

Special Temporary Authority Request GSM Spacecraft Test

UbiquitiLink, Inc.

July 27, 2018

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Applicant Description

About the Applicant

UbiquitiLink, Inc. (UBLink), is a Virginia corporation, incorporated on January 21, 2017. Its management team includes veterans of NASA, Nanoracks, Orbcomm, SpaceHab, Orbital, Fairchild, and Neustar. UBLink is developing a last-mile ubiquitous communications solution for Internet of Things (IOT) [REDACTED] utilizing a constellation of small satellites.

UBLink's team consists of world leaders in nanosat markets, technology and launch.

Charles Miller, CEO, has 30 years' experience in the space industry and has been the founder or co-founder of multiple private ventures and organizations. He co-founded Nanoracks LLC; Nanoracks LLC has launched over 700 payloads making it the world leader in nanosatellite launches. Miller served as NASA Senior Advisor for Commercial Space from 2009-2012 where he advised leadership on commercial public private partnerships (PPP). At NASA in 2009, Miller managed a USG team of more than two-dozen civil servants (including representatives from AFRL and FAA) that developed a commercial partnership strategy for developing reusable launch vehicles. Miller then successfully persuaded senior NASA leadership to support a \$300 million per year overguide request in the FY 2011 budget process using PPPs to develop reusable launch vehicles.

Key members of our technical team include Mike Johnson, Tyghe Speidel and Dr. Joseph Bravman.

Mike Johnson, is our Chief Technology Officer (CTO), and prior to UBLink he was the co-founding CTO of NanoRacks, LLC. Prior to Nanoracks, Mike worked with SPACEHAB, Inc. in various capacities for over 18 years, culminating as Vice President for Advanced Programs, as well as founding two other startups. In total, Johnson has delivered nearly 500 payloads to orbit and over 200 nanosatellites.

Tyghe Speidel, our Vice President of Technology & Strategy, is the inventor of the key IP enabling our orbital cell tower technology, among other patents in UBLink's intellectual property portfolio. He is a former spacecraft engineer at NASA's Jet Propulsion Laboratory (SMAP, Curiosity), and the founder and global lead of the commercial space practice at Accenture.

Dr. Joseph Bravman, our Vice President of Operations, previously was Orbital's Senior Vice President/Corporate Development, Corporate Chief Engineer, Senior Vice President of Orbital's Advanced Systems Group, and Senior Vice President for Engineering and Operations. During his time at Orbital, Dr. Bravman managed the construction of the ORBCOMM satellite constellation and Orbital's role as provider of the ORBCOMM space segment. Prior to Orbital, Dr. Bravman was Corporate Executive Vice President of Fairchild and President of its Defense Electronics division that produced avionics, satellite communications, and mission planning ground support systems.

Summary

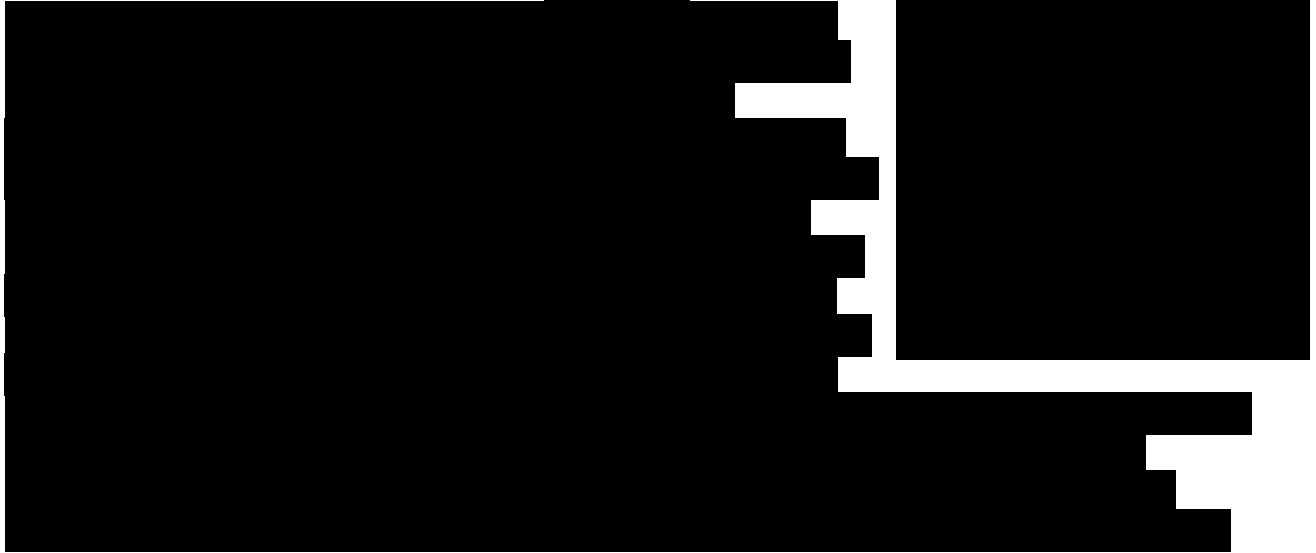
Frequencies	[REDACTED] Downlink Portion: 869.2 MHz to 893.8 MHz
Locations	Centered at 35.9498 N, 110.0844 W (Northeast Arizona, Navajo Nation)
Power	[REDACTED] 42 dBm EIRP Earth-to-Space
Timing	15 January 2019 to 15 March 2019
Duration of Test	10 day period, 2 minutes for each test, 40 minutes total transmit time.
Testing Time Frame	15 January 2019 to 15 March 2019
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
UbiquitiLink Kill Switch Contact	Mr. Tyghe Speidel, +1 (240) 705-9409

Our extensive interference analysis (discussion in detail below) demonstrates that there is no harmful interference from this test. The interference discussion describes why there will be no harmful interference impacting the existing licensed service quality due to the presence of the satellite downlink signal. This is the result of a number of combined factors that first reduce the probability of occurrence to extremely low levels and then allow the existing device protocol to completely eliminate any residual effects to the normal operation of licensee user equipment.

UBLink is developing a [REDACTED] nanosat communications network. The service would provide [REDACTED] service around the globe operating between 820 and 960 MHz, [REDACTED]
[REDACTED] sing a Low Earth Orbiting (LEO) nanosat [REDACTED].
[REDACTED]. There is a need to perform testing on prototype equipment, which will provide important information regarding the performance of the links and the network/system control capabilities. Initially, UBLINK desires to perform a series of short tests at a location in the Southwest USA. The FCC Special Temporary Authority request seeks to test using specific

spectrum ranges, using specialized equipment operating at specified power densities, at a specific area, and at times within the US.

The proposed test configuration involves



The UBLink communications payload is

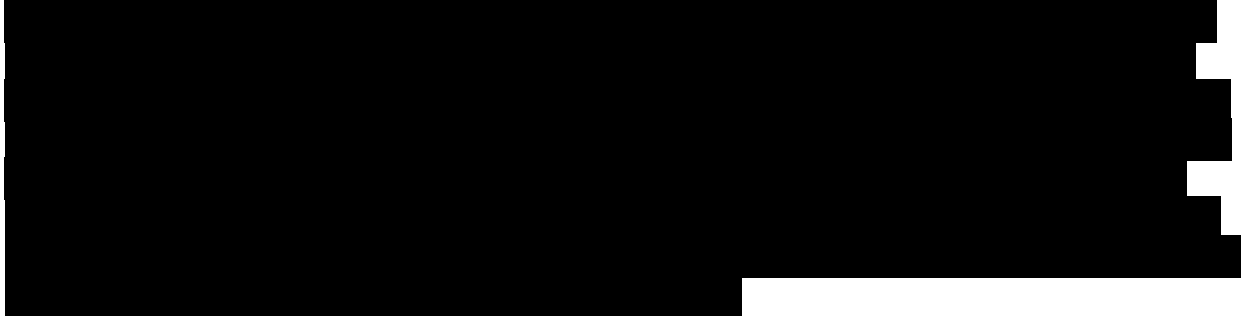


Figure 2 below depicts the UBLink payload





link architecture is shown in Figure 3 below.

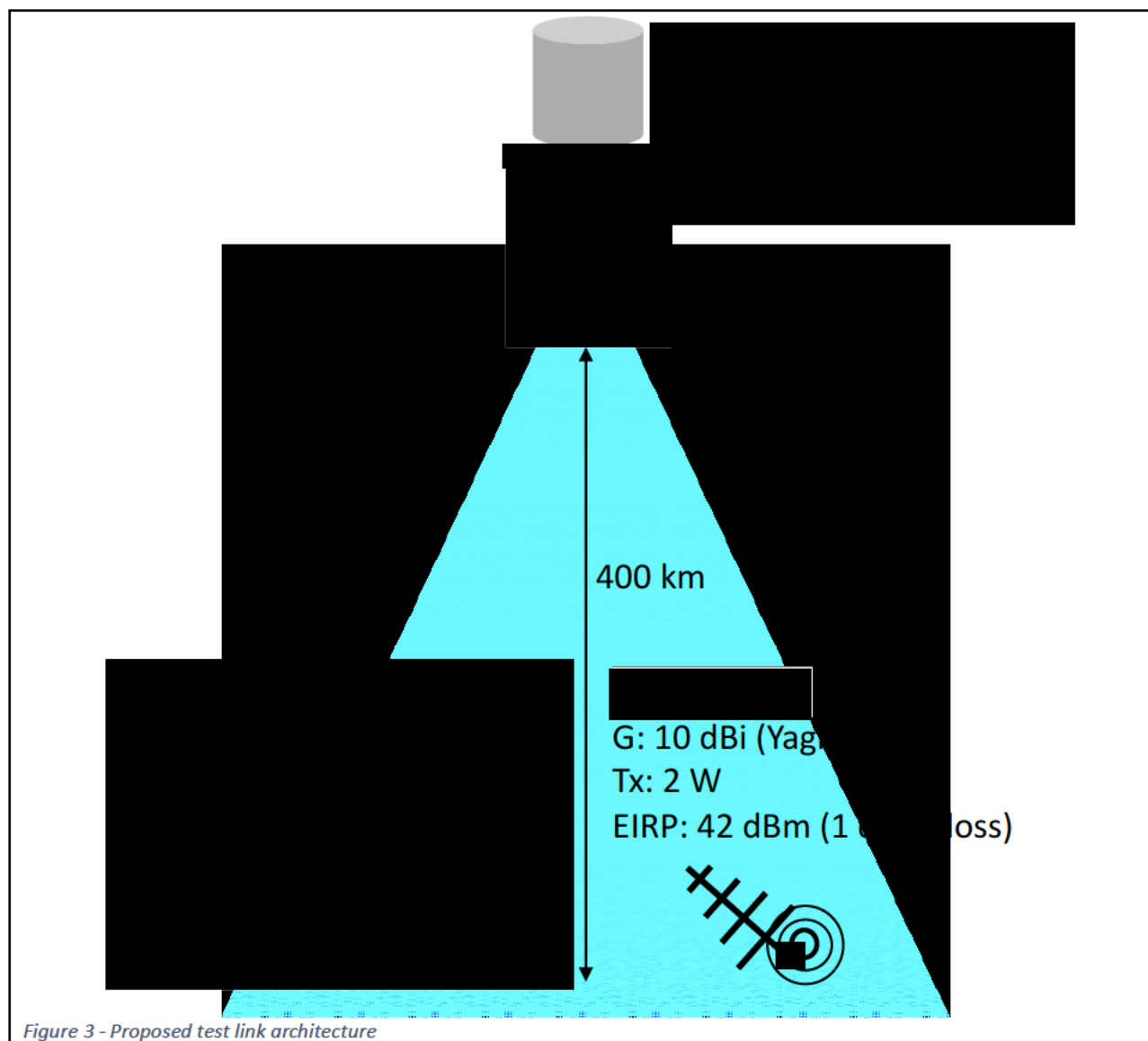


Figure 3 - Proposed test link architecture

[REDACTED] The transmit carrier frequency may be changed during flight by a stored command to conform to the licensed spectrum of the terrestrial test participants and locations. The design provides the capability to operate this [REDACTED] depending on global location.

Ublink has been working with GSM service provider Smith Bagley, Inc. (d/b/a Cellular One). Cellular One has given Ublink written permission to operate the test on Channel 152 of their spectrum license, which is at 874.0 MHz on the downlink [REDACTED]. See attached letter from Cellular One. The coverage area will be centered near a Cellular One quiet zone in an isolated area in northeast Arizona, which Cellular One has identified as near 35.9498 N, 110.0844 W.

