Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	}	
	}	
Multispectral Solutions, Inc. Request for	}	ET Docket No. 06-103
Waiver of Part 15.250	}	
	}	

Reply Comments of Multispectral Solutions, Inc.

Multispectral Solutions, Inc. (MSSI) is pleased to provide the following Reply Comments in the above referenced Docket.

1. Regarding Outdoor Infrastructure

Part 15.250(c) states that "[e]xcept for operation onboard a ship or a terrestrial transportation vehicle, the use of a fixed outdoor infrastructure is prohibited. A fixed infrastructure includes antennas mounted on outdoor structures, *e.g.*, antennas mounted on the outside of a building or on a telephone pole."

MSSI's *Sapphire* DART Precision Asset Location System™ utilizes a set of purely passive receivers, with portable, active tags present *only* on the items to be tracked – e.g., personnel or assets (in the case of a petrochemical facility) or animals (in the case of livestock tracking). In our discussions with the FCC's Office of Engineering and Technology (OET) leading to the release of the Second Report and Order and Second Memorandum Opinion and Order[1] which created Part 15.250, *purely passive receivers* are not considered to constitute an outdoor infrastructure. Rather, the prohibition against outdoor infrastructure, as originally discussed in the FCC's First Report and Order for Ultra-Wideband systems[2], was a mechanism to prevent the creation of fixed, point-to-point, communications systems in which the wideband or ultra wideband transmitters were affixed to fixed outdoor structures such as poles, buildings, etc.

The outdoor use of *Sapphire* DART was also fully addressed in the Commission's Further Notice of Proposed Rule Making (FNPRM)[3] leading to the Second Report and Order.

---

[1] "Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems," FCC 04-285, Second Report and Order and Second Memorandum Opinion and Order, 15 December 2004.

[2] "Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems," FCC 02-48, First Report and Order, Paragraph 199, 14 February 2002.

[3] "Memorandum Opinion and Order and Further Notice of Proposed Rule Making," in ET Docket 98-153, 18 FCC Rcd 3857, 2003.

2. Average Emission Levels of *Sapphire* DART

It was pointed out by the National Radio Astronomy Observatory (NRAO) that the average radiated emission level from a *Sapphire* DART tag (FCC ID: QCJPAL6511X1) was measured at 6.54 dB below the FCC limit, while the peak radiated emission from the same tag was measured at 1.22 dB below the FCC limit. However, rather than an "unevenness of its emission spectrum" as suggested by NRAO, the measured average radiated emission level is a natural consequence of the limitations of the measurement apparatus used to perform the tests. This can be readily seen as follows:

(a) From the Metlab test report for QCJPAL6511X1[4], it is noted that the average radiated emissions summarized in the Table on page 14 were measured *without* an external preamplifier. In a previous Metlab report[5] for a nearly identical tag (FCC ID: QCJPAL650), operating only at a slightly lower frequency (5.751-7.001 GHz) under Part 15.517, the average radiated emissions were measured *with* a low noise, 30.9 dB external preamplifier, and were actually determined to be 14.89 dB below the FCC limit. This substantial 8.35 dB difference in average radiated emission levels for essentially identical emitters is simply due to the fact that the average measurement is dominated by the *internal noise within the measurement system*, which in the case of the measurement setup for QCJPAL650 was lower due to the use of an external, low noise, microwave preamplifier. In fact, neither number was an accurate measure of the true average emission level as shown below.

(b) Each *Sapphire* DART UWB tag transmits, on the average, approximately 60 to 100 UWB pulses per second, with each pulse approximately 2 nanoseconds in duration. These RF pulses are transmitted in a single packet burst at a 1 Mpps (million pulses per second) intersymbol rate, resulting in a maximum transmission duty cycle[6], i.e., the ratio of RF "ON" time to "OFF" time, of

$$\textit{Transmission}\ \text{Duty Cycle} = 2\ \text{ns} \times (100\ \text{pulses})/\text{sec}$$

$$= 2 \times 10^{-7} = 0.00002\%.$$

Thus, the *average* radiated emission level, which is directly proportional to the transmission duty cycle, is an exceedingly small number (-67 dB *below* the peak emission value). In fact, as discussed above, this average radiated emission level falls well below the noise floor of the measurement instrumentation used for FCC compliance testing. It is this extremely low transmission duty cycle that enables

---

[4] "Electromagnetic Compatibility Criteria Test Report for the Multispectral Solutions, Inc. PAL651 1x1 Tag," MET Report EMC16838-FCC250, 7 March 2005.

