DoD Uplinks Status Report

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Abstract

In the ET Docket 00-258 Fourth MO&O, the FCC affirmed that DoD uplinks could use both the 1.8 GHz federal government SGLS band and the refarmed 2 GHz TV BAS band, albeit subject to successful frequency coordination with incumbent BAS, CARS and LTTS licensees. As a result of that decision, SBE has been in contact with DoD regarding how those uplinks will protect 2 GHz TV BAS operations. This paper reports the results of the first two SBE meetings with DoD representatives.

Background

In the July 7, 2003, ET Docket Fourth Notice of Proposed Rulemaking (NPRM) the FCC proposed authorizing up to eleven Department of Defense (DoD) tracking, telemetry and commanding (TT&C) satellite uplink stations that now use 1,761–1,842 MHz federal government Space Ground Link Subsystem (SGLS) band to be able to also use the refarmed 2,025–2,110 MHz TV Broadcast Auxiliary Services (BAS) band. This move was triggered by the reallocation of the 1,710–1,755 MHz federal government band to the commercial sector, for still more Advanced Wireless Services (AWS) spectrum.

This, in turn, supposedly meant finding additional capacity for DoD uplinks now operating in that band due to the relocation of other Federal users from 1710-1755 MHz into the SGLS band. DoD, IRAC (Interdepartmental Radio Advisory Committee), NTIA (National Telecommunications and Information Administration), and, of course, the FCC, decided that the 2 GHz electronic news gathering (ENG) band would be a good place for these relocated DoD uplinks. The DoD uplinks are located in Camp Parks (CA, near San Francisco), New Boston (NH), Denver, Albuquerque, Cape Canaveral (FL), Colorado Springs, Lompoc (CA), Kaena Point, Oahu (HI), Prospect Harbor (ME) and Guam. The uplinks will have maximum equivalent isotropic radiated powers (EIRPs) of up to 104 dBm operating into a 13-meter uplink dish. The side lobe suppression of the uplink dish is only about 60 dB or so, meaning that the leakage toward the horizontal, and therefore toward ENG receive only (ENG-RO) sites, could be as high as 44 dBm EIRP. Since a typical ENG truck has an EIRP of around 65 dBm, this means that the DoD uplinks would have co-channel "leakage" at low elevation angles that could be only 20 dB less power than the main beam power of an ENG truck.

Despite the opposition comments of the Society of Broadcast Engineers, Inc. (SBE), the National Association of Broadcasters (NAB), the Association for Maximum Service Television (MSTV), and others, in the October 21, 2004, ET Docket 00-258 Seventh Report and Order (R&O) the FCC decided that DoD uplinks in the 2 GHz TV BAS band could be made to work.

SBE, NAB and MSTV then filed Petitions for Reconsideration of the Seventh R&O, but in an April 11, 2006, Memorandum Opinion and Order (MO&O) the Commission affirmed its Seventh R&O decision. Thus, the issue of the wisdom of creating a co-channel allotment with 2 GHz

TV BAS stations, and also Community Antenna Relay Service (CARS) TV Pickup stations and Local Television Transmission Service (LTTS) stations, is moot. The task facing broadcasters is now to make the sharing work. Perhaps the brightest spot of the Seventh R&O was the unequivocal decision that the newcomer DoD uplinks must protect incumbent TV BAS, CARS and LTTS operations. Further, in the Fourth MO&O, the Commission clarified that protection of 2 GHz TV BAS operations includes the protection of existing ENG-RO sites.

First DoD/SBE Meeting- El Segundo

The first DoD/SBE meeting occurred on November 8, 2006, in El Segundo, California, at The Aerospace Corporation. The Aerospace Corporation is a major government non-profit consulting firm that supports DoD in all of its space programs. Present for SBE were President Chriss Scherer, Immediate Past President Ray Benedict, Director Ralph Beaver (Chairman of the SBE Frequency Coordination Committee), Director Dane Ericksen (Chairman of the SBE FCC Liaison Committee), SBE General Council Chris Imlay, and SBE Executive Director John Poray. There were nine DoD representatives, three of which were active duty USAF officers, plus four civilian DoD and two Aerospace Corporation persons.