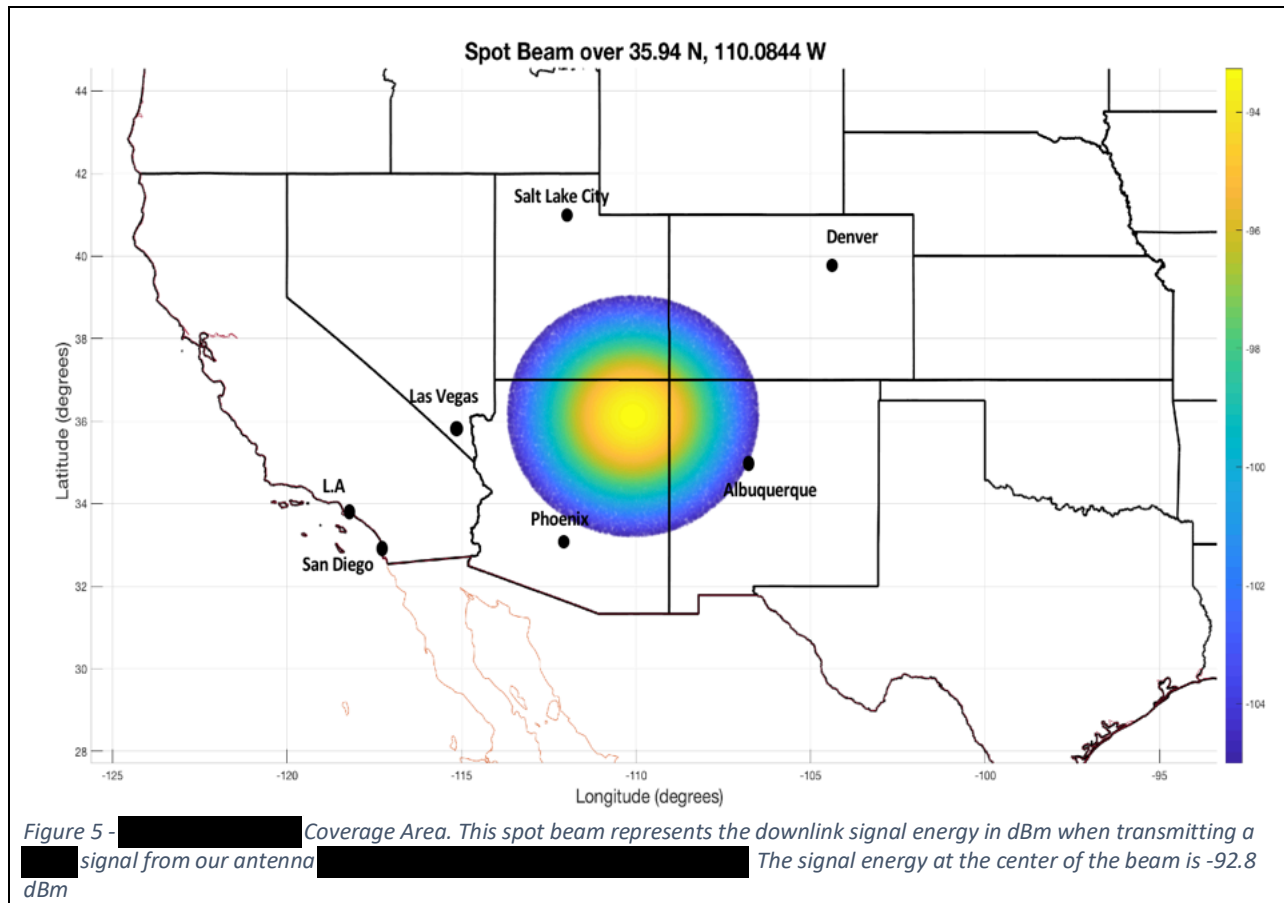


Figure 4 - Satellite image of proposed testing site

Figure 5 below shows the operational area for the ground equipment and the size of the beam from the spacecraft. The test defined above requires authorization for UBLINK to transmit for approximately 40 minutes of total time spread out over a 10-day period in the first quarter of 2019, in increments of 2 minutes for each overpass. The exact dates of operation are governed by the [REDACTED] launch date and the detailed maneuvers that occur [REDACTED]

The payload, and especially its transmitter, is under the strict control of commands uploaded over [REDACTED] Mission Control. These commands are time tagged for execution at specific times, and consequently at specific locations and positions. Th [REDACTED]

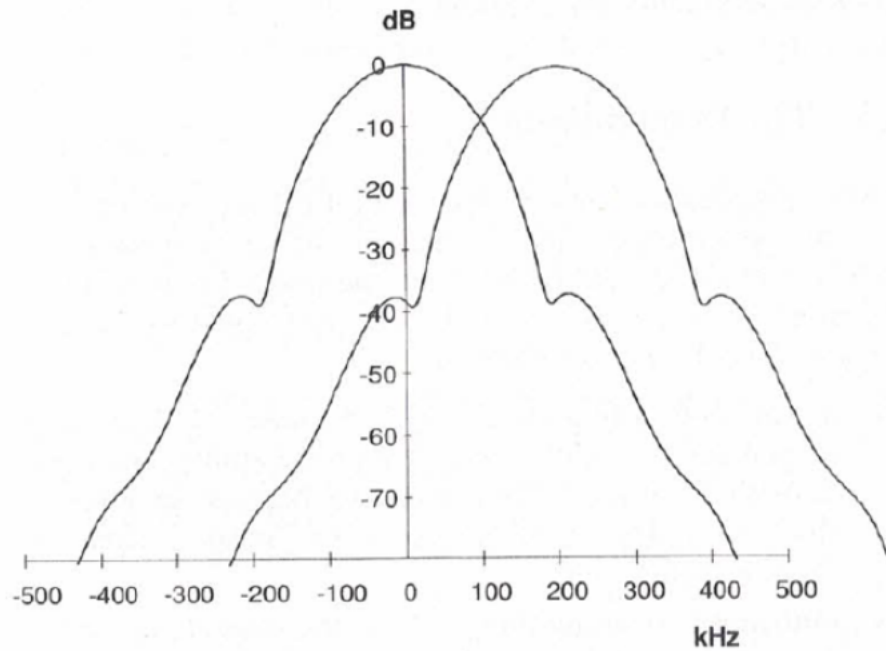
[REDACTED] As such the center of the spot beam depicted below will be accurately controlled and the transmission intervals precisely planned and executed. This will insure that the transmissions will only occur over the desired test areas, and that no transmissions will occur over Canada or Mexico unless authorized by either of those administrations. As described in the sections evaluating the potential for harmful interference, the energy outside of the main lobe of the antenna will be below the minimum signal sensitivity of user devices (-105 dBm).



[REDACTED]

The [REDACTED] use a 10 dBi Yagi, and 2 W max transmit power, to produce an EIRP of 42 dBm. The signals are 200 kHz in bandwidth and modulate at a 270.8333 kbps bit rate. The [REDACTED] signal energy bandwidth is illustrated in Figure 6 below. The operational parameters for the ground and space stations are shown in Table 2 – (a) and (b) – below.

Additional information on these [REDACTED] and the link analyses is provided in Appendices 2.1, 2.2, and 2.4.



GMSK GSM spectrum showing ACI
Level in a 200 kHz channel

Figure 6 - GMSK GSM Spectrum showing ACI Level in a 200 kHz channel

Table 2(a) - UbiquitiLink Uplink (Earth-to-Space) Transmitter Technical Parameters

[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
GSM Module		
• Antenna: Gain	Linear or Circular Polarized: 10	dBic
• Power EIRP	42.0	dBm
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
Location of all Ground Stations		
Navajo Nation, Arizona		
lat/long (NAD83):		
35.9498, -110.0844		
Antenna Height		
[REDACTED]		
Radius of Operation		
~300 km		
Test Dates approx..		
First Quarter 2019,		

	~40 minutes over 10 days	
Table 2(b) - [REDACTED] Payload		
Scheduled Launch & Test Date	Mid-November, 2018/February 2019	
Test Orbital Parameters		
• Altitude	400km	
• Inclination	51°	
• [REDACTED]	[REDACTED]	
Space-to-Earth Tx Freq	850 GSM Band (900 GSM capable)	
Center Frequencies	874 and 829 [REDACTED]	MHz
Channel Bandwidth	200	kHz
Power (W)	[REDACTED]	Watt
Antenna Gain	[REDACTED]	
Antenna Type	[REDACTED]	dBi
EIRP	[REDACTED]	dBm
ERP	[REDACTED]	dBm
S/C Orbital Height	400	km
FSL (Free Space Loss)	[REDACTED]	dB
PSD (Power Spectral Density - Max) dBm per kHz signal bandwidth	-92.8	dBm per 200 kHz
PSD (Power Spectral Density) at beam edge	-105.00*	dBm per 200 kHz

*-105 dBm is selected as the beam edge because this represents the receiver sensitivity of GSM devices

Table 2 - UbiquitiLink STA Request Operational Parameters

Interference Mitigation

The engineering and spectrum team at UBLink has conducted a very detailed analysis to compute, via Monte Carlo methods, that the probability of harmful interference from this test will be non-existent.

The UBLink system shall use a specific channel licensed to Cellular One in this area. The main area of testing is in a remote portion of northeastern Arizona. Operation in a quiet area is preferred since the downlink signal from the spacecraft is very low, and is intended to be the “tower of last resort”. It, therefore, should not compete with terrestrial communications. This low signal power level will preclude harmful interference in all instances. The quiet area, or zone, is outside cell tower coverage and we are purposefully selecting for an area away from cell towers for testing.

Attachment 2 is a detailed description of the Concept of Operations for this test.

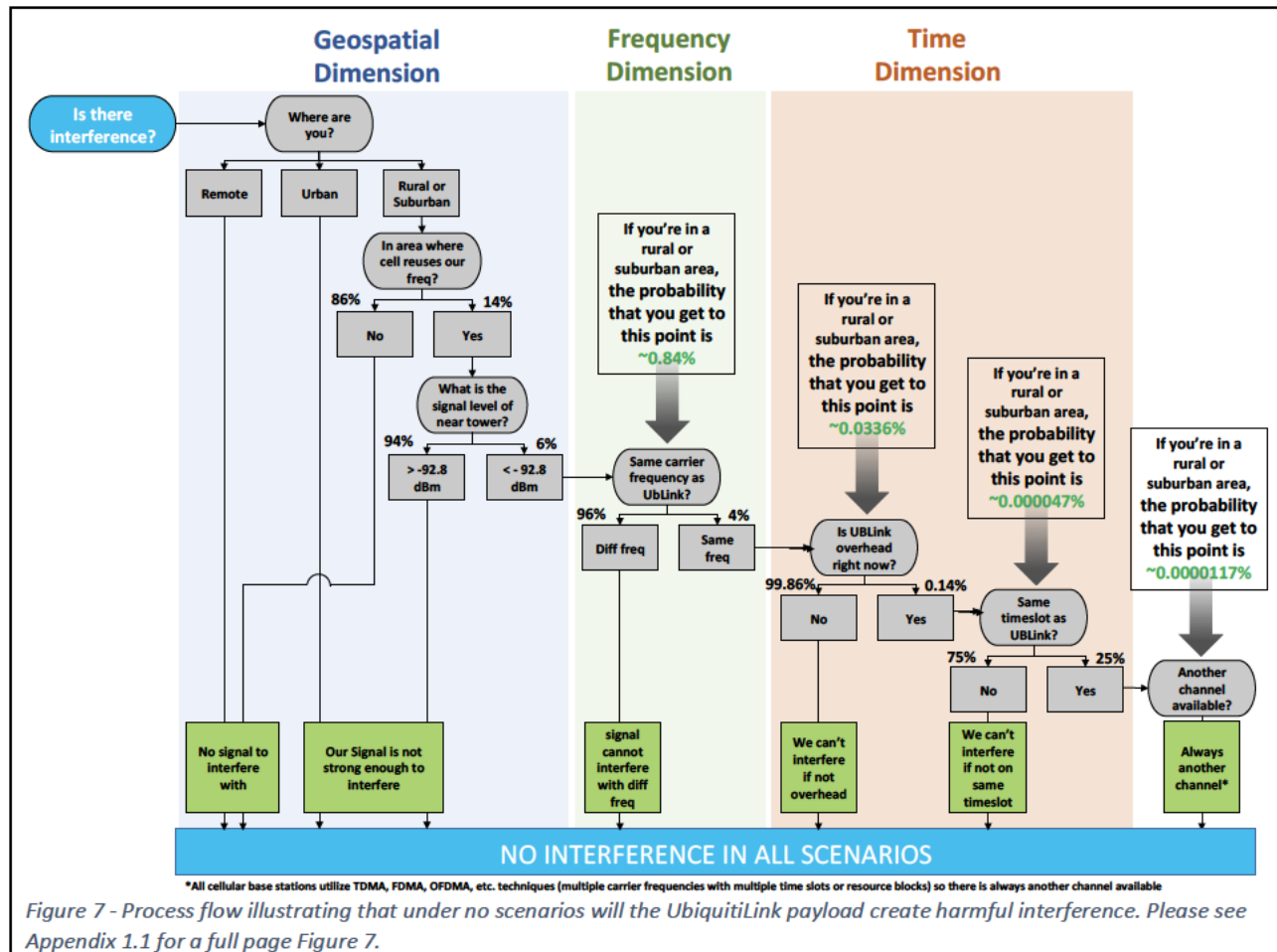
Within the CONOPS description (referenced elsewhere) is information and charts illustrating the orbital path of the spacecraft and downlink beam patterns over time. It is expected [REDACTED] will be moved into the proper orbit sometime not earlier than January 2019 and [REDACTED] perform testing not earlier than mid-January. The opportunity for testing will occur over approximately a 10-day time period. [REDACTED]

A particular point on the surface of the Earth that meets this criterion [REDACTED] would experience approximately 2 minutes of [REDACTED] connectivity centered on Cygnus's overpass. This 2-minute time period is a testing session. The number of testing sessions within the US during a given [REDACTED] session may be on the order of 2 or 3 depending on the latitude of the location. The number of testing sessions at the location provided by Cellular One during any given [REDACTED] session is only 1. This means that all of the testing at the testing location in Southwest US will occur for about 2 minutes once each day over about a 10-day period, or about 20 minutes in total (10 pointing sessions x 1 testing session per [REDACTED] session x 2 minutes per testing session). Only a single 200 kHz channel will be accessed during this testing.