[5] "Electromagnetic Compatibility Criteria Test Report for the Multispectral Solutions, Inc. PAL650," MET Report EMC13888-FCC517, 26 June 2003.

[6] The expected value of the transmission duty cycle is actually a fraction of this value since the pulses are transmitted with an ON-OFF keying technique, the absence of a transmission representing a logic "zero".

the safe and non-interfering operation of this system in close proximity to systems using frequencies in or near the same spectral band around 6 GHz.

The NRAO's statement that "unevenness of its emission spectrum forces the device to operate 5.3 dB below the permitted mean EIRP level, so that the requirement on peak power is not violated" is entirely incorrect. Indeed, as seen above, the exceedingly low duty cycle of this class of UWB waveforms forces the average radiated emission level far below the FCC limit, enabling MSSI to request an increase in the peak EIRP limit without a corresponding increase in the average EIRP limit. Furthermore, as indicated in MSSI's first set of Reply Comments in this Proceeding[7], MSSI has recommended to the FCC that the maximum out-of-band peak power density not exceed the current limit under Part 15.250 without the waiver.

It should be further noted that transmissions from multiple tags are totally asynchronous; i.e., there is no relationship between the epoch or transmission time of one tag vis-à-vis that of any other tag. As a consequence, there is no coherent accumulation of tag transmissions within a particular time slot creating an appreciable aggregate effect. Since the probability of an RF emission from an individual tag is exceedingly small ($2x10^{-7}$ as indicated earlier), the probability of pulse overlap is also exceedingly small. From a queuing theory perspective, this is essential for the robust operation of the system with multiple tags, as collisions between tag packets ultimately limit the number of tags that can be simultaneously tracked.

3. Field of Use

MSSI would like to reiterate that its waiver request is solely for the two applications cited, namely the tracking of cattle and the tracking of personnel and assets at petrochemical facilities.

4. Higher Power Justification

MSSI's request for a 12.75 dB increase in peak power density is consistent with the desire to keep *power spectral densities* in the 5925-7250 MHz band at or below the same limits as those afforded to non-wideband devices operating under Parts 15.35(b) (Measurement detector functions and bandwidths) and Part 15.209 (Radiated emission limits, general requirements).[8]

More specifically, under Part 15.209 the maximum average field strength intensity from intentional radiators shall not exceed 500 microvolts per meter at a measurement distance of 3 meters for devices operating above 960 MHz. This translates into a maximum permissible average EIRP of -41.25 dBm/MHz when measured in a 1 MHz bandwidth.

---

[7] Reply Comments of Multispectral Solutions, Inc., ET Docket 06-103, 8 June 2006.

[8] Note that, under Part 15.205 (Restricted bands of operation), the frequency band from 5.46-7.25 GHz is fully available for unlicensed use by intentional emitters operating under the general emission levels specified by Parts 15.35 and 15.209.

Under Part 15.35(b), there is an additional limit on the peak level of the radio frequency emission. For intentional radiators, the maximum permitted peak limit is 20 dB above the maximum permitted average emission limit. Thus, the maximum permitted peak limit is -21.25 dBm. Under the general emission limits, the FCC interprets this maximum permitted peak limit on a full bandwidth basis. Wideband waveforms, i.e. those having bandwidths appreciably above 1 MHz, do not in general fit under these regulations since, while their peak power *density* may be less than -21.25 dBm/MHz, their *full bandwidth* peak power may exceed the absolute -21.25 dBm limit. The FCC addressed this issue in its analyses leading to the wideband and ultra wideband regulations outlined in Parts 15.250, 15.252 and 15.509-15.519 where the requirement for pulse desensitization correction (see below) was either removed or made optional.

On a peak power *density* basis, -21.25 dBm/MHz is equivalent to +12.75 dBm/50 MHz for pulsed emitters having pulse repetition frequencies (PRFs) at or below 1 MHz. Thus, a pulsed emitter operating under the proposed waiver would have a peak power density less than or equal to that of a narrowband emitter operating under the FCC's Part 15 general emission limits.

