, the antenna system on the SkySite will be configured so that the incident forward channel signal at ground level will be essentially constant throughout the coverage area. This characteristic will maximize efficient use of SkySite transmit power and minimize interference with terrestrial BTS operation. This leads to a definition of the vertical pattern for an optimal antenna (assuming an antenna gain of 16 dB), as shown in Figure 2.

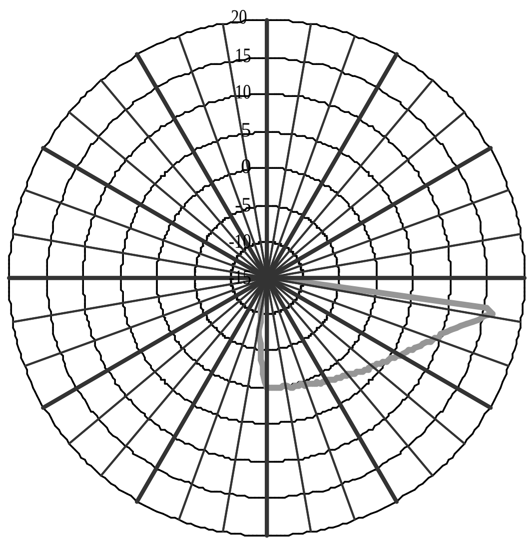

Figure 2: Ideal SkySite Antenna Vertical Pattern

In practice, it is unlikely that this ideal vertical pattern will be achieved, meaning that the incident signal at various points within the desired coverage area will vary from the desired level.[1] Since this desired level is determined by minimum requirements

[1] It is recognized that, depending upon the air interface technology used, forward channel transmit power may be variable. For purposes of this analysis, it is assumed that the SkySite is transmitting at maximum power.

(determined by path loss and throughput requirements), the antenna will need to be configured so that variance from the ideal pattern will always be in the positive direction, meaning that variance from desired incident signal level will always be positive. It is reasonable to assume that a practical antenna configuration will constrain this variance to +3/-0 dB.

FORWARD CHANNEL INTERFERENCE ANALYSIS

The air interface technology or technologies that will be used in the SWBN will be determined through collaboration between the PSST and the eventual D-block license holder(s). It is therefore impractical at this time to perform an interference analysis based upon signal levels required to support particular levels of capacity and performance with a specific air interface technology. However, operational requirements specified in the BID can be used to estimate relative signal levels as well as required carrier-to-interference ratios.

The BID defines required minimum network performance for five different morphology categories as shown in Table 1

Table 1 SWBN Performance Requirements per the BID

Morphology Category	Building Penetration Margin	Coverage Availability	Sector Loading	Downlink Channel Throughput (Individual user at cell edge)	Uplink Channel Throughput (Individual user at cell edge)
Dense Urban	22 dB	95%	70%	1.0 Mbps	256 kbps
Urban	19 dB	95%	70%	1.0 Mbps	256 kbps
Suburban	13 dB	95%	70%	512 kbps	128 kbps
Rural	6 dB	95%	70%	512 kbps	128 kbps
Highway	6 dB	95%	70%	128 kbps	64 kbps

All areas intended to be served by SkySite will fall into either the "rural" or "highway" categories, so performance will be defined by the higher requirements for "rural" areas. This suggests that the downlink signals transmitted from a SkySite must be sufficient to provide a 512 kbps user throughput with an additional path loss margin (over and above the free space loss between the SkySite and ground level) of 6 dB. The coverage from SkySites at ground level should be inherently ubiquitous, so no additional margin will be required to achieve the 95% coverage availability requirement.

From the requirements shown in Table 1, in "dense urban" areas the minimum downlink signal level outdoors at ground level must be such that a user throughput of 1.0 Mbps can be delivered after an additional 22 dB of building penetration loss.[2] Assuming the same air interface technology is used, the higher throughput rate (relative to what is required for "rural" and "highway" areas) can be achieved either by using a wider channel or by using a higher modulation rate and/or a lower coding rate.