Since the proposed testing will occur for only up to two minutes during any particular pointing session the probability that any user's [REDACTED] device on the ground is interfered with is incredibly low, and the probability that the user's service is impacted is essentially zero.

The reasoning is described below and follows from a series of compounding low probability events. The various scenarios are divided into Urban, Suburban/Rural, and Remote. When needed (such as in the case of Suburban/Rural scenarios), sub-scenarios are considered in the dimensions of space (geospatial), frequency, and time.

Figure 7 below reflects a summary of the analysis in the form of a process flow. The conclusion is that no matter the scenario or sub-scenario there is no chance of harmful interference. The flowchart reads from top left to bottom right. The flow chart uses color-coded columns to indicate the dimension being analyzed along that particular point in the process flow decision line. Later in this analysis, the exact probabilities for the possible outcomes within this process flow are numerically computed.



Urban Interference Analysis:

There will be no impact to urban users.

Urban environments contain a large number of closely spaced towers to provide ample performance in the presence of significant multipath, shadowing, and attenuation. Additionally, towers are spaced closely in order to leverage frequency re-use and support a large number of subscribers and substantial bandwidth demands. The only locations in urban geographies where cellular signals drop to levels comparable to those from the satellite payload satellite are when attenuation from obstructions, multipath, building penetration, etc. occur. At these locations, any signal losses due to multipath, obstructions, or other attenuation will equally impact the signal from the satellite payload. Thus, there is no material case in which a customer in an urban location will suffer impeded service due to the presence of the satellite's weak signal.

In Figure below, the urban interference analysis is conducted in columns 3 through 5 and shaded in dark blue. Urban cell radii typically do not exceed 3 km. The overlap with a neighboring cell (for handoffs); therefore, would occur at a smaller radius away from a cell tower. As indicated by the color of the cells in the 5th column, the signal energy from the UBLink

payload would not raise the co-channel interference floor enough to cause harmful interference per the GSM specification for C/I when designing cellular signals for co-channel interference mitigation.

Suburban/Rural Interference Analysis

There will be no impact to users in suburban or rural geographies.

Suburban and rural users live in areas where cell edges have the greatest risk to be impacted by the power from the satellite payload because cells are generally larger and more spread-out. Although most at risk for potential interference from the UBLink payload, the following rationale details why suburban/rural geographies will experience no harmful interference. Customers will experience no harmful interference, because:

- 1) the potential for interference is infinitesimally small (0.0000117%), and
- 2) the inherent design of the terrestrial cellular network is designed to be automatically robust enough to mitigate instances of potential interference.

The terrestrial cellular network is designed to deploy the use of its spectrum to users across 3 dimensions to maximize throughput: space, time, and frequency. In other words, the spectrum is deployed geographically via expansive frequency re-use and then each cell channelizes communications across the domains of frequency and time using multiple access schemes. Therefore, in order for interference to occur, it must occur at a particular place and time/instant, and on a particular carrier frequency.

The following discussion analyses the probability of interference from the UBLink payload on the terrestrial cellular network across the following dimensions:

- 1) Spatial/geospatial
- 2) Time
- 3) Spectral/frequency.

The following analysis shall prove that even individually, the potential for interference along any one of the three dimensions in the cellular communications infrastructure is itself unlikely. Furthermore, we demonstrate that all 3 dimensions must be invoked at the same time in order for interference to occur for any given cellular device user in the real world.

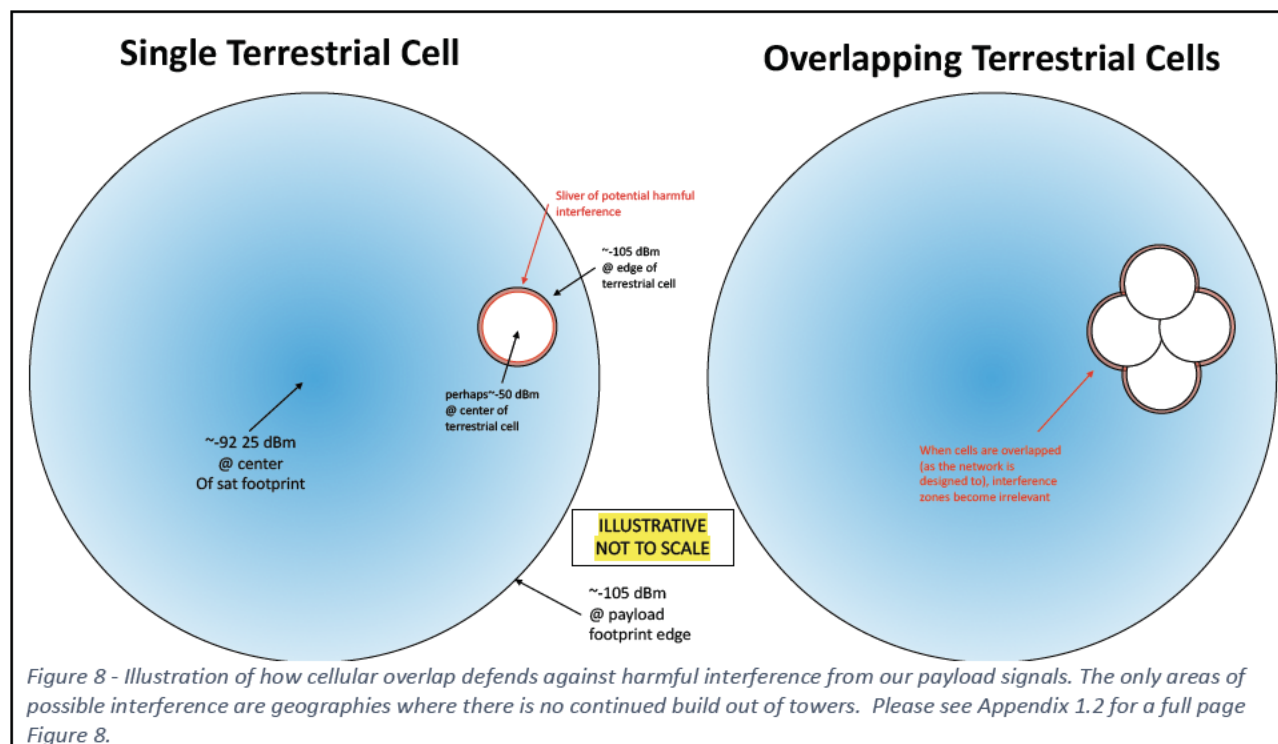
The conclusion of the analysis below is that there is about 0.0000117 % probability that the UBLink payload will create interference to a Suburban/Rural user's *initially* chosen carrier. However, the GSM device will then automatically select another carrier should this extremely unlikely event occur, and in such regions the availability of another carrier is nearly certain. Thus, the final likelihood of actual harmful interference impacting the service is zero.

Impact of potential interference spatially/geospatially

Spatially speaking, across the US, our analysis suggests that there is about 0.84% chance of interference.

The cellular structure relies on a frequency re-use pattern to avoid self-interference from adjacent cells operating at the same frequency. Since the test satellite operates on a single 200 KHz carrier frequency, only a fraction of the towers within the footprint could ever even be impacted. Typical frequency re-use schemes in suburban/rural geographies are on the order of every 7 or 9 towers. So numerically, the percentage of towers within a footprint that would even be sharing the same co-channel would be on the order of 14% in a worst-case scenario.

Of the 14% of tower cellular coverage areas on the ground, any impact from our payload signal would only happen at the portions of cells that represent the edge of regional coverage. Therefore, the central regions of suburban and rural locations and those that abut higher density regions (e.g., urban) would see no impact. This is represented in Figure 8 below where the design cell edges of suburban and rural towers are indicated in cases of overlap and no overlap. In geographies where cells overlap interference is mitigated, but those cells that represent the edge of regional cellular coverage or stand-alone, are subject to possible interference. The only areas that could be impacted within these cells are the slice between -92.8 and -105 dBm, which are generally areas of overlap with adjacent cells. However, at the edge of regional cellular coverage, these may be the only signals available in some geographies (where very few, or no people live). Below -105 the phones won't work, and so there can be no interference. At or above -92.8 dBm (the upper limit of the payload downlink signal energy) the tower dominates.



Attachment 2 contains a Monte Carlo simulation analysis related to the potential interference related to geospatial factors during the test. The analysis illustrates that the percentage of all land area in the US that might have access to a signal from only one tower and where the signal from that one tower is between -92.8 dBm and -105 dBm is ~6%. In other words, the theoretical possibility of interference is at most 6% of the US geography.

In conclusion, the probability that there could be interference from our payload solely enabled by the geospatial criteria is 0.84% because only 14% of towers representing the 6% of the US geography that could possibly experience interference will use the same group of carrier frequencies as the UBLink payload.

Impact of potential interference in time

Our analysis suggests that the UBLink payload can only interfere 0.035% of the time across the proposed testing period.

Our payload will be operational over the test site for about 20 minutes total over 10 days of testing. This represents 0.14% of 10 days-time and, therefore, from a time dimension, there is a 0.14% chance that the UBLink payload could even be transmitting while over the proposed location in the Southwest US.

Furthermore, the signals from the UBLink payload will

[REDACTED]

[REDACTED] remain quiet on at least 6 out of 8 of the downlink timeslots at all times

[REDACTED] Therefore, along the timing dimension, the probability that there will be interference when the UBLink payload is transmitting is 25%. In other words, there is a 25% chance that there is a burst from the UBLink payload on the downlink channel that coincides with a burst from a terrestrial cellular tower downlink channel on the same exact timeslot.

In conclusion, the temporal probability that there is interference is 25% of 0.14% or 0.035%.

Impact of potential inference in frequency

A typical cellular tower might utilize 5 MHz of spectrum. For any given cellular tower below the spotbeam that operates across 5 MHz of spectrum, 200 kHz represents 4% of the spectrum on any given tower.

Thus, the probability of interference on a spectral dimension is likely not higher than 4%.

Impact of potential inference accounting for ALL 3 factors

In conclusion, the probability that a user's device is 1) operating on a cell tower in a rural area near the test site with a cell signal lower than the signal from our payload, 2) on the exact frequency we are using for the test, and 3) at the exact time that we are overhead using it is $0.84\% * 0.035\% * 4\% = 0.0000117\%$.

However, unlikely as that is to happen, the GSM protocol is designed to be resilient to various issues with individual carriers that may temporarily degrade performance of an individual user device with individual carriers. Should the effect occur with a 0.0000117% probability the device and its base station will simply move to another available carrier. The fact that this is only an issue at the fringes of the network, where user density is very low assures that alternate carriers will be in plentiful supply.

Thus, the final probability of harmful interference is zero.

The tests are being conducted with the express cooperation and participation of the terrestrial licensee, [REDACTED]

[REDACTED] It is a primary objective of the UBLink test program to accumulate data to validate these assumptions and provide a design baseline for enhancements to the network aimed at delivering and improving the service.

Remote User Interference Analysis

There will be no impact to remote users:

Remote users, by definition, are those who reside in regions in which there are no towers sufficiently close to produce service. These users are enabled by the UBLink service without which they would have either no or unusable connectivity.

Variable	Value	Units	Comments
Frequency	874	MHz	Based on highest frequency we might use
Base Station Height, Urban (hb)	30	m	An urban base station at 30 m high will have line of sight to 19.56 km away on a bald earth. Will likely be designed for 1-3 km radius
Base Station Height, Suburban (hb)	60	m	A suburban base station at 60 m high will have line of sight to 25.25 km away on a bald earth. Will likely be designed for 3-10 km radius
Base Station Height, Open Area (hb)	80	m	A rural base station at 80 m high will have line of sight to 31.95 km away on a bald earth. Will likely be design for 10-30 km radius
Base Station EIRP (dBm)	62	dBm	Based on maximum base station EIRP
Mobile Station height (hm)	1.5	m	
Minimum Usable GSM Level	-105	dBm	Per GSM spec
Ubi Sat D/L Sign Level	-93.25	dBm	From UBL link budget
Antenna Correction Factor (Ch)	0.014736029	dB	Calculated
Wavelength	0.34301	m	Calculated

Distance to Base Station (km)	Free Space Loss (for ref only) (dB)	Urban			Suburban			Rural			
		Path Loss Lurban *	GSM Carrier level (urban)** (dBm)	C/I urban (Ubi Sat)** (dB)	Path Loss Lsuburban *	Carrier level (suburban) (dBm)	C/I suburban (Ubi Sat)** (dB)	Path Loss Lopen *	Carrier level (open) (dBm)	C/I open (Ubi Sat)** (dB)	
1	91.3	126.1	-64.1	29.2	111.6	-49.6	43.7	91.8	-29.8	63.4	Urban cell radiuses
2	97.3	136.7	-74.7	18.6	121.5	-59.5	33.7	101.6	-39.6	53.7	
3	100.8	142.9	-80.9	12.4	127.3	-65.3	27.9	107.3	-45.3	48.0	
4	103.3				131.4	-69.4	23.8	111.3	-49.3	43.9	Suburban cell radiuses
5	105.3				134.6	-72.6	20.6	114.5	-52.5	40.8	
6	106.8				137.3	-75.3	18.0	117.0	-55.0	38.2	
7	108.2				139.5	-77.5	15.8	119.2	-57.2	36.0	
8	109.3				141.4	-79.4	13.9	121.1	-59.1	34.2	
9	110.4				143.1	-81.1	12.2	122.8	-60.8	32.5	
10	111.3				144.6	-82.6	10.7	124.2	-62.2	31.0	
15	114.8							129.9	-67.9	25.3	Rural/Open cell radiuses
20	117.3							134.0	-72.0	21.2	
25	119.2							137.1	-75.1	18.1	
30	120.8							139.7	-77.7	15.5	
35	122.2							141.9	-79.9	13.4	limit on GSM protocol

* Based upon Okumura-Hata Model - generally good from 1 to 20 km

** GSM C/I must be above 9 dB, GSM carrier level must be above minimum level from above. Areas where the C/I is below required and still within operational carrier levels are shown in red.