Decisions from the first meeting included:

1. While no agreements have been reached formally, DoD considers that the protection criteria for ENG-RO sites would be a noise threshold degradation of no greater than 0.5 dB has merit (this was the protection criteria cited in the Seventh R&O).

2. DoD indicated that they will make every effort to avoid operation in the 2,025-2,025.5 MHz lower Data Return Link (DRL) band, and in the 2,109.5-2,110 MHz upper DRL band. This is in recognition of the important role that the forty 25-kHz wide DRL channels are likely to play in future ENG operations.

3. While the DoD/SBE meetings are intended to provide guidance to both DoD and broadcasters regarding protection of ENG operations, the actual frequency coordination for each DoD uplink operating in the 2 GHz TV BAS band will have to include all local TV BAS, CARS and LTTS licensees. Meetings with these local licensees will be held in a venue near the to-be-converted uplink, and will include the local above-1 GHz BAS frequency coordinator.

It should be noted that a 0.5 dB noise threshold degradation criteria constitutes a *frequency re-use* criteria, which is an important element of an overarching *frequency-sharing* criteria. Under frequency re-use, the two operations are engineered so that both co-channel transmissions can occur in the same area and at the same time, without interference being caused to either party. This is commonly done for fixed, point-to-point terrestrial microwave links. However, those links have the considerable benefit of using highly directive, large-diameter parabolic dish transmitting and receiving antennas, and typically being cross-polarized with a nearby co-channel link. Additionally, the path geometries between fixed links in known in advance, and does not change. Unfortunately, these conditions do not apply for ENG operations, which, by their very nature, are itinerant or mobile in nature, and are often not scheduled in advance (although some ENG uses, such as the coverage of national political conventions or sports coverage, can benefit from advance frequency coordination).

Other technical details learned during the first meeting were than the uplink dishes would be 13-meter antennas rather than the 10-meter antennas estimated by SBE in its Fourth NPRM comments. Also that the maximum Unified S-Band (USB) EIRP would be 104 dBm, as opposed to the 115 dBm maximum EIRP for SGLS operations (USB is the term the NASA and DoD uses for the 2 GHz TV BAS band). Further, it was learned that the 104 dBm EIRP an emergency, spacecraft-in-trouble, power level. The EIRP typically used for normal, 99% of the time communications would be a 14 dB lower 90 dBm EIRP. Finally, it was learned that the occupied bandwidth of a typical USB uplink signal would be about 2 MHz.

Second DoD/SBE Meeting- Las Vegas

The second SBE/DoD meeting was held on January 11, 2007, in Las Vegas, Nevada (this coincided with the Consumer Electronics Show and the winter SBE Executive Committee meeting). Preliminary interference calculations for the first DoD uplink scheduled to operate in the 2 GHz TV BAS band, at Vandenberg AFB near Lompoc, California, were reviewed at this meeting.

The validity of the SBE-proposed 161 km (100 mile) inclusion radius around a DoD uplink was tested. As shown by Figures 1, 2 and 3 below, a total of twenty-six Southern California known or possible ENG-RO receive sites were tested.