For a moment, however, let us put aside the issue of different throughput rates and consider the interference situation as if they were identical for "rural" and "dense urban" areas. If that were the case, then we can calculate worst-case interference from a SkySite, as measured outdoors in a "dense urban" area as follows:[3]

Margin required for SkySite:	6 dB	
Margin required for "dense urban" terrestrial BTS:	22 dB	
Difference in required outdoor signal levels		16 dB
Allowance for non-optimal SkySite antenna pattern:	3 dB	
Worst-case C/I at equal throughput rates:		13 dB

We now need to consider the ramifications of the different downlink throughput requirements for the "rural" areas that might be served by a SkySite and "dense urban" areas. First let's assume that the 2X higher throughput (at cell edge) for "dense urban" areas is achieved through the use of twice the channel bandwidth (as will be feasible in some "fourth generation" air interface technologies). Then the total channel signal power will double (to retain the same energy per bit), increasing the worst-case C/I by 3 dB to 16 dB.

As noted above, the higher throughput requirement could also be achieved by using higher modulation rates and/or lower coding ratios. Per Shannon's Law this will result in a higher required signal-to-noise ratio. At cell edge, noise is generally defined by thermal noise, so higher SNR can only be achieved by increased signal level. How much the level needs to be increased in order to double the throughput for a given channel bandwidth depends upon the starting point. For example, according to Shannon's Law, and assuming perfect transmitter and receiver, going from an error-free throughput of 1.0 bps/Hz to 2 bps/Hz requires an increase in SNR of nearly 5 dB.[4] A doubling of throughput from 0.2 to 0.4 bps/Hz requires an increase in SNR of a bit over 3 dB. These throughput efficiency values likely bracket the range that will be practical for cell-edge operation, so it is probably reasonable to assume that the higher throughput for "dense urban" areas, if achieved in the same channel bandwidth used by SkySites, will require at least a 3 dB increase in signal level. Conveniently, that will increase the worst-case C/I by the same factor associated with doubling channel bandwidth.

[2] In order to achieve the required 95% coverage availability, outdoor signal levels in "dense urban" areas will often need to be considerably higher than this minimum.
[3] It is quite reasonable to consider worst-case interference outdoors because signals from a SkySite will most likely be attenuated at least as much by building penetration as will signals from a nearby terrestrial BTS.
[4] The value of bps/Hz defines channel throughput efficiency in bits per second of data throughput per Hertz of channel bandwidth.

From the above analysis, we can conclude that in “dense urban” areas the effective level of interference from co-band signals transmitted from a SkySite will be at least 16 dB below the signal level from a serving terrestrial BTS. This represents a quite benign level of interference for an urban wireless network. In fact, it is virtually certain that signals from other nearby terrestrial BTSs will provide greater effective levels of co-channel interference[5] in some places within the specified 95% coverage availability. Therefore, it appears that SkySite will not significantly interfere with downlink channel operation in “dense urban” areas.

Analysis of potential downlink channel interference from SkySites to terrestrial SWBN BTSs serving “urban” areas, based upon requirements shown in Table 1, follows the same course provided above for the “dense urban” case. However, because the building penetration margin required for “urban” areas is 3 dB less than that required for “dense urban” areas, and therefore the outdoor signal level can be 3 dB lower, we can conclude that in “urban” areas the effective level of interference from co-band signals transmitted from a SkySite will be at least 13 dB below the signal level from a serving terrestrial BTS. This C/I level is probably about comparable to that associated with effective co-channel C/I for terrestrial BTSs in “urban” areas with 95% coverage availability. This suggests that co-band interference from a SkySite in “urban” areas could be non-trivial, but also should be manageable in the configuration of the terrestrial BTSs serving such areas.

In “suburban” areas, again following the same course of analysis, worst-case outdoor co-band downlink channel interference levels from a SkySite would be only 4 dB below the level of signals from a serving terrestrial BTS, which would clearly be significant to the configuration of the terrestrial network. However, this potential interference situation can likely be addressed in the following manner.

According to definitions of the different morphological categories in the BID, population densities in “suburban” areas are at most only about 17% of those in “dense urban” areas. At the same time, the amount of spectrum available for the SWBN is expected to be the same in both (and indeed throughout all areas of the U. S.).

For various reasons, it will be most practical to operate SkySites using relatively narrow channel bandwidths occupying only a small portion of the combined D-block/PSST broadband spectrum. For purposes of analysis, it is probably reasonable to assume that SkySite downlink operation could practically be restricted to at most 50% of the SWBN downlink channel band (i.e. 25% of the total SWBN spectrum). Any downlink interference from SkySites will therefore be limited to just that portion of the entire band available for use in “suburban” areas, where the SWBN can be configured to either not use that spectrum or to use it only in situations where the potential interference from SkySites could be tolerated. For example, channels subject to potential downlink interference from SkySite transmissions could be limited to serving users in areas where

[5] Characteristics of “effective” co-channel interference will depend upon the air interface technology in use. For example, in CDMA systems operation is common at C/I levels equal to or even slightly less than 0 dB. However, processing gain provides significantly higher “effective” co-channel C/I.

such interference is not significant, such as indoors or outdoors in relatively close proximity to the serving terrestrial BTS. Given the relatively modest population densities of "suburban" areas these limitations should not present an excessive burden.

