L-3 Communications Security and Detection Systems, Inc.

Request for Waiver of Sections 15.31, 15.35, and 15.205

TECHNICAL STATEMENT

January 22, 2016

L-3 Security Next Gen ProVision®
Operating Characteristics and Interference Analysis

L-3's ProVision® system presently operates over the frequency range 24.25-30 GHz, while the next generation wideband system ("Next Gen ProVision®") will operate across 20-40 GHz, so to achieve better resolution.

1. System Overview

The L-3 Next Gen ProVision® will use the same basic mechanical sweep operating configuration as the presently fielded 24.25-30 GHz L-3 ProVision® systems. Vertical antenna arrays will rotate through an arc of approximately 110 degrees while scanning the subject as shown in Figure 1 below.

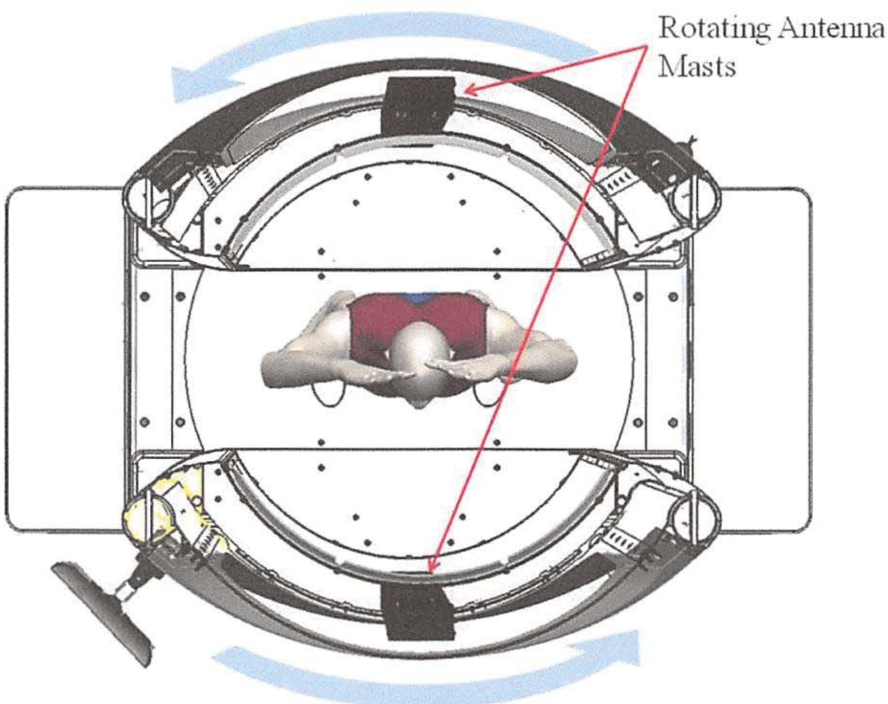


Figure 1: Top View of L-3 System Showing Moving Antenna Masts

The Next Gen ProVision® will incorporate two identical antenna masts with circularly polarized transmitting elements distributed along the two meter vertical height. The transmitter in the system repeatedly sweeps an un-modulated sine-wave ("FMCW") signal over the frequency range 20-40 GHz at a rate of 1.46 MHz/nanosecond as shown in Figure 2c. The transmitted waveform, or chirp, over the 20-40 GHz band takes 13.7 microseconds. There is a 0.5 microsecond period with the transmitter disabled between chirps to switch to the next sampling point on the mast resulting in a total chirp repetition period of 14.2 microseconds, as shown in Figure 2d. This chirp is repeated at each of the transmit antenna sampling positions along the height of the mast during a vertical scan line data capture sequence, as shown in Figure 2c. As the antenna mast rotates through the nominal 110 degree mechanical travel, vertical scan lines are triggered at equidistant intervals around the circumference of the mast path, as shown in Figure 2b. The system remains idle with the transmitter disabled until the system operator initiates the next scan sequence. A full subject scan data capture sequence takes 1.3 seconds, followed by a pause to process the image and analyze the results. The minimum possible time between scans is approximately 7 seconds, but depending upon checkpoint loading and the time required by the operator to clear alarms, the time between scans is typically 10 seconds or more as shown in Figure 2a.