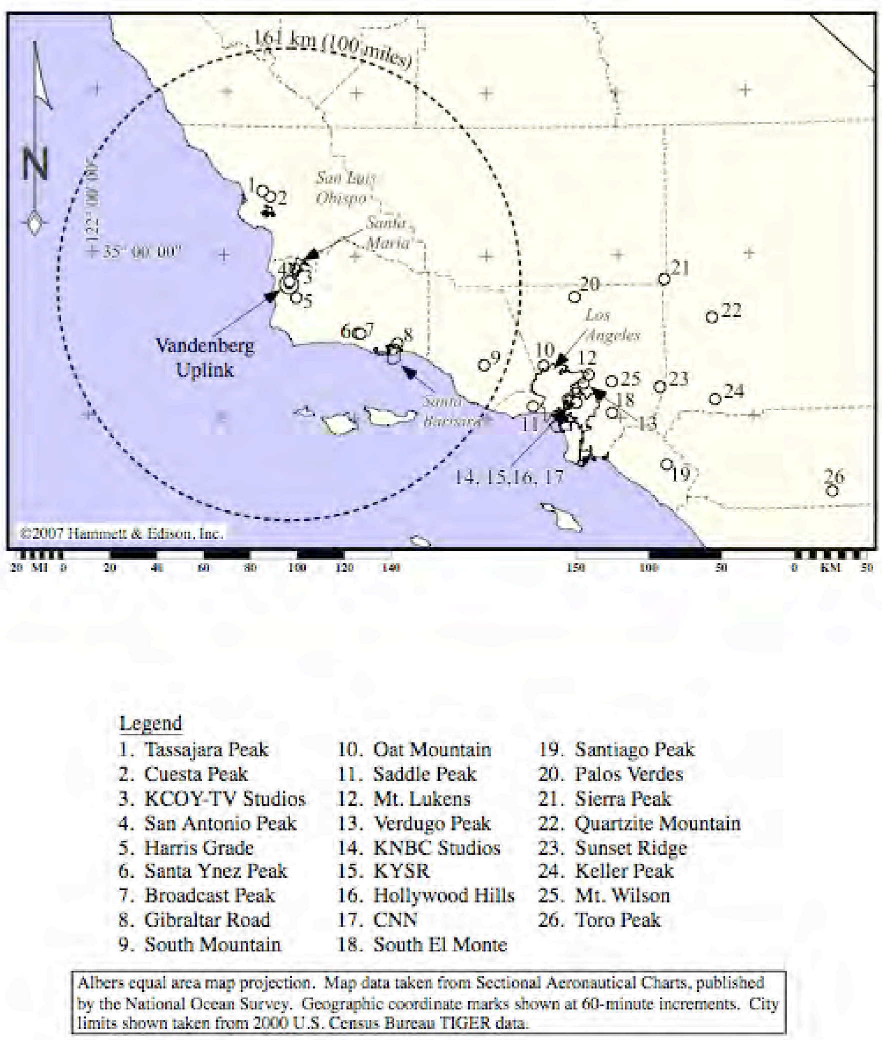
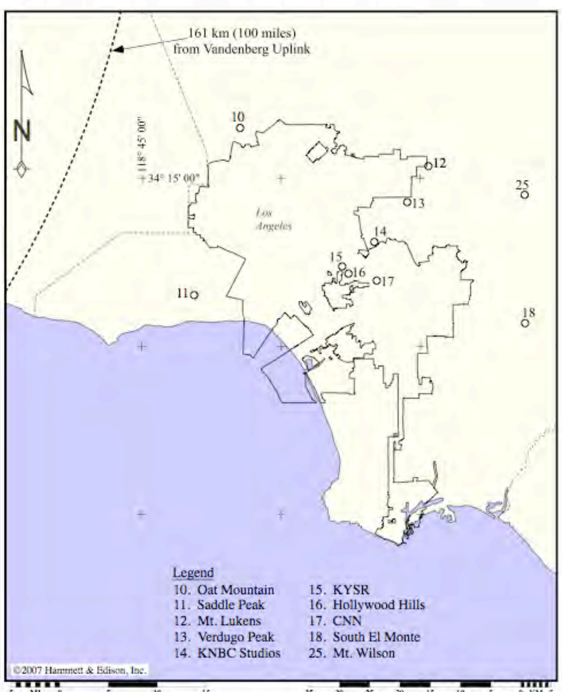


Figure 1. Possible and actual Southern California ENG-RO sites tested for main-beam illumination by the Vandenberg USB uplink dish.

Legend
1. Tassajara Peak
2. Cuesta Peak
3. KCOY-TV Studios
4. San Antonio Peak
5. Harris Grade
6. Santa Ynez Peak
7. Broadcast Peak
8. Gibraltar Road
9. South Mountain

Lambert conformal map projection. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. Geographic coordinate marks shown at 30-minute increments. City limits shown taken from 2000 U.S. Census Bureau TIGER data.