Suitable restrictions on SkySite operation, both in terms of allowed band of operation (which would be a limited portion of the combined D-block/PSST broadband spectrum) and maximum ground-level signal strength, would provide a basis for configuration of the terrestrial SWBN in "suburban" areas to manage potential downlink interference from SkySites.

In "rural" and "highway" areas, as defined in the BID, it is clear that co-band downlink interference from SkySites could significantly impinge upon operation of terrestrial BTSs. Fortunately, in these areas it is most likely that configuration of terrestrial BTSs will be governed by concerns of coverage rather than capacity. Therefore, the amount of spectrum required to meet capacity needs, given that BTS deployment density will be determined by coverage demands, should be relatively modest. Accordingly, a partition of available spectrum between SkySite and terrestrial BTS operation should be quite practical, thus eliminating concerns of co-band interference. Based upon the proposals of Space Data, this partition could be easily managed without regulatory intrusion because the holder of the D-block "Rural" license will have operational control of both terrestrial BTSs in "rural" areas and SkySites. However, the spectrum partition would have to satisfy restrictions on SkySite spectrum use that might be introduced in order to protect the holder of the D-block "Urban" license.[6]

A summary of the impact of downlink interference from SkySite operation on terrestrial SWBN BTSs in the various BID-defines morphological areas is shown in Table 2.

Table 2 Downlink Interference from SkySites in Terrestrial SWBN BTSs

Morphology Category	**Worst-case C/I**	**Impact on Terrestrial BTSs**	**Means of Interference Mitigation**
Dense Urban	16 dB	Negligible	None required
Urban	13 dB	Small but manageable	Terrestrial SWBN configuration may need to address worst-case interference
Suburban	4 dB	Significant	Restriction on portion of SWBN band on which SkySites may operate and on maximum SkySite ground level downlink signal strength. Terrestrial SWBN configuration will need to accommodate
Rural	<0 dB	Severe	Partition of SWBN band between terrestrial BTS and SkySite operation
Highway	<0 dB	Severe	Partition of SWBN band between terrestrial BTS and SkySite operation

[6] Per Space Data proposals, the "Urban" license would be composed of the "dense urban," "urban," and "suburban" areas as defined in the BID.

OTHER INTERFERENCE CONSIDERATIONS

In general, between operation any two co-band wireless BTSs there are four potential interference scenarios, as follows:

1. Downlink signals from BTS A can interfere with reception of downlink signals from BTS B by a mobile station (MS) being served by BTS B.

2. Downlink signals from BTS B can interfere with reception of downlink signals from BTS A by an MS being served by BTS A.

3. Uplink signals from MSs being served by BTS A can interfere with reception of uplink signals from an MS being served by BTS B.

4. Uplink signals from MSs being served by BTS B can interfere with reception of uplink signals from an MS being served by BTS A.

Let's assume for purposes of analysis that in the SWBN, BTS A is a SkySite and BTS B is a terrestrial BTS.

Scenario 1 has been addressed by the analysis presented above.

Scenario 2 relates to downlink signals from a terrestrial BTS interfering with reception of downlink signals by an MS being served by a SkySite. Since we have made the assumption that an MS will preferentially be served by a terrestrial BTS if possible, it follows that the MS in this scenario is in an area where there is no useable coverage from a terrestrial BTS. Now we can make the reasonable additional assumption that wherever MSs are served by SkySites the nearest terrestrial BTSs will be those serving "rural" areas. Based upon the Scenario 1 analysis, these "rural" terrestrial BTSs will not operate co-channel with SkySites on the downlink. This removes any likelihood of Scenario 2 problems.

Scenario 3 relates to uplink signals from MSs being served by a SkySite interfering with uplink channel reception at a terrestrial BTS. As discussed for the Scenario 2 case, an MS being served by a SkySite will not be anywhere close to a terrestrial BTS that might operate (on the downlink) co-channel with the SkySite. Assuming conventional fixed uplink/downlink spacing, this removes any likelihood of Scenario 3 problems.