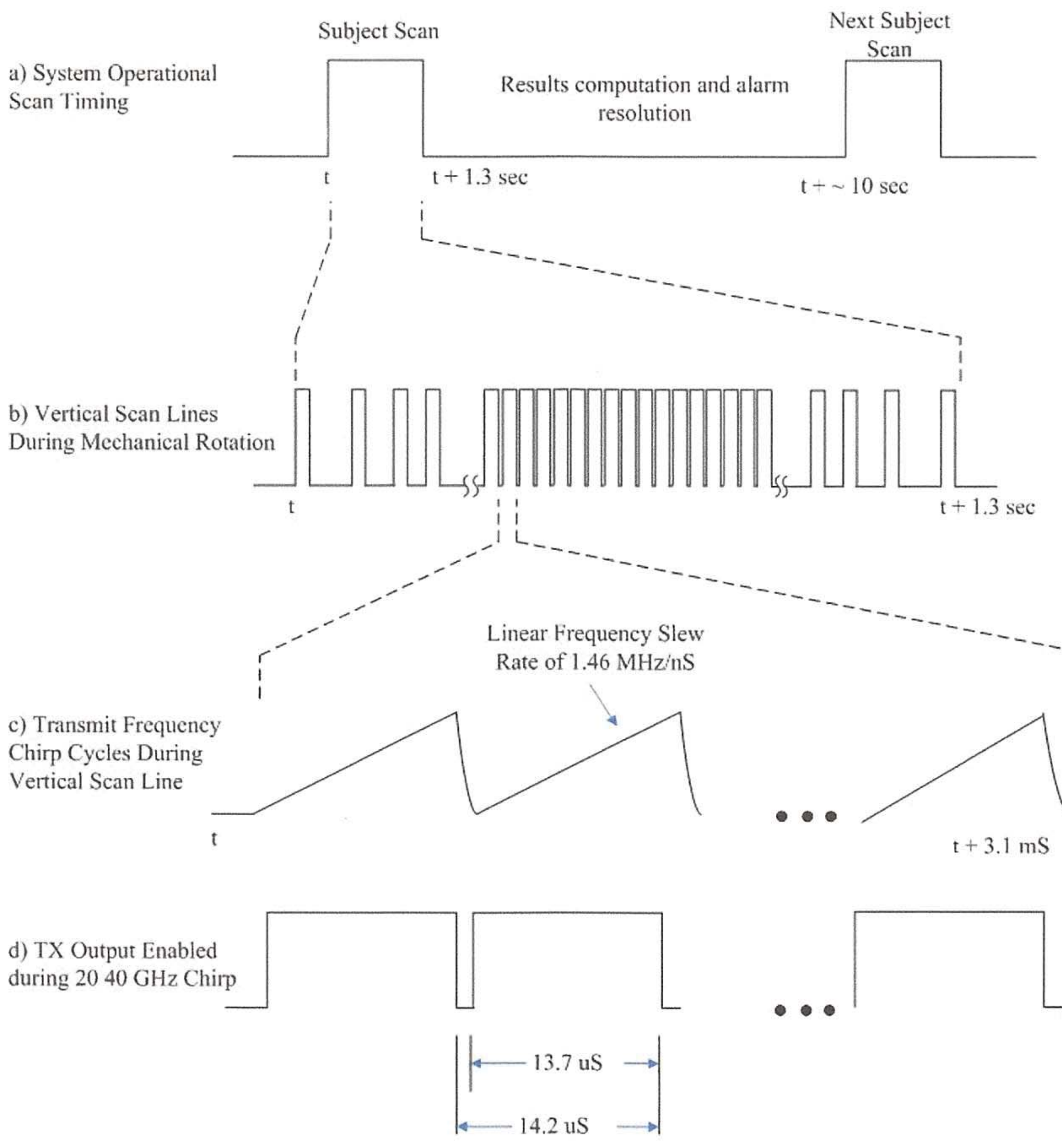


Figure 2: L-3 Next Gen ProVision® System Timing

2. Interference Analysis for Point-to-Point Radio Receivers

One question regarding the deployment of the Next Gen ProVision® system is the potential interference to incumbent fixed licensees at 23, 24, 28, 31, and 39 GHz. Except at 23 GHz, relatively few of these systems are in operation. The following analysis takes 28 GHz LMDS as prototypical for all fixed point-to-point operations in these bands.

There are different bandwidth, modulation schemes and cell layouts used by these systems, but a general example is presented below with an analysis of the potential impact that the next generation L-3 wideband system would have. The subscriber station system parameters below were extracted from an example hub to subscriber link in the IEEE 802.16 Wireless Working Group document: IEEE 802.16sc-99/17.[1] **This analysis includes an absolute worst case assumption of 0 dB building attenuation.** The resulting maximum distance the L-3 system would present an interference level at an assumed -10 dB[2] Interference/Noise ratio (I/N) is 159 meters and this is only present in the highly improbable scenario of the Next Gen ProVision positioned directly on the LMDS receiver antenna boresight.