Figure 9 - Analysis of potential interference across rural, suburban, and urban cellular sites. No cell that operates within a greater honeycomb structure will be impacted; however, some regional cellular borders, where no cellular towers continued to be built out, will have signal energy that fades off at distances in excess of the coverage area design limits. These eventually may experience potential interference from UbiquitiLink's payload signal. Harmful interference will not occur as discussed above. See Appendix 1.3 for a full page of copy of Figure 9.

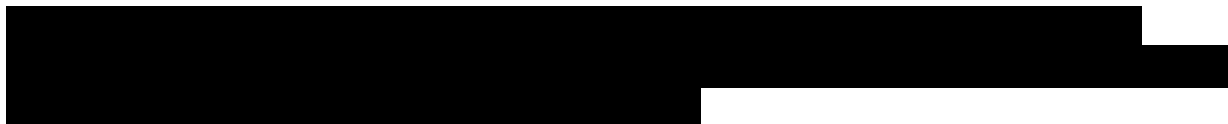
Frequencies of Operation

Description of GSM 850/900 Bands and Spectrum of Operation

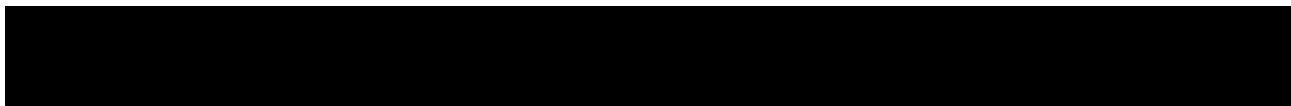
The spaceflight demo [REDACTED] uses a single [REDACTED] carrier at any one point in time. The satellite circumnavigates the globe in a 51.6 degree inclination orbit and overflies many regions that use the two bands presented in Table 3. As such, the communications payload operates flexibly over a range of frequencies and bands under the control of a payload processor that executes largely geospatially based stored commands. These stored commands will articulate how and when signals are transmitted from the payload using an SDR implementation for the transceiver. Presently this duplex carrier may fall in either the GSM 850 or GSM 900 Bands depending on location in orbit. During the flight over the location provided by Cellular One, the carrier will be within the GSM 850 band.

Freq. Band	Uplink Portion (MHz)	Downlink Portion (MHz)
GSM 850	824.2 – 848.8	869.2 – 893.8
GSM 900	890.0 – 915.0	935.0 – 960.0

Table 3 - Uplink and Downlink frequencies of the UbiquitiLink payload. Note that our application is only requesting use of GSM 850 at this time—the values shown are payload capabilities.



The GSM 850 and 900 Bands allow for multiple power class devices. We will be using the highlighted power class level (with our baseline testing plan assumptions).



[REDACTED]

Point of Contact to Suspend Transmission

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] Tyghe Speidel should be contacted to inform that the request to initiate the kill switch was made. Mr. Speidel is also the point of contact if additional assistance is required to turn payload power off [REDACTED]
[REDACTED]

[REDACTED]

[REDACTED] This will be performed using either of 2 methods:

- The transmitter must be enabled by and may be disabled by [REDACTED] [REDACTED] TT&C system.
- All DC Power [REDACTED] may be applied or removed by [REDACTED] [REDACTED] TT&C system.

[REDACTED]

[REDACTED]

[REDACTED] In this way, UBLink will be able to control and reprogram the configuration files, itinerary files, and as required software/protocol management functions on the payload during operations. The short duration of this mission will limit the potential to make significant software changes, but certain test modes will be preloaded and controlled during various stages of the mission.

Orbital Debris Mitigation Statement Pursuant to 47 CFR § 5.63.

The UBLink payload was designed to eliminate the potential, to the extent possible, of creating orbital debris. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Attachment 1



1500 S White Mountain Rd
Show Low, AZ 85901

P: (928) 537-0690
cellularoneonline.com

Author's Direct Contact Information:
(928) 537-0690 Ext. 2282 or 2286
gturley@cellularoneaz.com

July 26, 2018

Via Electronic Mail Only

Federal Communications Commission
Office of Engineering and Technology
445 12th Street, SW
Washington, D.C. 20554
Attention: Chief Engineer OET

**Re: Spectrum Licensee Smith Bagley, Inc. dba Cellular One of North East Arizona's
Grant of Permission to
UbiquitiLink, Inc.'s Special Temporary Authority (STA)
for Testing of Satellite Payload**

Dear Madam/Sir:

It is our understanding that UbiquitiLink, Inc. is seeking Special Temporary Authority (STA) to perform an experiment with its satellite payload in the 850 and 900 MHz bands [Block & Channel designations] at specified locations in the United States [REDACTED] for a sixty (60) day period commencing approximately February 1, 2019. These tests are on a non-interference basis as part of their development process and will also lead to prospective overseas uses of this satellite payload.

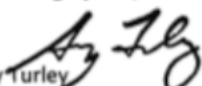
As the FCC licensee for a portion of this spectrum, we have no objections to non-commercial tests for a limited period of time in our band as described below:

- Frequency 829 uplink, 874 downlink /channel 152; and
- Testing location 35.9498 -110.0844.

We anticipate participating in these tests.

Sincerely,

Smith Bagley Inc., dba Cellular One of North East Arizona


Guy Turley
Chief Technical Officer

cc: **Via Electronic Mail Only**
International Bureau, Chief

Attachment 2

UbiquitiLink Cygnus Test CONOPS

Description of GSM 850/900 Bands and Spectrum of Operation

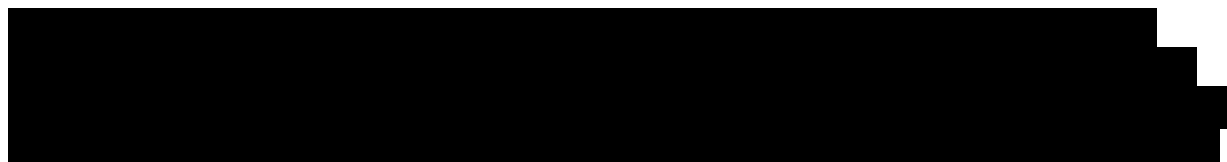
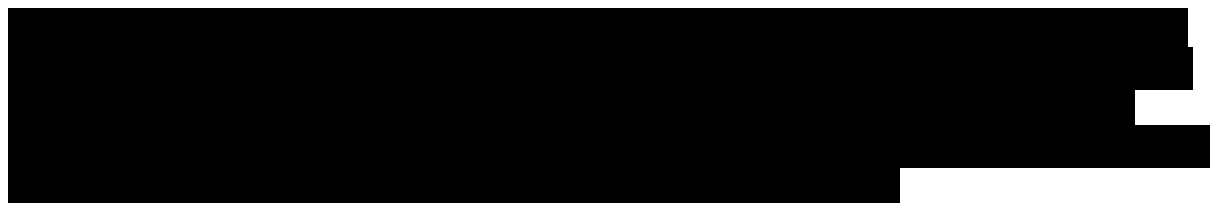
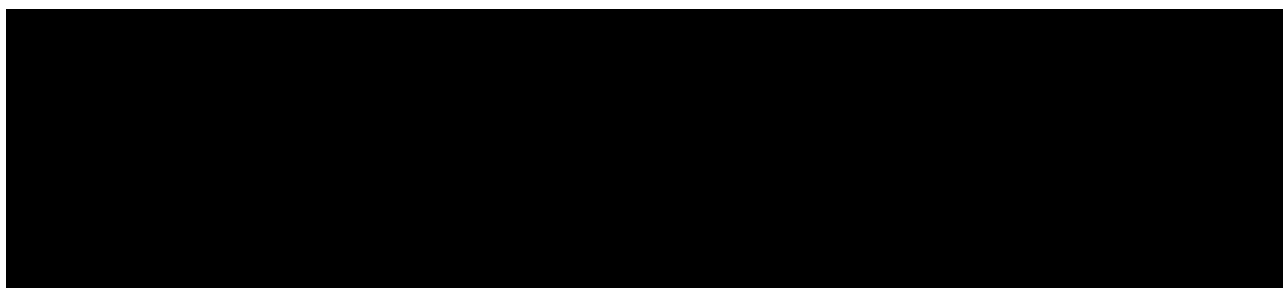
The flight demo will operate a [REDACTED] single [REDACTED] carrier at any one point in time. [REDACTED] carrier may fall in either the GSM 850 or GSM 900 Bands.

Freq. Band	Uplink Portion (MHz)	Downlink Portion (MHz)
GSM 850	824.2 – 848.8	869.2 – 893.8
GSM 900	890.0 – 915.0	935.0 – 960.0

Table 5- Uplink and Downlink frequencies of the UbiquitiLink payload. Note that our application is only requesting use of GSM 850 at this time—the values shown are payload capabilities.

The uplink and downlink portions are paired in what is called Absolute Radio Frequency Channel Numbers (ARFCN). The uplink and downlink portions are always separated by 45 MHz (with the uplink being the lower portion of the band).

The GSM 850 and 900 Bands allow for multiple power class devices. We will be using the highlighted power class level (with our baseline testing plan assumptions).



[REDACTED]

[REDACTED]

Description of CONOPS during communication session

The CONOPS is as follows.

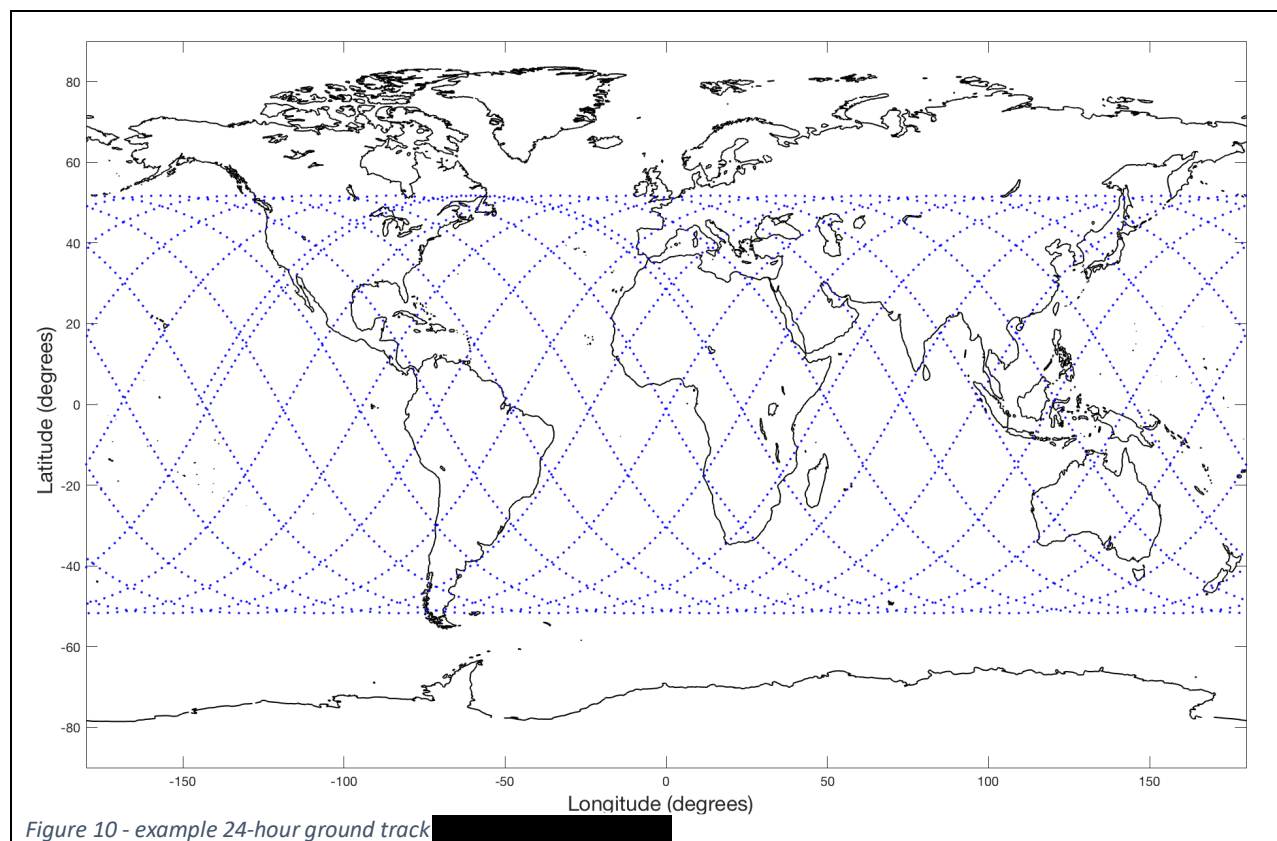
[REDACTED]

[REDACTED]

[REDACTED] at an altitude of approximately 400 km, inclined by 51.6 degrees to the equator, and approximately circular.