Lambert conformal conic map projection. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. Geographic coordinate marks shown at 15-minute increments. City limits shown taken from U.S. Census Bureau TIGER/Line 2000 data.

Figure 2 (top): Vandenberg uplink area sites.

Figure 3 (bottom): Los Angeles area sites.

Shadowgraph studies were then made. These studies indicated that all of the possible/actual ENG-RO sites more than 161 km from the Vandenberg uplink lacked line-of-sight to a presumed 9.1-meter (30-feet) AGL receiving antenna at the studied sites. While greater AGL heights for mountain-top ENG receiving antennas are certainly possible, these shadowgraph maps indicate that at least for the Vandenberg uplink that ENG-RO sites more than 161 km distant are unlikely to be affected.

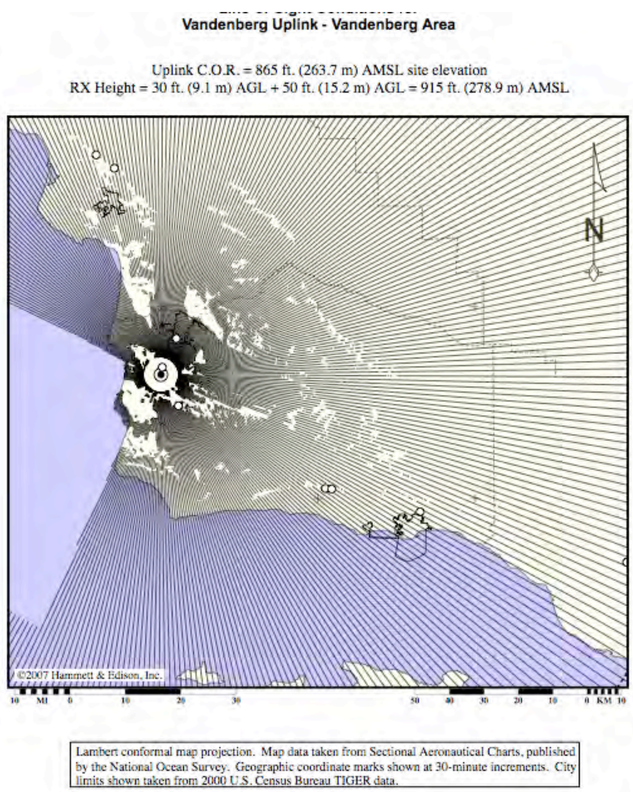


Figure 4. Shadowgraph showing line-of-sight conditions for the Vandenberg uplink antenna in the San Luis Obispo/Santa Maria/Santa Barbara area.