[1] R. Duhamel, LMDS Cell Sizing and Availability, IEEE P802.16 Broadband Wireless Access Working Group, IEEE 802.16sc-99/17.

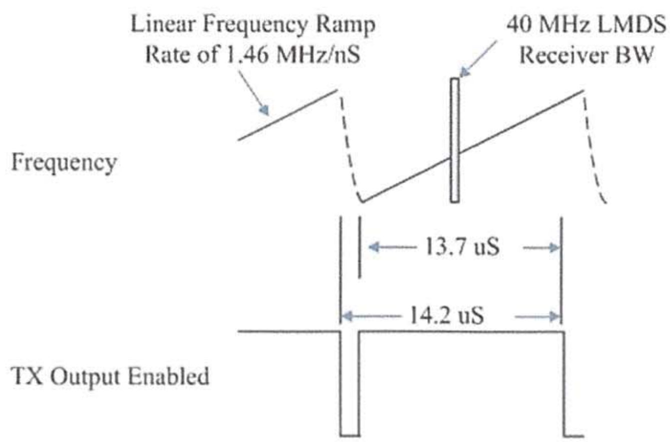
[2] This number was chosen because it was asserted to be reasonable by a LMDS licensee. *See* Opposition of Hughes Network Systems, Inc. at p. 7, ET Docket 04-373 (filed Oct. 22, 2004).

Parameter Value	Description
28	Operating Frequency (GHz)
0.0107	λ – Wavelength (m)
40	Receiver Bandwidth (MHz)
6	Remote terminal noise figure (dB)
-10	Remote terminal Interference/Noise ~ 10e-6 BER threshold
-91.8	System Noise Floor (dBm)
-101.8	***Pr*** - Max Interference level (dBm)
31.0	***Gr*** - Receiver antenna gain (dBi)
-27.15	***Dt*** - Wideband duty cycle in remote terminal bandwidth (dB)
0	Duty cycle averaging due to additional factors (sweep time, scans/hour etc.) (dB). Note: Included in *Dt* above for distance calculation
-0.3	L-3 system peak transmit power (dBm EIRP) ***Pt·Gt*** in distance calculation
0	***Bt*** - Building attenuation (dB)
159	Distance for system to exceed interference noise threshold (on receiver boresight) (meters)[3]

[3] $$Distance = \frac{\lambda}{4\cdot\pi\sqrt{\frac{Pr}{Pt\cdot Gt\cdot Bt\cdot Dt\cdot Gr}}}$$