A 12.75 dB increase in peak power translates into an increase in range, utilizing an approximate R^4 path loss model for tags operating near to the ground[9], of a factor of 2.08 or approximately double. Currently, MSSI's *Sapphire* DART Precision Asset Location System™ utilizes tags operating under FCC Part 15.250 which have ranges of 200 to 300 meters, 650 to 1000 feet, depending upon tag height above ground.[10]

Thus, the request for an increase of 12.75 dB in peak power was selected to be consistent with the peak power limitations of non-wideband devices operating under Part 15 general emission limits and to permit a doubling of the range for the devices in open terrain. In complex, blocked environments such as those typically encountered in petrochemical facilities, the 12.75 dB increase, while not providing a two-fold increase in range, still provides enough of an increase (from tests performed under experimental license at BP's Cherry Point refinery) to significantly reduce the requisite passive receiver infrastructure and wiring, the major cost in any refinery installation.

---

[9] Hata, M., "Empirical formulæ for propagation loss in land mobile radio services", *IEEE Trans. Vehicular Technol.*, VT-29(3), 317–325, 1980.

[10] Time Domain Corporation, in "Comments of Time Domain Corporation, ET Docket 06-103", stated that MSSI uses "low sensitivity receivers" and, hence, was asking for additional transmitter power to compensate for this "low fidelity" performance. However, it should be noted from Time Domain's own product sheet for its "P210 Tracking System" (see, http://www.timedomain.com/products/P210TrackingKitcutsheet.pdf) that the coverage area for its UWB-based tracking system, based upon its "sophisticated implementations (such as highly coherent receivers)", is typically 2,700 sq. ft. with a 4 reference system. This translates into a maximum distance from tag to receiver of 52 feet. Furthermore, the P210 system cannot be used outdoors as it does not operate in the 15.250 frequency band and utilizes a transponder-based approach with all devices actively transmitting, further increasing the noise floor.

5. Radio Astronomy Protection

As pointed out by the National Spectrum Managers Association[11], the Radio Astronomy Service (RAS) operates in the 6650 – 6675.2 MHz band. This frequency band is used primarily for observations of the 6668.5 MHz methanol (CH_3OH) line (cf., ITU-R RA.314) and MERLIN (Multi-Element Radio Linked Interferometer Network). MERLIN and Methanol line studies are typically performed at night with narrow channel bandwidths (e.g., 2 MHz spectral bandwidth at the Methanol maser line frequency of 6668 MHz, further divided into 512 sub-channels[12]), significantly reducing the effects of wideband or ultra wideband emissions because of pulse desensitization effects.

It is well known that the occupied spectral width of a pulsed signal is inversely proportional to the pulse width, and is accompanied by an associated reduction in observed spectral level as the spectral width increases.[13] For a fixed bandwidth receiver (e.g., spectrum analyzer or radio astronomy receiver), the measured signal decreases as the pulse width decreases. This phenomenon is known as pulse desensitization (cf. also 47 CFR Part 15.35), and is measured as 20 times the natural logarithm of the product of the pulse width and receiver bandwidth. For a 2 nanosecond UWB pulse and a 2 MHz processing bandwidth, the measured peak power of the recovered pulse at the output of the victim receiver is reduced from the peak power at the input to the device by the pulse desensitization correction factor

$$\text{Pulse desensitization correction (PDC)} = 20 \log (2\text{x}10^{-9} \text{ x } 2\text{x}10^{6}) = -48 \text{ dB}.$$

Thus as indicated above, a radio astronomy receiver will only see a tiny fraction of any incident UWB pulse energy. Furthermore, this only occurs in the event that the radio astronomy installation is in close proximity to the refinery or feedlot in which the UWB tags are operational.

Respectfully submitted,

/s/ Robert J. Fontana, Ph.D.
President 26 June 2006

---

[11] "In the Matter of MSSI's Request for a Waiver of Part 15 of the FCC Rules, ET Docket 06-103, Comments of the National Spectrum Managers Association," undated.

[12] Etoka, S., R.J. Cohen and M.D. Gray, "MERLIN 6-GHz Maser Emission from W3(OH)", Proceedings of the 7th European VLBI Network Symposium, 12-15 October 2004, Toledo, Spain.

[13] Engelson, M., *Modern Spectrum Analyzer Theory and Applications*, Artech House, Dedham, MA, 1984.