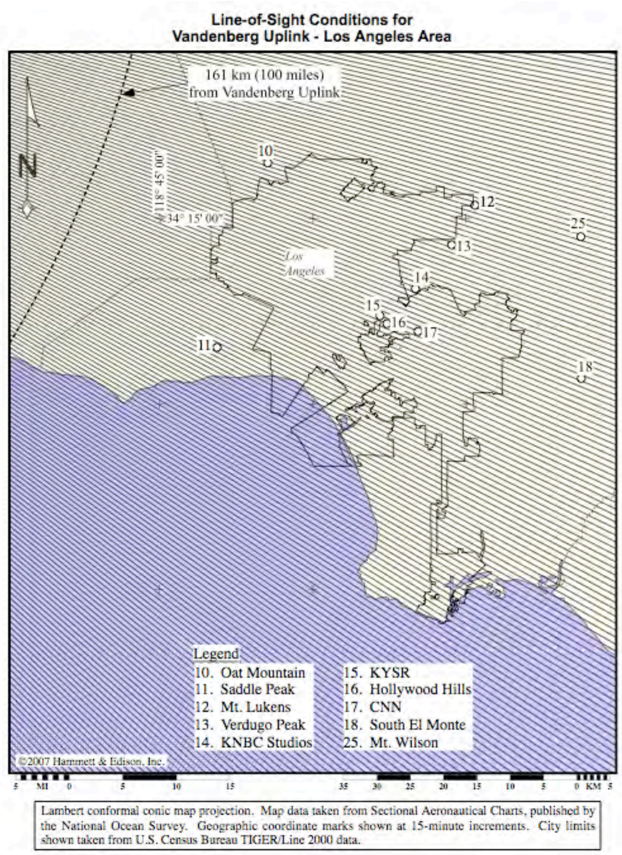
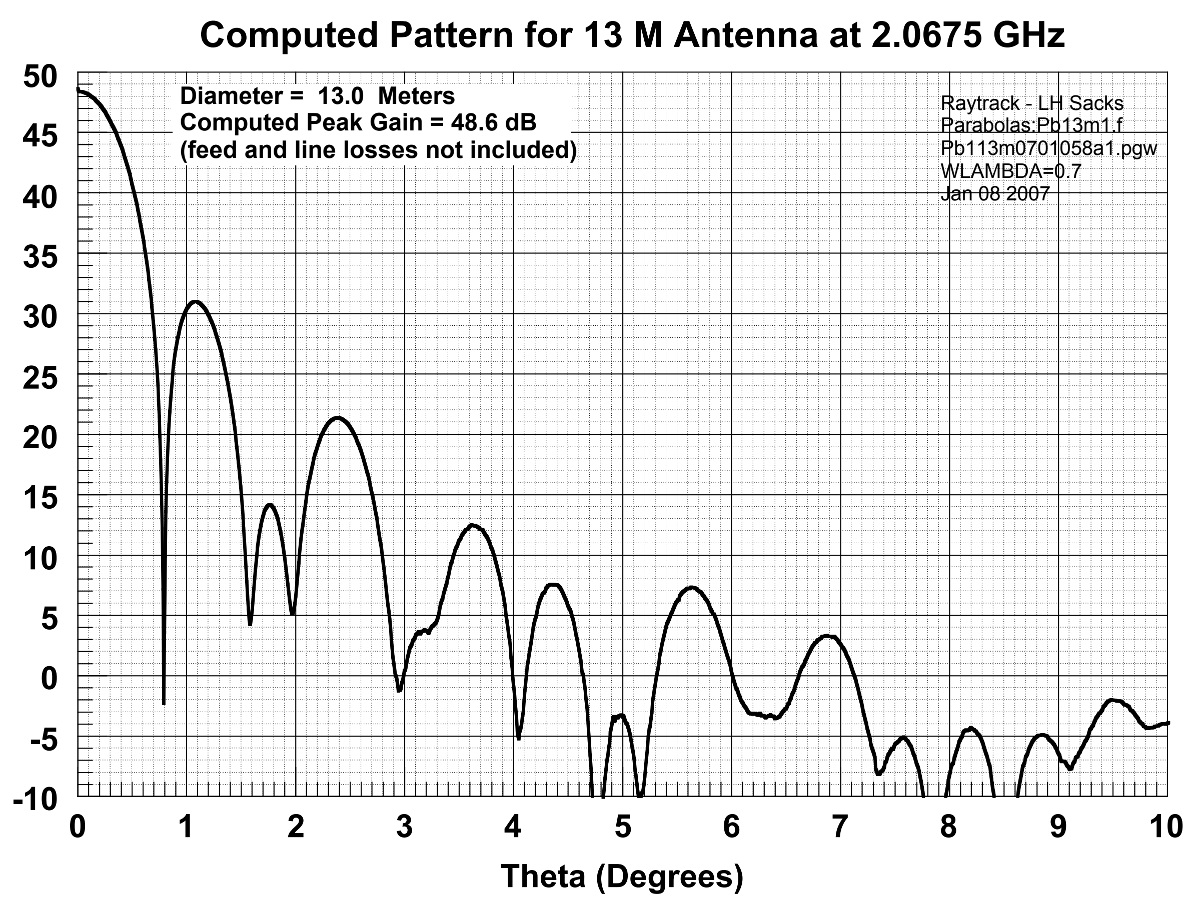


Figure 5. Shadowgraph showing line-of-sight conditions for the Vandenberg uplink antenna in the Los Angeles area.