Duty Cycle Calculation

The duty cycle for the receiver bandwidth in the above interference analysis example was calculated as:



$$\text{Duty Cycle} = 10 * \text{LOG}\left(\frac{\text{Receiver BW}}{\text{Ramp Rate}} * \frac{1}{\text{Chirp Period}}\right)$$

$$\text{Duty Cycle} = 10 * \text{LOG}\left(\frac{40\,\text{MHz}}{1.46\,\text{MHz/ns}} * \frac{1}{14.2\,\text{uS}}\right) = -27.15\,\text{dB}$$

Figure 3: Duty Cycle Calculation for Example 40 MHz Bandwidth Receiver

The interference analysis example presented above includes a number of worst case assumptions which are very unlikely to occur in practice. The most significant element in further minimizing the interference potential of the Next Gen ProVision® is the narrow beam of the remote LMDS receiving antenna. For the boresight example above, the hub unit would need to be co-located with the L-3 system, which is highly unlikely. (An airport operator can choose not to install fixed microwave equipment in close proximity to the L-3 equipment.) As the LMDS receiver antenna axis angles away from the L-3 system, the receiver antenna gain falls off rapidly which significantly reduces the interference signal level from the L-3 system. Using the Statgain antenna beam calculations presented in Section 4.4.2 of NITA document TM-13-489,[4] the gain versus angle off boresight was calculated for the 31 dB gain antenna used in the interference analysis presented above. The antenna gain response is shown in Figure 4 below.

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[4] Wang C.W., Keech T., NTIA TM-13-489: Antenna Models for Electromagnetic Compatibility Analysis. U.S. Department of Commerce.