Scenario 4 relates to uplink signals from MSs being served by a terrestrial BTS interfering with uplink channel reception by a SkySite. Actually, because of the very large coverage "footprint"[7] provided by a SkySite sector we need to modify this scenario

[7] In this analysis, "footprint" refers to the sector as defined by the SkySite antenna pattern, not the area actually being served at a given point in time. As shown in Figure 2, the "footprint" is thus restricted to a

somewhat to consider the possible impact of collective interference from the potentially large number of MSs being served by all of the terrestrial BTSs that might be within that "footprint." In the worst-case situation, the "footprint" of a particular SkySite sector may at some point in time include areas where it provides the only SWBN service but also areas of urban and dense urban morphology where it can be expected that very large numbers on users, served by terrestrial BTSs, will be located. Such a situation is illustrated in Figure 3.

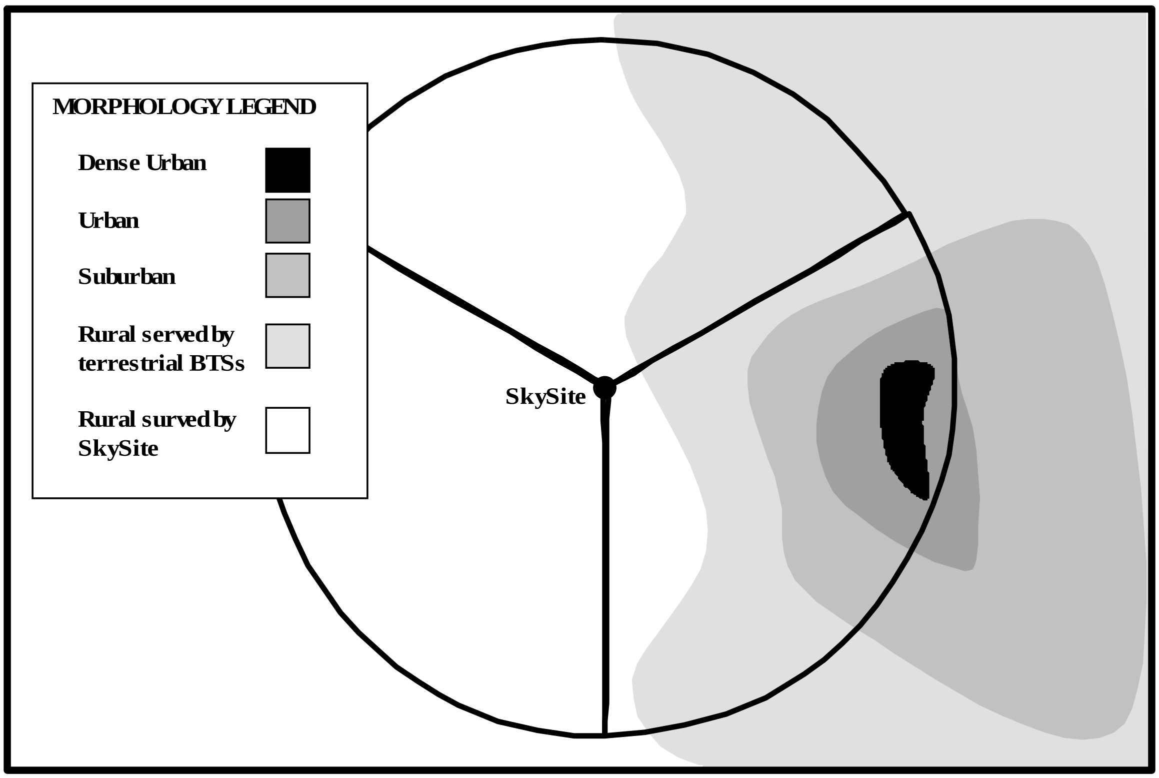

Figure 3: Worst-Case Situation for "Scenario 4" Interference

The "footprint" of one of the three SkySite sectors shown in Figure 3 includes areas of dense urban, urban and suburban morphology where MSs being served by terrestrial BTSs may operate co-frequency with MSs being served by the SkySite. At the same time, a small portion of the same sector "footprint" covers rural areas that can only be served by SkySite.