[REDACTED]

The spacecraft will have a ground track represented by Figure 10, which shows a 24-hour ground track of the orbit described above. Since the RAAN (Right Ascension of the Ascending Node) is unknown at this time, the ground track may be shifted east or west depending on the date. However, the sinusoidal shape will be preserved. The exact timing of communications testing and enabling of the transmitter will also be adjusted as required to compensate for these orbital parameter variations.

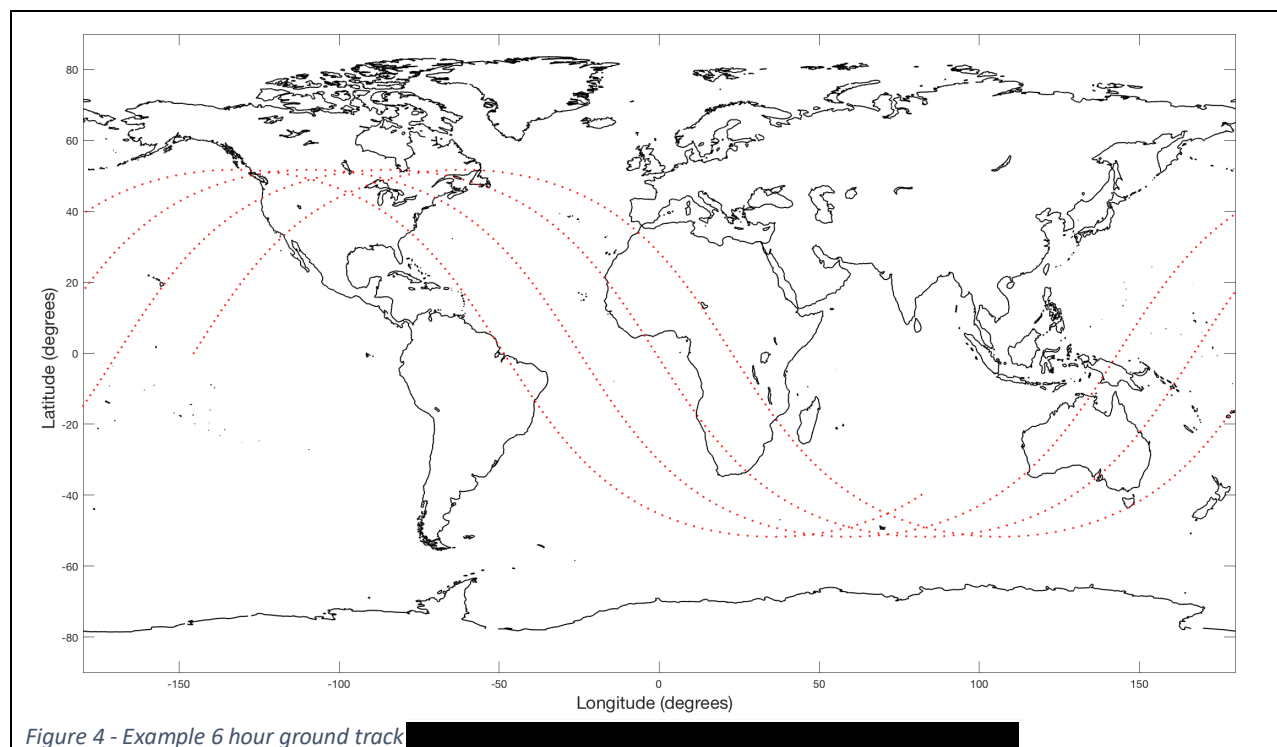


During the test mission, [REDACTED]

In order to conduct the planned testing, [REDACTED]

Figure 11 shows a hypothetical 6-hour ground track. [REDACTED]

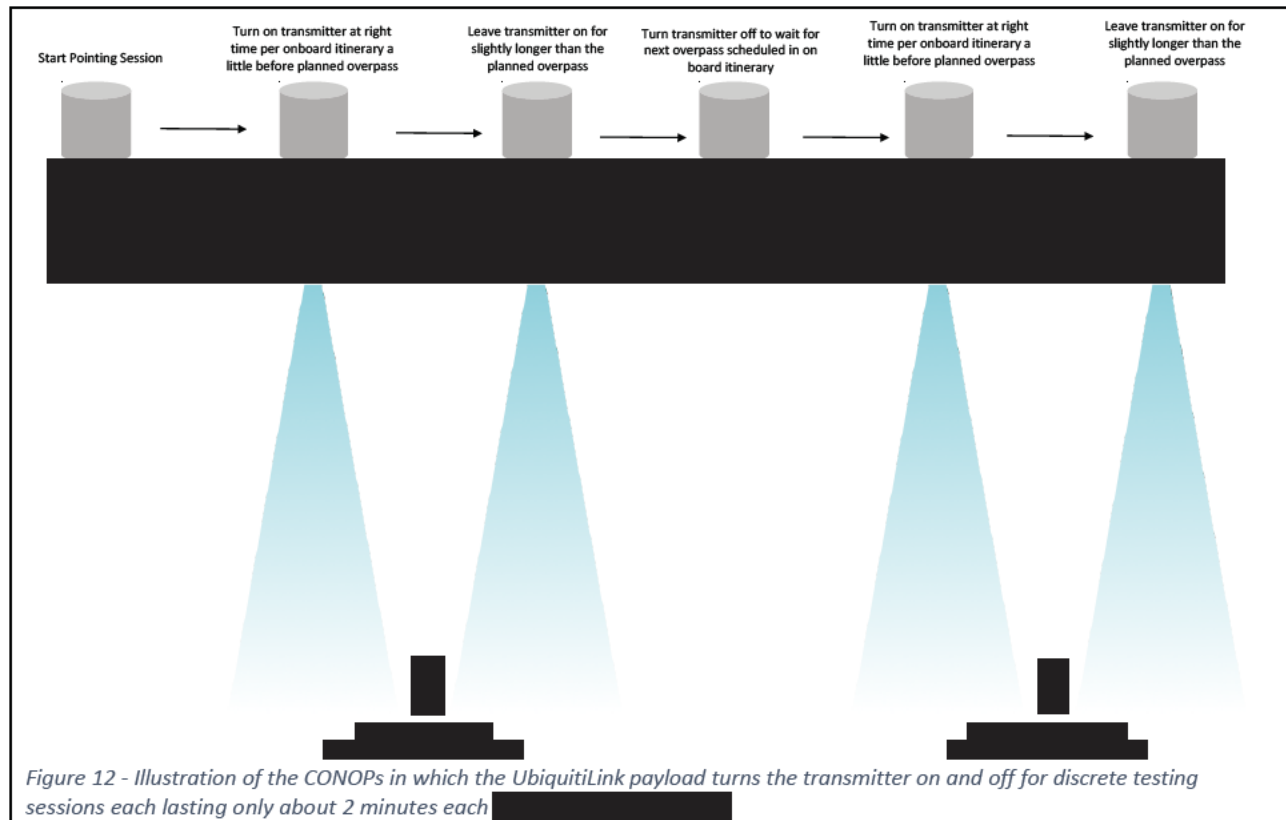
[REDACTED] It is anticipated that about 10 such [REDACTED] sessions will be possible. As stated above, the shape of this curve is accurate, but depending on desired testing locations the time when the maneuver is initiated is chosen to move this curve to the east or west so that they test locations fall within the 4 orbits of the pointing session.



the payload will use its on-board clock to track along an on-board stored itinerary, which will know when to transmit and stop transmitting, on what frequency, etc. Each itinerary item will include a start and end time with configuration information (uplink/downlink frequency pairs, transmitter power level, etc.). there may be several “communications sessions” that occur in series and are articulated over the course of the entire session. This is illustrated in Figure 12 below.

During each communication session, the payload will operate with the following concept of operations:

- The signals are 200 kHz in bandwidth and have a 270.8333 kbps bit rate. This is illustrated in the diagram below.



Description of Spacecraft Power, TT&C, and “Kill Switch”

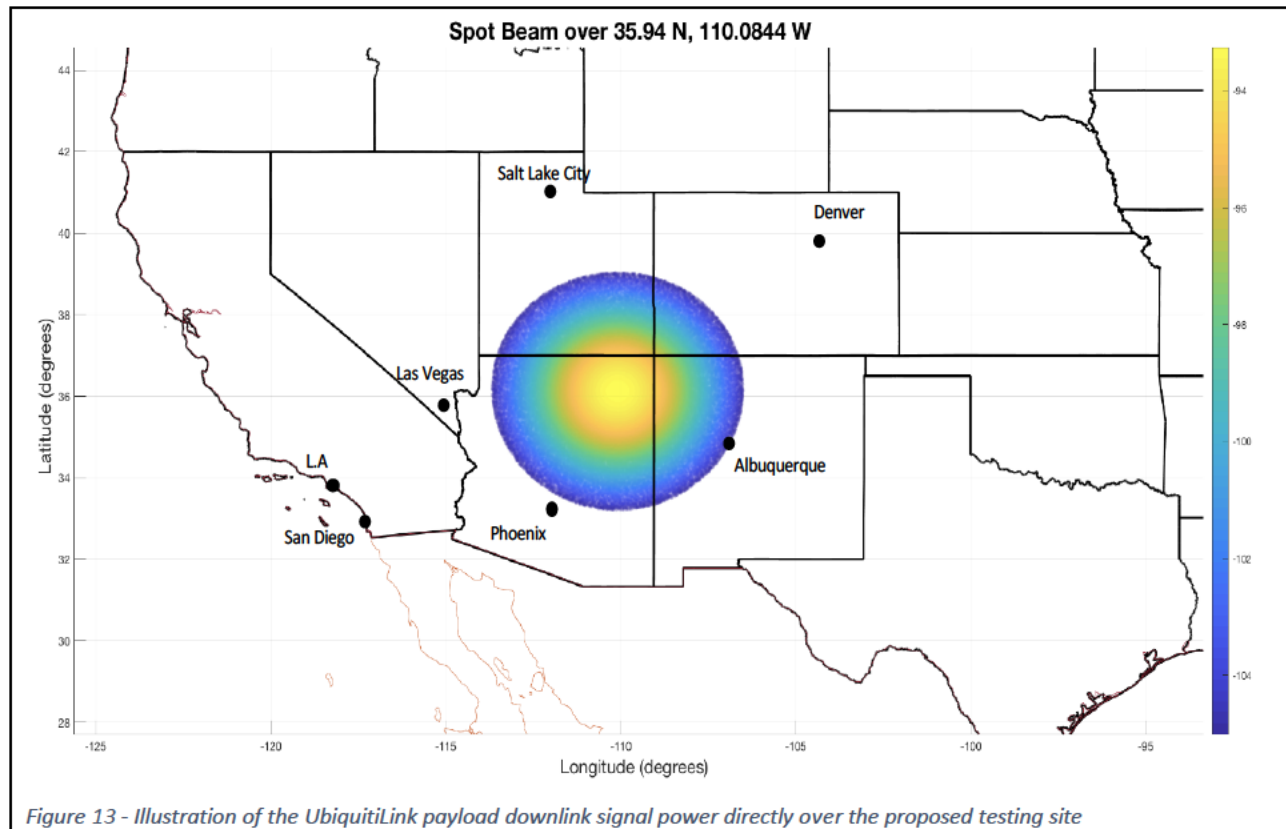
A procedure and contact information is in place with the operations personnel at the Mission Operations Center.

In addition, there is a telemetry and command link. This implements a path for commanding the transmission, and for data movement to/from the payload for telemetry, commands and other data, which then is accessed. This will enable the control and reprogram of the configuration files, itinerary files, and software/protocol management functions on the payload prior to and during operations.

Tracking of the payload is straightforward since it will have the same TLE orbital description (Two Line Elements) spacecraft, and it will be accurately determined

Description of Downlink Power Levels

Figure 13 below shows the signal power radiated on the surface of the Earth when the transmitter is on at max transmit power



The figure shows the signal power on the ground as a function of radius away from the footprint center (the sub-satellite point). The vertical axis color key shows the signal power to the phone receiver in dBm, and the x and y axes show latitude and longitude.

The importance of this graph is to indicate how steeply the signal energy falls off as the radius away from the center of the spot beam increases. Only a very small portion of the payloads area of view is subject to signals that fall above the receiver sensitivity of GSM devices on the ground (-105 dBm). Figure 14 illustrates that only inside the first ~300 km of the ~2400 km radius field of view of the payload has signal energy above -105 dBm.