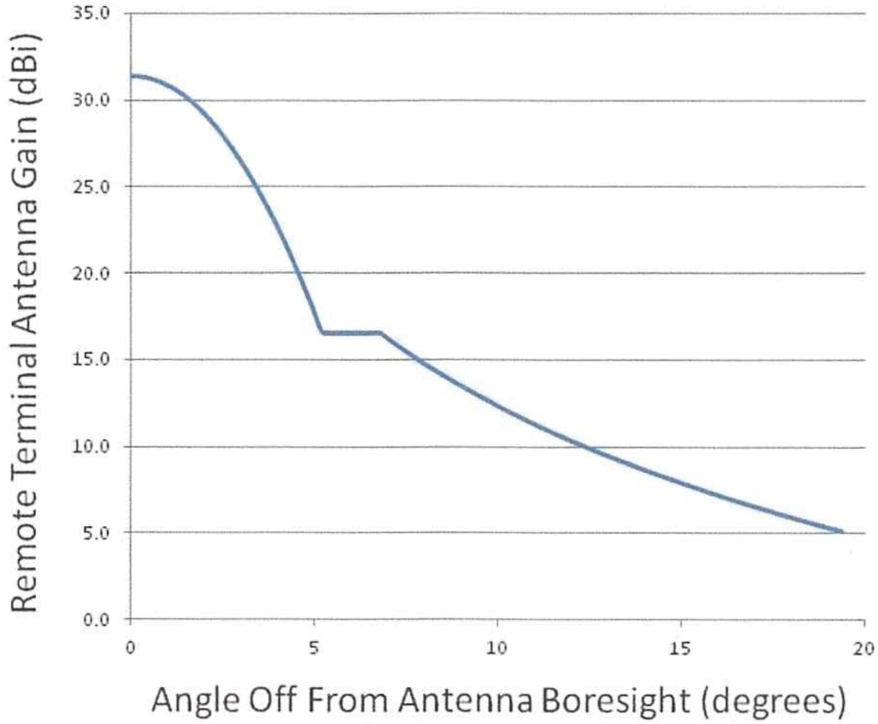

Figure 4: Antenna Gain Calculated for Example Receiver

Using the antenna response and the interference path example above, the distance from the receiver for the specified I/N level can be calculated as a function of the angle off boresight at which the next generation L-3 system is positioned. A plot of the distance versus angle from boresight is shown in Figure 5 below. At these interference threshold distances, it would be highly unlikely for the LMDS radio components to be positioned close enough and directed in a manner that the L-3 system could degrade the data link. For example, to reach the -10 dB I/N ratio, a system at 5 degrees off boresight would need to be located within 30 meters of the L-3 system, an unlikely scenario (and one that assumes no attenuation from building materials). Even if both technologies were deployed in the same indoor environment such as a large airport terminal, the high directionality of the LMDS receiver antenna should make possible a practical installation configuration in which the Next Gen ProVision® does not present a harmful level of interference.[5]

[5] In addition to the path loss, there is further obstruction in the line of sight transmission for a significant portion of the L-3 system antenna beam-width due to the fact that a person is positioned approximately 0.5 meters from the transmitting element during normal operation of the system.

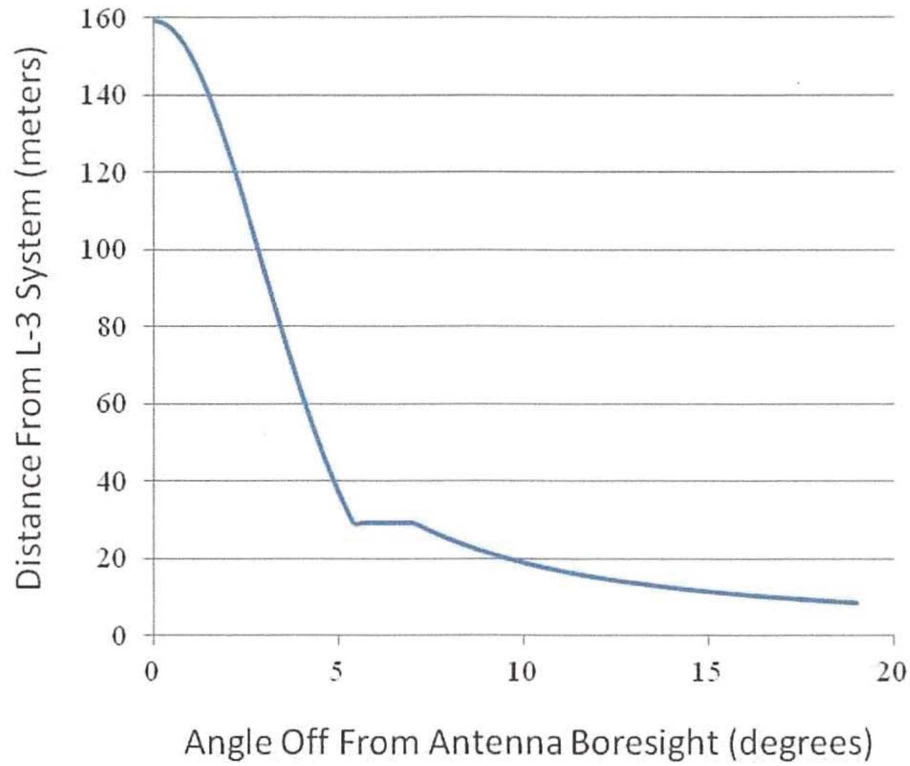

Figure 5: Interfering Distance from LMDS Receiver to L-3 System vs. Angle off LMDS System Boresight

Additional Factors Reducing Interference (Building Attenuation)

The analysis above used the worst case assumption of a clear air transmission path between the Next Gen ProVision® and the LMDS receiver. Given the indoor installation of the L-3 system, it is reasonable to assume further path loss would be experienced in a fielded operating scenario for both systems. The graph in Figure 6 shows attenuation levels versus frequency for a variety of common building materials. The vast majority of the L-3 installation sites are airports or government and large commercial buildings, which generally are constructed of concrete and steel materials exhibiting significant attenuation of at least 35 dB across the proposed operating band of the system.