The interference to SkySite uplink reception provided by the many MSs operating in nearby suburban, urban and dense urban areas will depend upon a large number of factors. Chief among these will be: the actual number of such potentially interfering MSs that are transmitting at any given instant; the average interfering MS transmit power as

120 km radius by the vertical beam shape, as signals emanating from ground level beyond that distant will be significantly attenuated.

reflected outdoors at ground level; and the fraction of suburban, urban, and dense urban area MS transmissions that occupy the same uplink frequency band used by SkySite-served MSs.

For purposes of analysis, it is probably reasonable to assume that in the worst-case, a total of 1000 MSs may transmit at any given instant in time within the suburban, urban, and dense urban areas within the "footprint" of any given SkySite sector.

Characteristics of uplink MS transmit power will depend to a large extent upon the air interface technology in use. However, based upon experience, and using CDMA technologies as a model, it is reasonable to assume that on average MSs operating outdoors in suburban, urban, and dense urban areas will transmit at a level roughly 35 dB below maximum.[8] MSs operating indoors will obviously transmit, on average, at a higher level, but at least for purposes of this analysis it is reasonable to assume that the average power level of each MS, as reflected outdoors at ground level, will be 35 dB below maximum.

Average MS transmit power level will also be influenced by average uplink throughput rates. However, for purposes of this analysis it is reasonable to assume that average uplink throughput demand will essentially be independent of the morphological area where a given MS is located.

As suggested in the analysis presented above for downlink interference, it is reasonable to assume that MSs operating on a SkySite will use no more than 50% of the available uplink band and that MSs operating in suburban, urban and dense urban areas will use 100% of the uplink band.

Armed with the preceding assumptions, we can now estimate the impact of worst-case uplink interference on SkySites as follows:

Number of potentially interfering MSs = 1000:	+30 dB
Average Interferer TX power relative to max:	-35 dB
Desired uplink margin for SkySite-served MSs:	+6 dB
Fraction of interference that will be co-frequency = 0.25:	-3 dB
Predicted worst-case uplink C/I	+8 dB

Depending upon the air interface technology in use and SkySite receiver performance, a C/I of +8 dB may be slightly marginal for delivering the specified rural morphology uplink data date of 128 kbps. This suggests that in such worst-case scenarios uplink throughput rate may be slightly depressed. If this is not tolerable, it would be possible to build out the rural areas served by terrestrial BTSs so as to provide a minimum geographic "buffer" between urban and dense urban areas and areas served by SkySite.

[8] Maximum transmit power for MSs depends upon air interface technology, but it is reasonable for this analysis to assume that the same maximum will apply to MSs being served by terrestrial BTSs and SkySites.

CONCLUSION

Major consideration in the deployment of the D-block/PSST nationwide SWBN will be the cost involved, and limited time allowed, in achieving required completeness of coverage in rural areas. To address these issues Space Data Corporation has proposed that the nationwide D-block be partitioned into two licenses, one for urban and suburban areas and the other for rural areas. Space Data has further proposed that, compared to reliance exclusively on deployment of terrestrial BTSs, rural SWBN coverage could be realized much more quickly and economically using a "hybrid" network with coverage in areas of lowest population density provided by high altitude SkySites.

The analyses presented in this document demonstrate that the proposed hybrid network can operate without unmanageable mutual RF interference between operations of SkySites and terrestrial BTSs, provided that certain modest restrictions be placed upon SkySite operation. Specifically, SkySites will need to be restricted to use of a limited portion (on the order of 50%) of the combined D-block/PSST broadband channel bands. In addition, downlink transmissions from SkySites will need to be restricted as to the maximum signal strength they can deliver at ground level. The specific signal level appropriate for such a restriction will depend upon the air interface technology employed by the SWBN, but should represent insignificant interference to terrestrial networks in dense urban areas and easily manageable levels of interference to terrestrial networks in other urban areas. In suburban and rural areas, this restricted downlink interference from SkySites may modestly constrain design and operation of terrestrial networks, but only in the limited portion of the shared spectrum where SkySite operation is allowed. In the context of presumed lower usage traffic densities in these areas (relative to those of urban and dense urban areas) such constraint should be acceptable.

The presented analyses suggest that no restrictions on terrestrial networks are required to protect SkySite operation from harmful interference. In very rural areas served by SkySites that are nonetheless in relatively close geographic proximity to large urban areas, interference emanating from those urban areas may slightly impact uplink SkySite performance, but any such impact should be manageable.

The restrictions and limitations described above should not seriously reduce the effectiveness of SkySite technology for providing cost-effective low density rural area coverage in the SWBN.