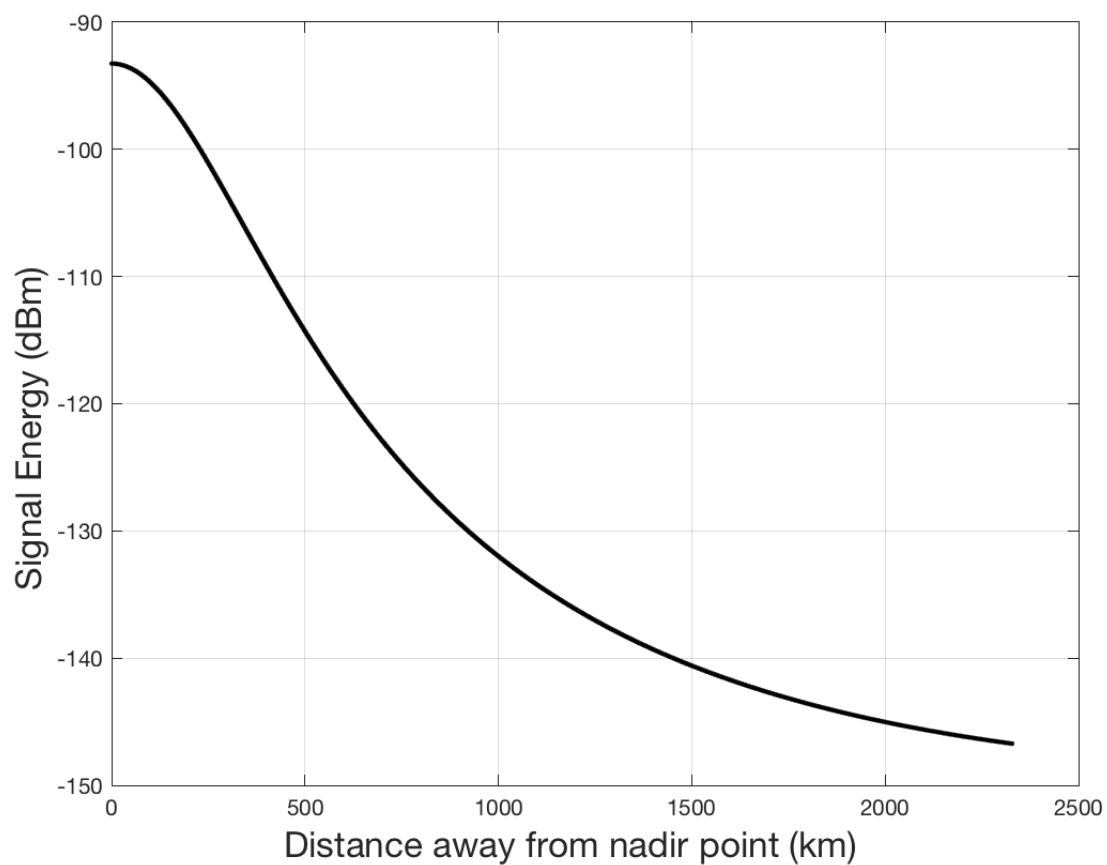


Figure 14 - The signal energy of the UbiquitiLink payload as a function of spotbeam radius to illustrate how steeply the signal energy falls off with distance away from the testing site

Attachment 3

Summary of UbiquitiLink Interference Analysis using Monte Carlo Methods

Utilized Data

<https://hifld-geoplatform.opendata.arcgis.com/datasets/cellular-towers>

The data provided in the link above is cellular tower locations throughout the US. It consists of cellular tower locations as recorded by the FCC, extracted from the FCC Universal Licensing System Database.

The Meta-data for the data set itself can be found here:

<https://www.arcgis.com/sharing/rest/content/items/0835ba2ed38f494196c14af8407454fb/info/metadata/metadata.xml?format=default&output=html>

Per the meta-data, it was last updated on December 20, 2016, by a Senior Engineer at the FCC.

It should be noted that the data set is only composed of 23,499 rows for 23,499 towers. Each row actually represents a transmitter, and some transmitters are located on the same tower (as will become evident later in this report). These 23,499 towers do not represent every cellular cell in the US and likely is only representative of macro cells. However, this is likely sufficient for this analysis as micro, pico, and femto cells don't represent likely candidates of harmful interference from UBLINK as they are predominately located indoors or underground and perform over very short distances.

Data Analysis – Tower locations and distances

The data is analyzed in the MATLAB environment. A CSV file is ported into the workspace and parsed into location vectors for each tower.

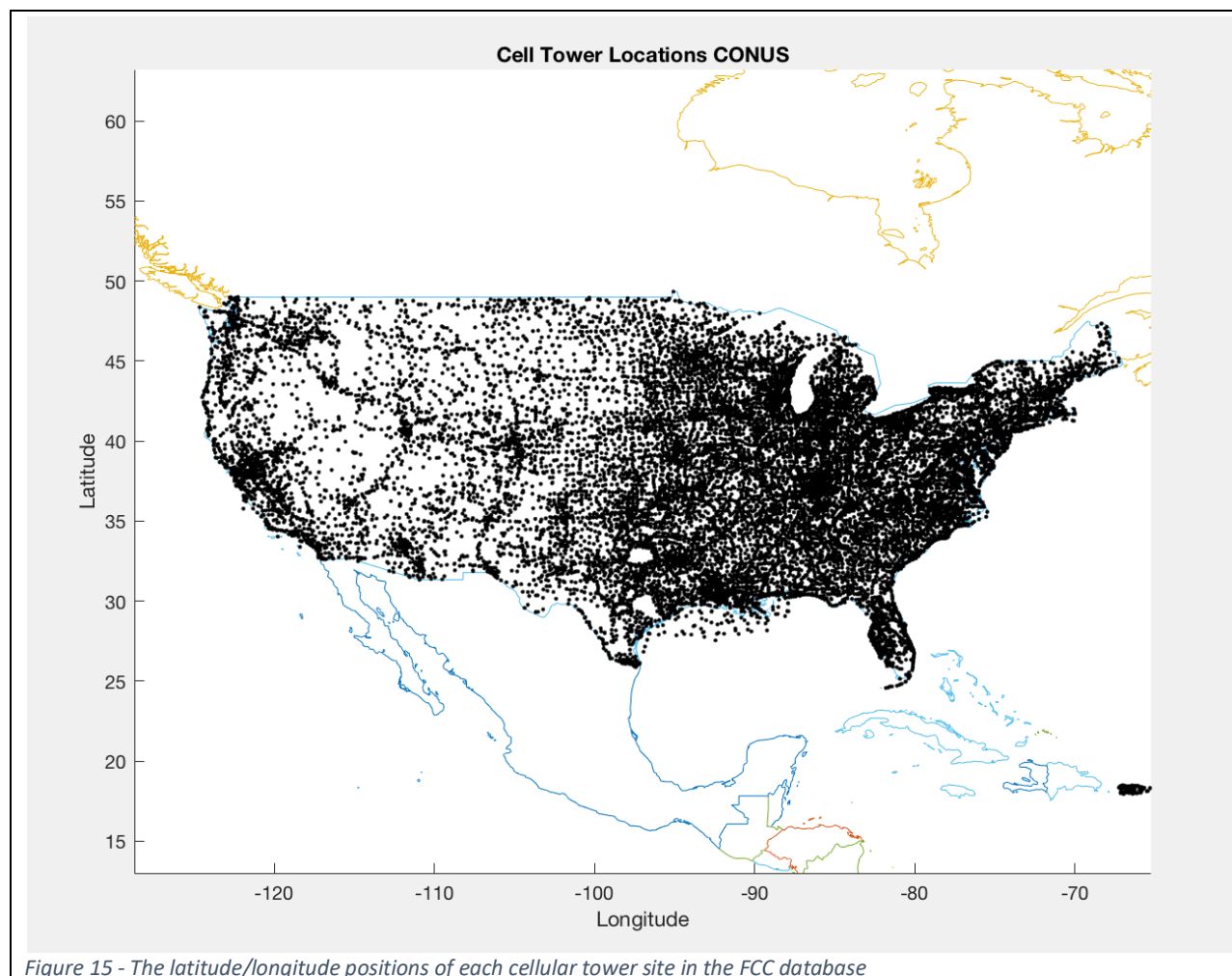


Figure 15 - The latitude/longitude positions of each cellular tower site in the FCC database

Using the latitude/longitude locations of the towers, a WGS84 Earth model is assumed to calculate the corresponding ECEF locations of the cellular towers in 3-D space (to account for the curvature of the Earth).

As a means to examine the distribution of towers that might be impacted an analysis was conducted using the positions of each cellular tower to calculate the distance its nearest neighboring tower. The following represents the probability distribution function for the distance to the nearest tower, for cellular towers.

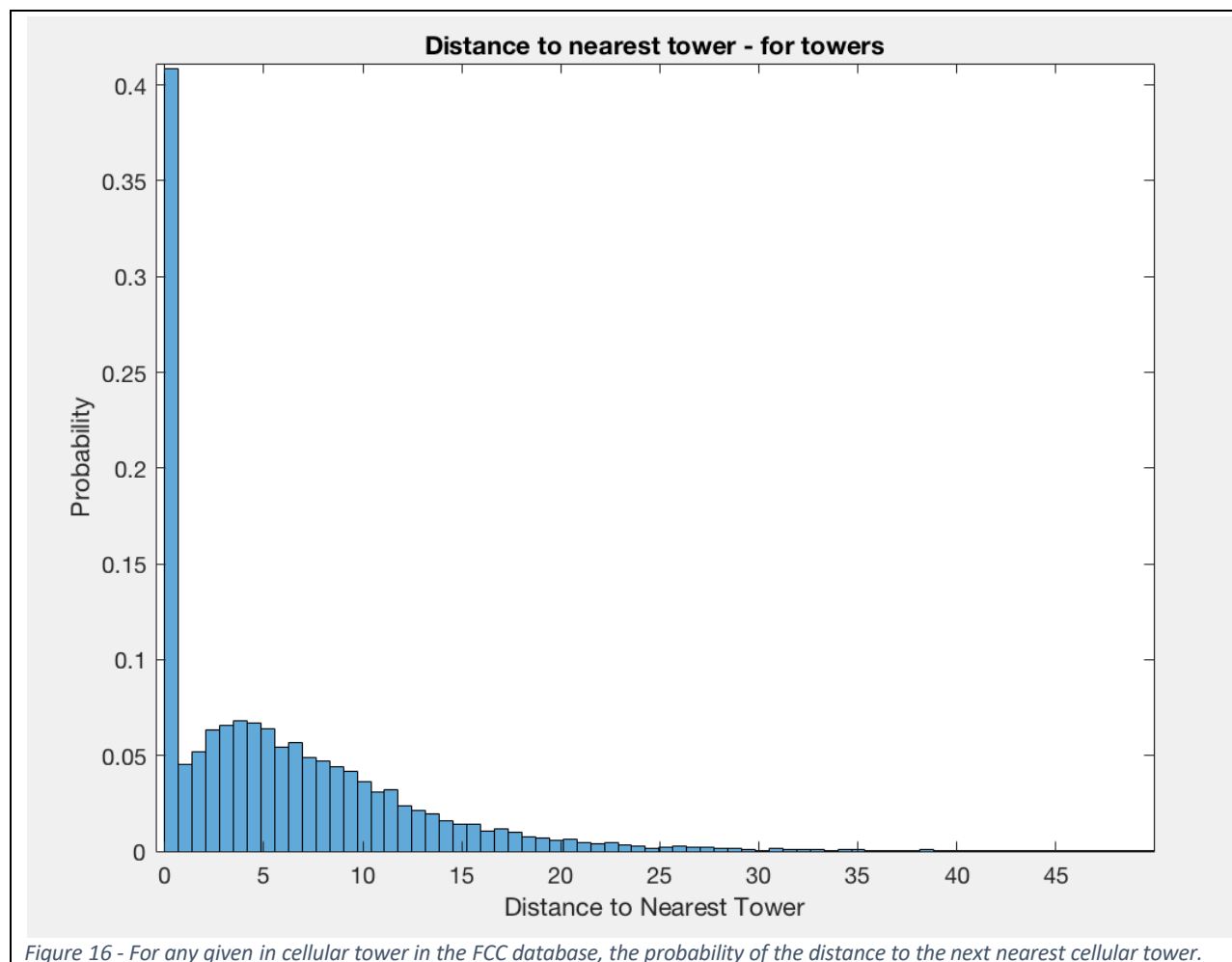


Figure 16 - For any given in cellular tower in the FCC database, the probability of the distance to the next nearest cellular tower.

Data Analysis – Monte Carlo RF Propagation Simulation

The data for tower locations were then used to generate a model for the strongest signal levels at any point across the country. Using a border file for the location of US borders, a Monte Carlo algorithm was developed to generate nearly 1 million points across the entire country. Each of these points is randomly generated (in latitude and longitude). The latitude and longitude positions are used to calculate ECEF positions for every Monte Carlo point.

Assumptions were made for critical signal propagation characteristics. The following are assumed (code snippet taken from analysis script)

```
%Inputs for Cellular Transmitter (on one carrier)
EIRP = 62; %dBm (https://sites.google.com/site/lteencyclopedia/lte-radio-link-budgeting-and-rf-planning)
n = 2.8; %path loss exponent
height = 65; %meters
freq = 874; %MHz
```

The path loss exponent of 2.8 was determined to be well aligned with the suburban Hata model, which seemed suitable for the current analysis.