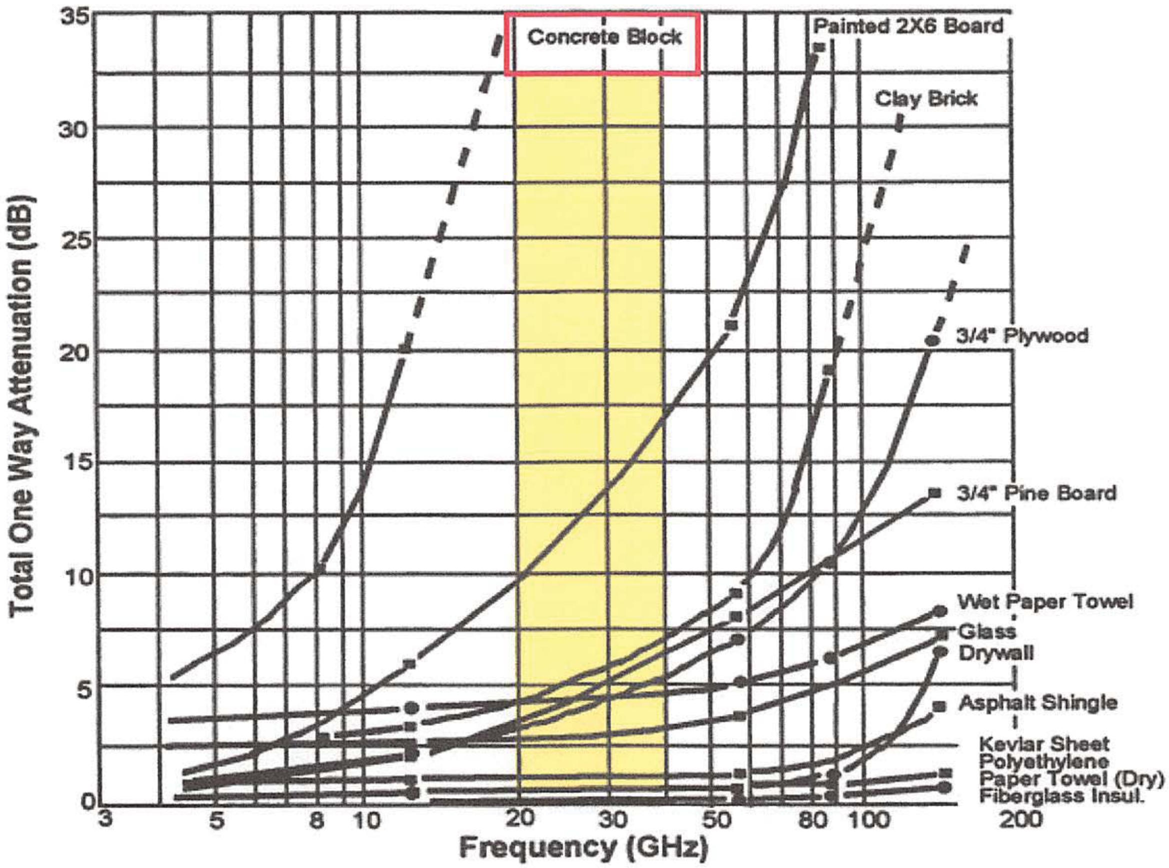

Figure 6: One Way Path Loss of Building Materials versus Frequency[6]

Point-to-Point Systems Interference Summary

The Next Gen ProVision® presents little if any potential interference to point-to-point microwave and other similar incumbent systems deployed, even under the worst case assumptions in the link analysis presented above. The low transmit duty cycle of the L-3 system in the LMDS receiving bandwidth presents minimal interference potential. This, coupled with the highly directional antennas for the remote receiving stations and reasonable assumptions on building and path attenuation, make it highly unlikely that the L-3 system would present a harmful level of interference to point-to-point operations.