The radiation pattern envelope (RPE) of the 13 meter USB uplink antenna that DoD will use was also discussed. Figure 6 shows the RPE from zero to 10° off axis, and Figure 7 shows the RPE from zero to 180° off axis (these are calculated, rather than measured, RPEs). Note that Figure 7 shows the additional side lobe suppression that might be possible by applying a 1.5-meter (5-foot) metal shroud around the circumference of the uplink antenna. These tentative shroud calculations were done by The Aerospace Corporation engineers; they do not include further suppression of side lobes that might be possible if the interior of the shroud is lined with microwave absorbing material. although whether this will prove to be a practical retrofit is still being studied. For example, and as shown by Figures 8 and 9, when a terrestrial point-to-point microwave dish is shrouded and lined with microwave absorbing material, improvements in the off-axis suppression of almost 30 dB are possible. It should be noted that any DoD antenna modification must be studied in detail and may not be supportable when all system factors are considered.

Figure 6 (below). Calculated RPE of 13-meter DoD USB uplink dish, zero to ±10° off axis. Courtesy of The Aerospace Corporation (Preliminary).



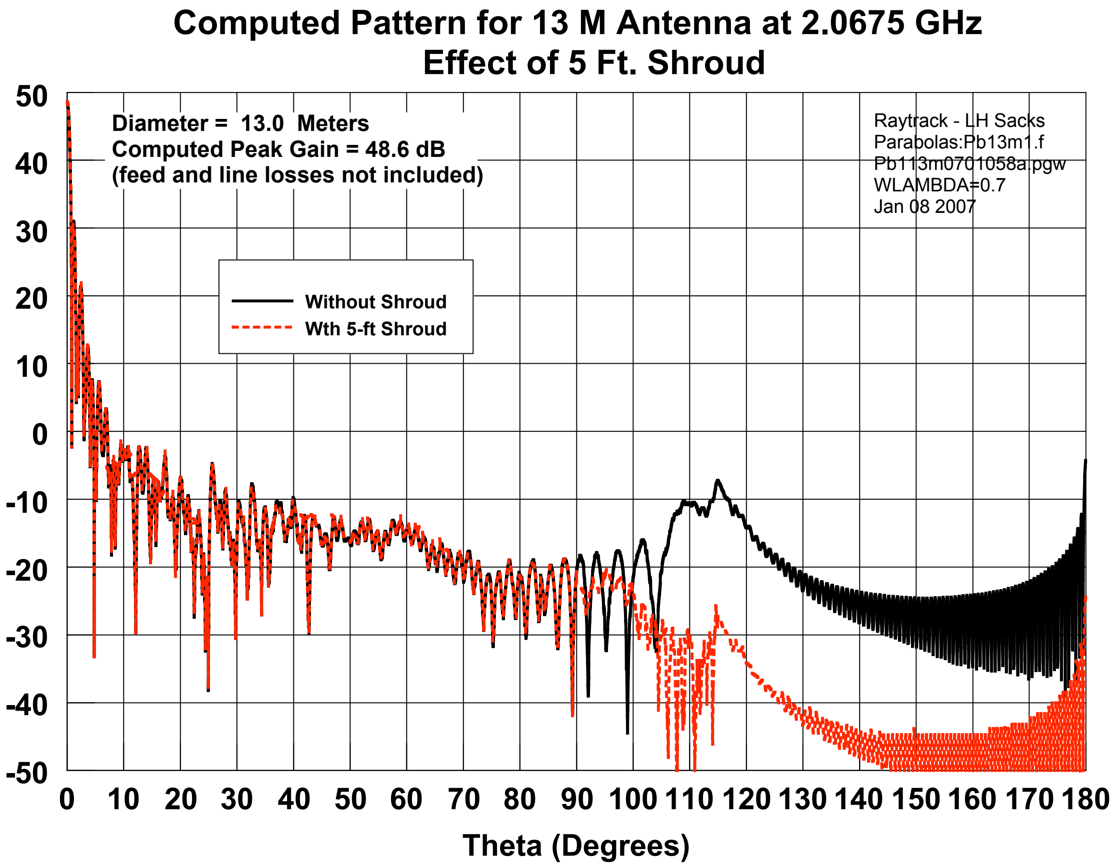
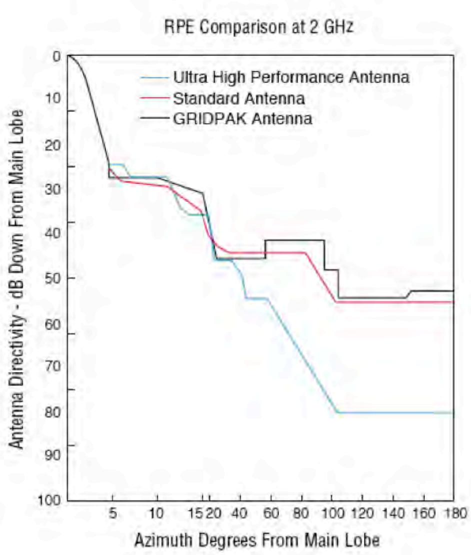
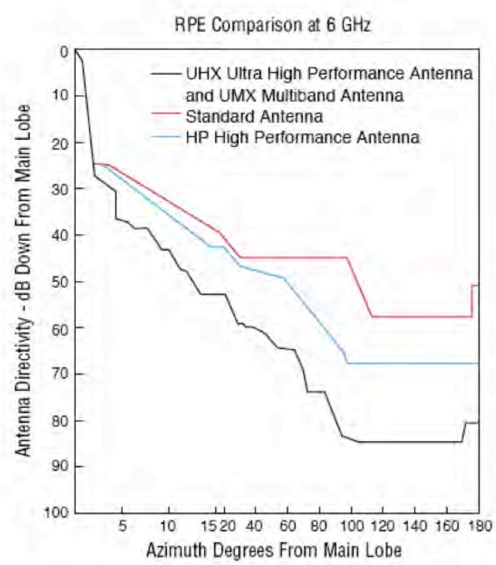