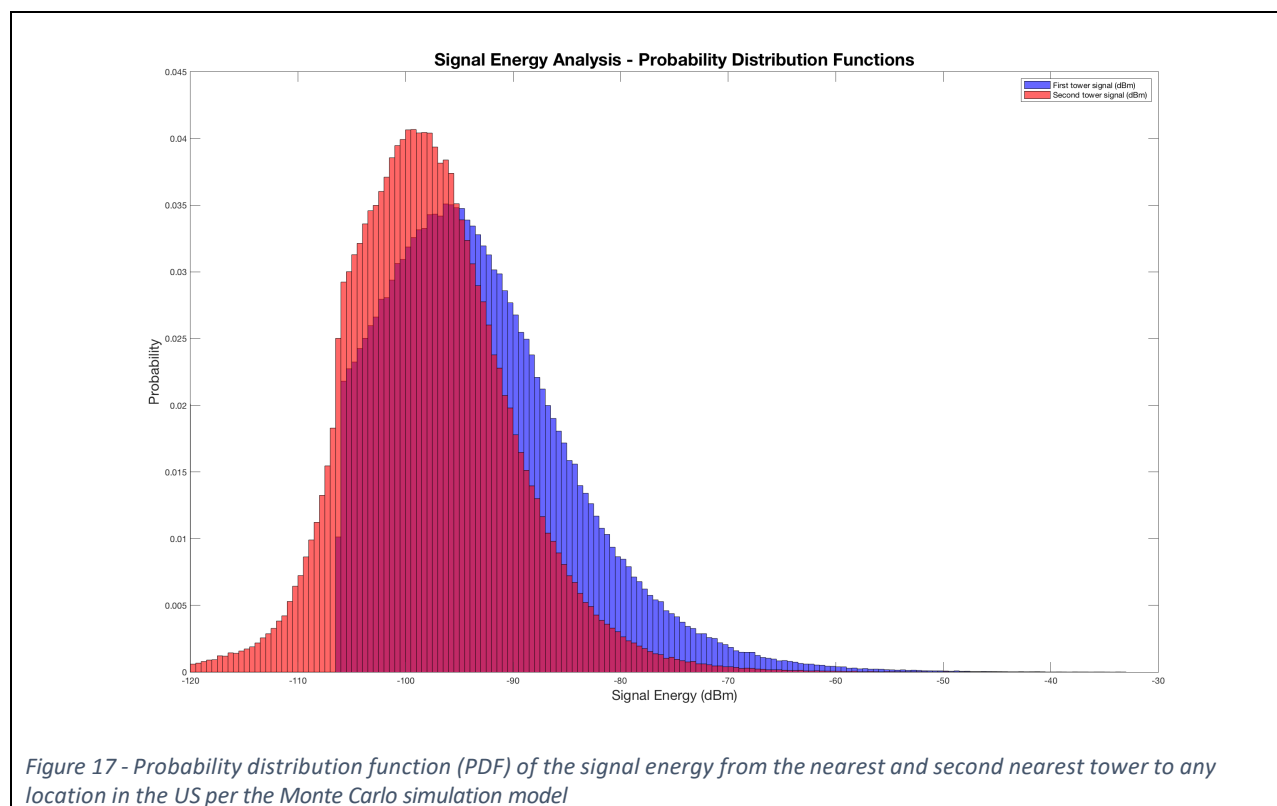
The Monte Carlo simulation points are used as the anchors for a long loop. For each point in the simulation set, the nearest cellular tower is computed. Given the distance to the nearest tower, the strongest signal energy is computed using a simplified exponential path loss model. The EIRP from the base station is assumed to be decremented by the calculated path loss estimate.

For each point, the second nearest tower is also computed, along with its distance and the signal energy from it.

Once the loop is executed, the 1 million simulation points all have a corresponding set of 4 vectors: distance to nearest tower, approximate signal energy from nearest tower, distance to second nearest tower, and approximate signal energy from the second nearest tower.

The following plots tell a revealing story:

Below is the probability distribution function of the signal energies calculated across all the Monte Carlo points in the simulation. The blue histogram represents the signal energy from the nearest, or first tower, to the Monte Carlo location point. The red histogram represents the signal energy from the second nearest, or second tower, to the Monte Carlo location point.



Below is the PDF of the distance to the nearest tower and second nearest tower to all Monte Carlo Simulation points. The nearest tower is in blue and the second nearest tower is in red.

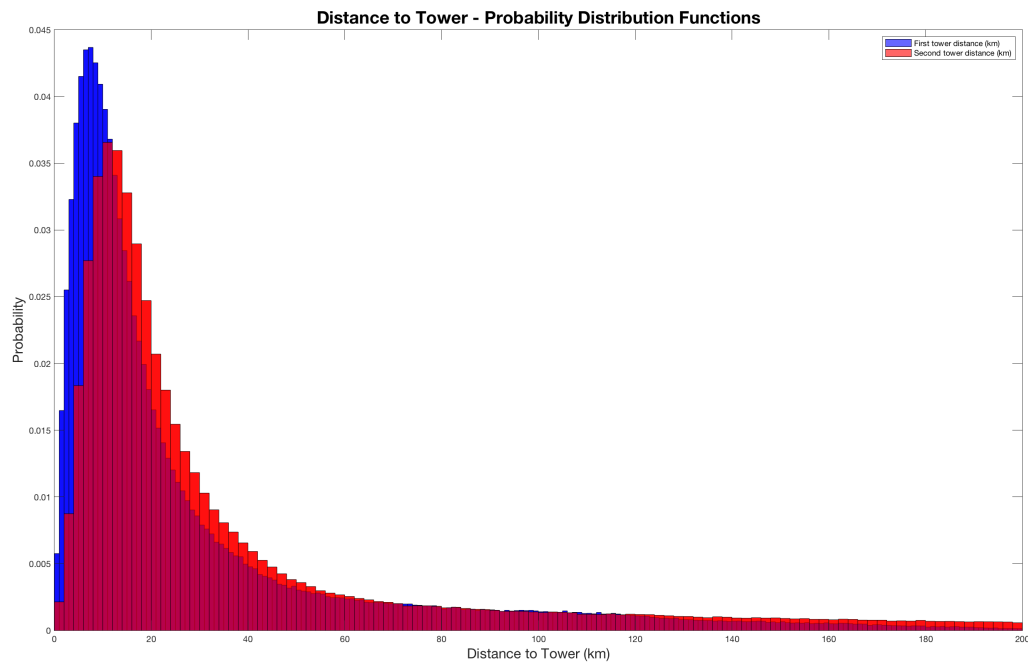


Figure 18 - Probability distribution function (PDF) of the distance to the first and second nearest tower for any location in the US per the Monte Carlo simulation model

Below is the resulting cell signal across CONUS from the simulation. Each point plotted is color-coded based on its signal energy. The color scale is from -105 to the highest signal energy calculated in the simulation. Deep blue is no connectivity.

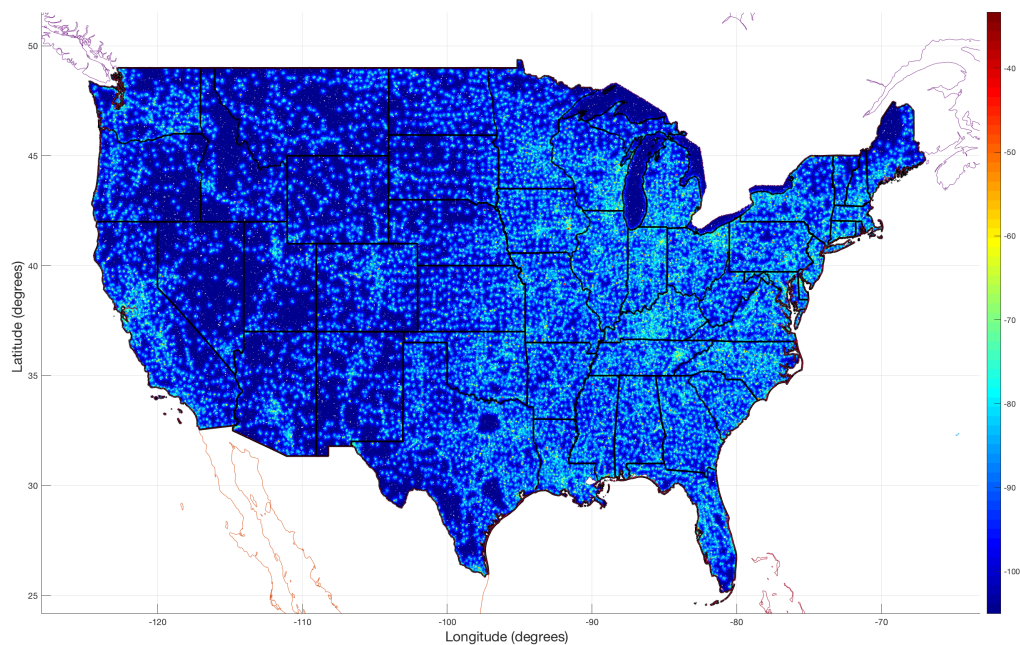
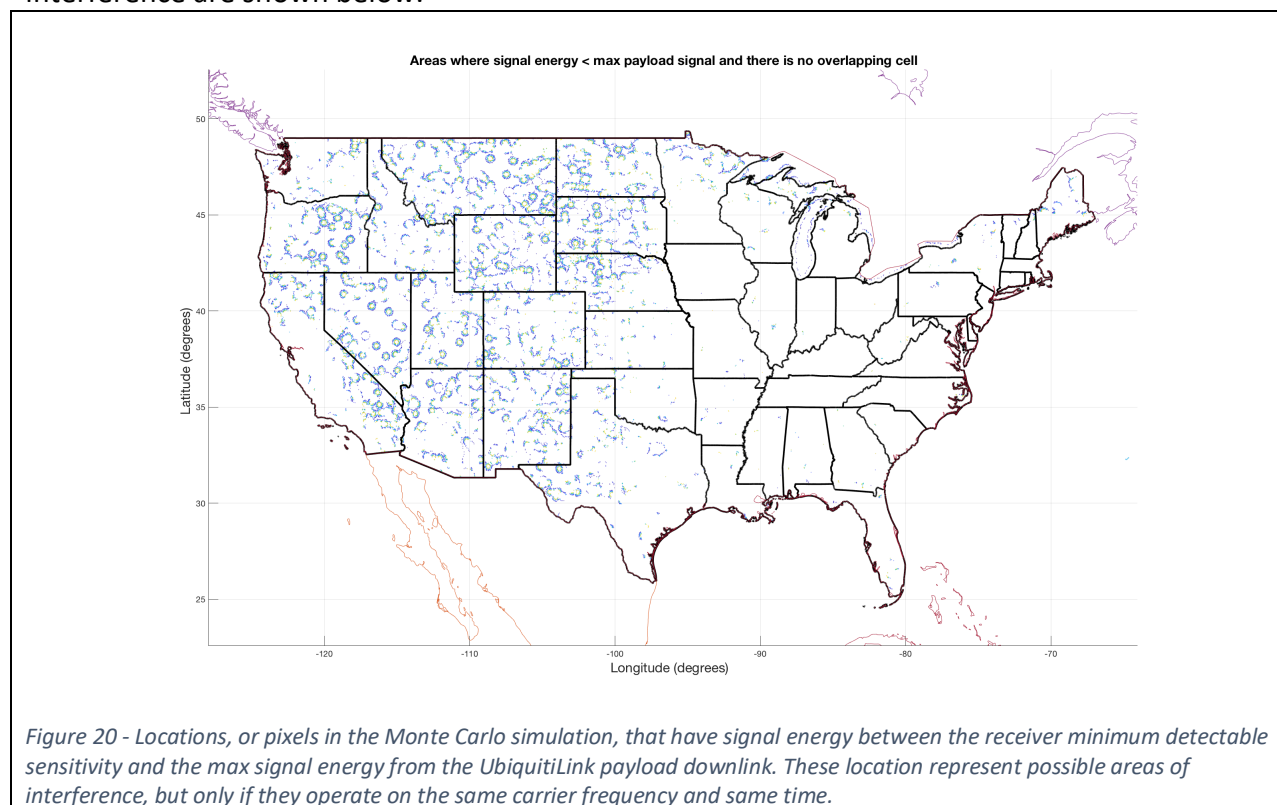


Figure 19 - The signal energy color contour map from the Monte Carlo simulation results