3. Interference Analysis for Amateur Radio

The waiver seeks permission to transmit through the amateur radio bands in the 24 GHz range, including the primary allocation of 24-24.05 GHz used in part for amateur satellite communications and the shared secondary allocation at 24.05-24.25 GHz. Amateur operators in

[6] Frazier, L. M., Radar Surveillance Through Solid Materials, SPIE Photonics East, Boston MA, Nov 18, 1996 Paper 2938-20.

these bands have told the Commission they primarily use highly directional antennas positioned in elevated outdoor locations to maximize the transmission path distance for communication links.[7] Similar to the LMDS remote terminal scenario described above, the highly directional antenna of the amateur band receiver provides a significant level of isolation unless aimed directly at an L-3 system. Although the receive bandwidth of the amateur radio systems may vary, the narrow pulse width of the L-3 Next Gen ProVision (0.7 nanoseconds per MHz of receiver pass band) will be significantly attenuated by the victim receiver IF and baseband filtering. This narrow in-band presence results in a duty cycle for a 1 MHz receiver bandwidth of -43 dB. Limited peak transmit power of the L-3 system (-0.3 dBm EIRP), very low duty cycle for narrow band victim receivers, fixed indoor-only operation and amateur system operating characteristics will essentially eliminate the potential for interference to amateur users in the 24 GHz bands.

4. Interference Analysis for Earth Exploration Satellite Service

Earth Exploration Satellite passive sensing measurements are susceptible to interference from sufficiently strong man-made signals in their operating bands. The proposed L-3 system would operate through the sensing bands in the 23.6-24 and 36-37 GHz ranges with a low duty cycle based on the 1.46 MHz/nanosecond frequency sweep rate. To assess the potential impact on a representative EESS receiver, an interference calculation is presented below. The satellite antenna gain, distance from the source, and operating frequency are based on the AMSR passive earth observing system.[8] The maximum interference level and reference bandwidth used in this example is based on the ITU-R RS.2017 recommendation.[9]

[7] Comments of ARRL, GN Docket No. 14-177 et al., at 3-4 (filed Jan. 15, 2015).

[8] National Snow and Ice Data Center. (n.d.). Retrieved December 18, 2015, from https://nsidc.org/data/docs/daac/amsre_instrument.gd.html

[9] ITU-R RS.2017, Performance and interference criteria for satellite passive remote sensing. (05/2012). Retrieved December 18, 2015, from http://www.itu.int/dms_pubrec/itu-r/rec/rs/R-REC-RS.2017-0-201208-I!!PDF-E.pdf.

Parameter Value		Description
23.8	**36.5 GHz**	**Center frequency (GHz)**
47.1	54.1	Satellite System Receiver Antenna Gain (dBi)
0.0126	0.0821	Wavelength (m)
1128	1128	Distance to the receiving satellite (km)[10]
-181.0	-184.7	Path loss for satellite distance and frequency (dB)
-0.3	-0.3	L-3 System maximum peak EIRP (dBm)
-20	-20	Building attenuation*
1.46	1.46	L-3 system frequency ramp rate (MHz/nS)
200	100	Receiver reference bandwidth (MHz)[11]
-20.2	-23.2	Duty cycle (dB) for L-3 Signal in the Satellite Receiver Bandwidth over the 2.6 mS integration time used by the AMSR satellite
-204.4	-204.1	Interference from L-3 system (dBW)[12]
2	2	Number of transmitters per L-3 system
32	32	Number of systems (presently the largest number at any site)
18.1	18.1	Worst case scenario of all systems scanning simultaneously (dB)[13]
-186.3	-186.0	Cumulative interference (dBW)
-166	-166	Maximum Interference level (dBW) per ITU-R RS.2017
20.3	**20.0**	**Margin of L-3 system relative to ITU RS.2017 interference level (dB)**

[10] Derived from Keiji Imaoka and Akira Shibata, AMSR Series in A-Train – JAXA Products and Services for AMSR-E, A-Train User Workshop, slide 4 (Oct. 25, 2010).