Figure 7 (above). Calculated RPE of 13-m USB uplink dish, zero to ±180° off axis. Courtesy of The Aerospace Corporation (Preliminary).





Figures 8 (left) and 9 (right). RPEs for Andrew Corporation standard performance, high performance and ultra high performance parabolic antennas at 2 GHz and at 6 GHz. These figures are courtesy of Andrew Corporation.

Next Tasks

Look Angle Histograms

DoD personnel indicated that the azimuths and elevation angles for a particular uplink as it tracks various military satellites (many in non-geosynchronous orbits) could be made, to see if these operational arcs include the azimuth(s) and elevation angle(s) to nearby ENG-RO sites that might not be terrain-shielded to the uplink location. For example, Figure 10 shows the terrain profile from the Vandenberg uplink to the ENG-RO site at Broadcast Peak, and Figure 11 shows the terrain profile to the ENG-RO site at Cuesta Peak. These are clearly unobstructed paths, where free space path loss (FSPL) conditions would apply.

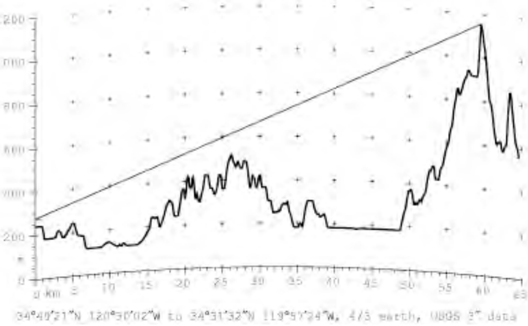


Figure 10. Vandenberg uplink to Broadcast Peak terrain profile. Path is 59.7 km at 123°T. Profile extends 5 km past the ENG-RO site.

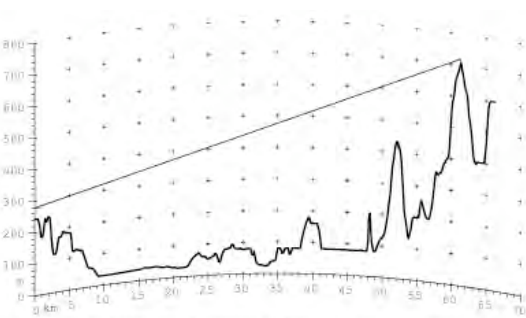


Figure 11. Vandenberg uplink to Cuesta Peak terrain profile. Path is 61.3 km bearing 347°T. Profile extends 5 km past the ENG-RO site.