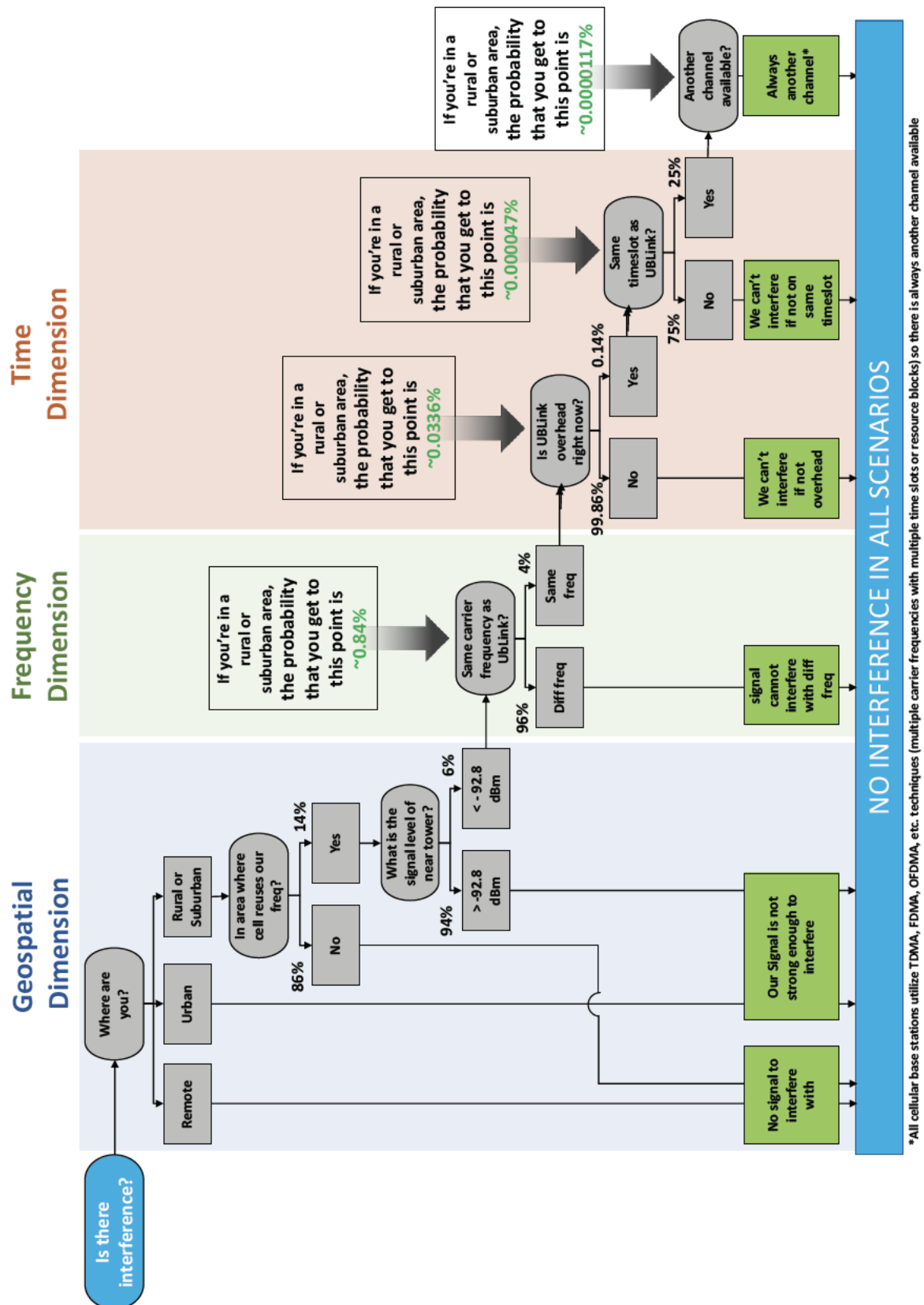
Below are the points in the Monte Carlo simulation which have a cell signal that the payload may interfere with (between -92.8 dBm and -105 dBm) and also have a signal from the second nearest tower that is not able to provide it sufficient service (signal less than -105 dBm). In other words, the following points represent those in the simulation that only have a connection to one existing tower that is a weak connection. Thus, the only places for potential harmful interference are shown below.



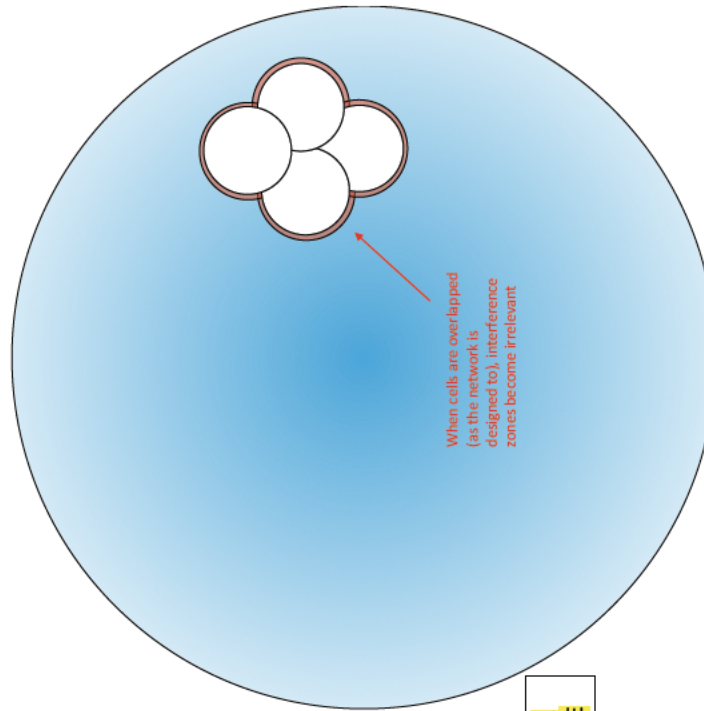
It is also important to include the following calculation details, keeping in mind that the number of points in the simulation is exactly 967,104.

1. Number of points in coverage = 299,127
2. Number of points out of coverage = 667,977
3. Number of points w/ possible interference from UBLINK = 420,108
4. Number of points w/ possible interference from UBLINK and no access to at least a second tower signal = 58,944
5. Percentage of America Geographically "Covered" per this model = 69.07%
6. Percentage of America Geographically "Not Covered" per this model = 30.93%
7. Percentage of all land area with possible interference from UBLINK and no access to a second tower = 6%

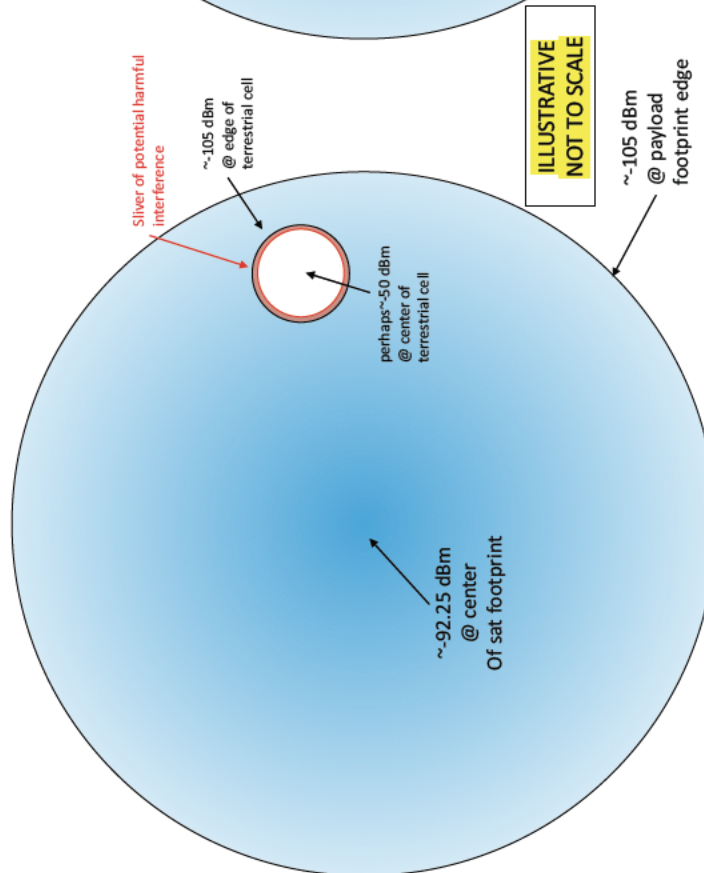
Appendix 1.1



Overlapping Terrestrial Cells



Single Terrestrial Cell



Appendix 1.3

Variable	Value	Units	Comments
Frequency	874	MHz	Based on highest frequency we might use
Base Station Height, Urban (hb)	30	m	An urban base station at 30 m high will have line of sight to 19.56 km away on a bald earth. Will likely be designed for 1-3 km radius
Base Station Height, Suburban (hb)	65	m	A suburban base station at 65 m high will have line of sight to ~28 km away on a bald earth. Will likely be designed for 3-10 km radius
Base Station Height, Open Area (hb)	80	m	A rural base station at 80 m high will have line of sight to 31.95 km away on a bald earth. Will likely be design for 10-30 km radius
Base Station EIRP (dBm)	62	dBm	Based on maximum base station EIRP
Mobile Station Height (hm)	1.5	m	
Minimum Usable GSM Level	-105	dBm	Per GSM spec
Ubi Sat D/L Sign Level	-93.25	dBm	From UBL link budget
Antenna Correction Factor (Ch)	0.0147	dB	Calculated
Wavelength	0.3430	m	Calculated

Distance to Base Station (km)	Free Space Loss (for ref only)	Urban			Suburban			Rural		
		Path Loss Lurban *	GSM Carrier level (urban)**	C/I urban (Ubi Sat)**	Path Loss Lsuburban*	Carrier level (suburban)	C/I suburban (Ubi Sat)**	Path Loss Lopen*	Carrier level (open)	C/I open (Ubi Sat)**
		(dB)	(dBm)	(dB)	(dB)	(dBm)	(dB)	(dB)	(dBm)	(dB)
1	91.3	126.1	-64.1	29.2	111.6	-49.6	43.7	91.8	-29.8	63.4
2	97.3	136.7	-74.7	18.6	121.5	-59.5	33.7	101.6	-39.6	53.7
3	100.8	142.9	-80.9	12.4	127.3	-65.3	27.9	107.3	-45.3	48.0
4	103.3				131.4	-69.4	23.8	111.3	-49.3	43.9
5	105.3				134.6	-72.6	20.6	114.5	-52.5	40.8
6	106.8				137.3	-75.3	18.0	117.0	-55.0	38.2
7	108.2				139.5	-77.5	15.8	119.2	-57.2	36.0
8	109.3				141.4	-79.4	13.9	121.1	-59.1	34.2
9	110.4				143.1	-81.1	12.2	122.8	-60.8	32.5
10	111.3				144.6	-82.6	10.7	124.2	-62.2	31.0
15	114.8							129.9	-67.9	25.3
20	117.3							134.0	-72.0	21.2
25	119.2							137.1	-75.1	18.1
30	120.8							139.7	-77.7	15.5
35	122.2							141.9	-79.9	13.4

* Based upon Okumura-Hata Model - generally good from 1 to 20 km

** GSM C/I must be above 9 dB, GSM carrier level must be above minimum level from above. Areas where the C/I is below required and still within operational carrier levels are shown in red.

Appendix 1.4

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

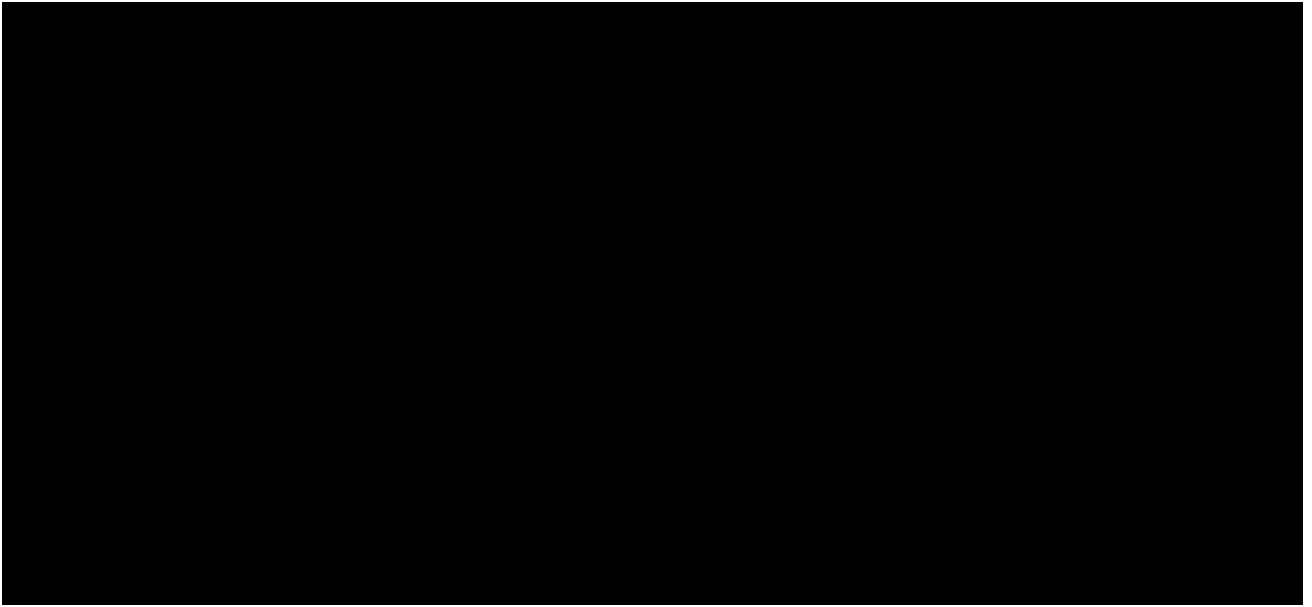
Appendix 1.5

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]



Appendix 1.6

[REDACTED]

[REDACTED]

[REDACTED]

Appendix 1.7

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]