[11] From *Performance and interference criteria for satellite passive remote sensing*, Recommendation ITU-R RS.2017 at 5, table 2(May 2012).

[12] Calculation: (L-3 system power = –30.3 dBW) + (EESS antenna gain) – (building attenuation) – (duty cycle) – (path loss).

[13] Calculation: 32 systems x 2 transmitters operating simultaneously per system = 64 or 18.1 dB. Because each system operate only1.3 seconds out of each 10-20 seconds during peak load times, the worst case of all operating simultaneously, assumed here, is highly unlikely to occur. The line-of-sight duty cycle calculations use one transmitter per system because the antenna masts in a given unit point in opposite directions. To assess cumulative interference we include both as a worst case assumption on the theory that the two signals could scatter and contribute to the total interference level.

The indoor operation of the L-3 system greatly reduces the potential for interference to passive Earth Exploration receivers. L-3 screening systems are typically installed in buildings with reinforced concrete floor and ceilings which provide significant attenuation to an overhead satellite receiver. A conservative value of 20 dB of attenuation was estimated for the example calculation above, assuming attenuation through the roof structure of the building in which the L-3 system is installed.

Using the unlikely worst case condition of 32 L-3 systems accumulated in one general location, all simultaneously scanning, the resulting interference level of -187 dBW is well below the maximum interference level of -166 dBW specified in ITU-R RS.2017. Based on this analysis, and L-3's suggested waiver conditions, the potential for interference to EESS receivers is negligible.

5. Summary

The L-3 Next Gen ProVision system presents an insignificant potential for interference to licensed radio communications, amateur users and passive sensing systems. The key attributes of the L-3 system that minimize or eliminate the interference to other users in the proposed band are as follows:

a. **Low power**: The device operates at maximum average power of –41.3 dBm/MHz (same as FCC Class B average limit) when measured with the sweep running using a 100 mS integration time. Peak power is –0.3 dBm (41 dB above average power limit).

b. **Indoor operation**: L-3 will not oppose maintaining the present waiver condition that limits operation to indoor locations. A victim receiver outside the building will benefit from attenuation through the building walls and roof.

c. **Sparse deployment**: The device is presently installed at only about 200 sites nationwide. Most are airports where fewer than four units are installed. There are also a few units at the World Trade Center memorial and courthouses, and in commercial loss prevention applications. Although these numbers may go up in the future, the high cost and specialized utility of the device place natural limits on deployment.

d. **Low duty cycle**: The L-3 system's very wide operating bandwidth, compared to a victim receiver's passband, results in its being within the passband for only 0.005% of the time per MHz of passband. The receiver will see only this fraction of the device's emitted energy.

e. **Short dwell time in receiver passband:** Due to its high speed, the sweep is present in a victim receiver passband for only 0.7 nsec per MHz of receiver bandwidth. The signal will be filtered out in many types of narrow band receivers.

f. **Revolving antenna**: The device's antennas are directional and in rotary motion while operating. A given victim receiver will be within the transmitter beam-width for only a portion of the rotation further reducing the energy reaching the receiver. Additionally, in almost all scanning events, a person is positioned in the L-3 system antenna boresight, further diffusing a portion of the transmitted energy.

g. **Location data**: L-3 will not oppose maintaining the present waiver condition that requires it to keep records of the locations of every device installed, and to impose the same requirement on buyers. If interference did occur, L-3 could promptly identify the offending location so as to take corrective action.

h. **FCC rule Section 15.5**: L-3 acknowledges its obligations under this rule to shut down the device if harmful interference to an FCC-authorized service cannot otherwise be alleviated.

Technical Certificate

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained above, that I am familiar with Part 15 of the Commission's Rules, that I have either prepared or reviewed the engineering information submitted herein and in the attached Waiver Request, and that it is complete and accurate to the best of my knowledge.

Scott Trosper
Director of Hardware Development Engineering
L-3 Communications Security and
Detection System, Inc.