If the Vandenberg uplink elevation angle is at least 10°, then for the Broadcast Peak ENG-RO site the predicted receive carrier level (RCL) at the ENG receiver input port can be estimated as +104 dBm EIRP worst case "emergency" power, -14 dB for routine, low power operation, -7.8 dB bandwidth factor (*i.e.*, 10log(2 MHz/12 MHz = -7.8 dB), -50 dB side lobe suppression, -134.3 dB FSPL, + 20 dBi assumed receive antenna gain = -82.1 dBm RCL. This misses the 0.5 dB noise threshold criteria RCL limit of -104.1 dBm by some 22 dB (*i.e.*, a co-channel undesired signal of -104.1 dBm added to a -95 dBm at-threshold coded orthogonal frequency division multiplex (COFDM) desired ENG signal would degrade the noise threshold to -94.5 dBm, or a 0.5-dB degradation).

However, if the uplink azimuth never got within ±100° of the 123°T direction from the Vandenberg uplink to Broadcast Peak, the off-axis suppression would improve by another 24 dB, reducing the RCL of the undesired DoD signal from -82.1 dBm to -106.1 dBm. This would then not only meet, but surpass, the 0.5 dB noise threshold degradation criteria. So a statistical look-arc analysis may demonstrate that a DoD uplink dish is so unlikely to be aimed in the direction of an ENG-RO site that protection of that ENG-RO can be effectively provided, even when line-of-sight conditions exist. Of course, if the look arc statistical analysis shows that the uplink antenna frequently sweeps through an arc that places less suppressed side lobes towards the ENG-RO site, then other mitigation measures will be required.

Possible D/U Interference Criteria in Lieu of Noise Threshold Protection Criteria in Certain Cases

Another area for planned future work is to derive the desired-to-undesired (D/U) signal ratio that a 12 or 6 MHz wide digital ENG signal needs in order to not be degraded by a 2 MHz wide USB signal. This could be accomplished in a laboratory using variable attenuators and directional couplers to introduce an undesired USB uplink signal into a digital ENG signal. The necessary D/U ratios for various levels of the "desired" ENG signal, and for various digital modulation schemes and combinations of forward error correction, could then be derived. Let's assume, for discussion purposes, that the most susceptible ENG signal is found to require a D/U ratio of 25 dB or better in order to not be affected. Let us also assume that an analysis of RCLs for a particular ENG-RO site show that 99% of the time the weakest incoming signal is -60 dBm (as opposed to the assumed receiver threshold value of -95 dBm). Then applying a D/U interference criteria instead of a noise threshold protection criteria may be reasonable. Doing so would then allow a RCL of -85 dBm for the undesired DoD uplink signal, as opposed to a limit of less than or equal to -104.1 dBm. Of course, it would be up to each TV Pickup, CARS, and LTTS licensee near a newcomer DoD uplink whether to accept a D/U ratio interference criteria rather than a noise threshold protection criteria. But in some situations that might be a reasonable approach.

Summary

Encouraging progress continues to be made. Especially if adding microwave absorbing material to an uplink dish shroud can reduce the side lobe leakage by another 20 dB or so (and this must be examined further and approached cautiously), then at least for the Vandenberg uplink the goal of frequency re-use has utility as a critical element of achieving an equitable frequency sharing strategy, at least to established ENG-RO sites.

For 2 GHz TV BAS receivers used by ENG relay trucks or satellite ENG (S-ENG) trucks that are themselves equipped with ENG receivers, frequency sharing, and real-time frequency coordination, will still be necessary. This is because, unlike fixed ENG-RO sites, the location of an ENG relay truck or an S-ENG truck will often not be known in advance. However, this should prove to be a much more tolerable burden than having to frequency coordinate regularly used ENG-RO sites.

Acknowledgements

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