BARON
Weather Solutions

Date: 10/17/06

Memo to: Mr. Ralph Puckett & Mr. George Wheeler
From: Bill Walker

Subject: Interference Analysis for 3500MHz – 3650MHz Frequency Band
Reference: Questions from Mr. Puckett's Office in the Pentagon

Background – This document is designed to bring everyone up to a level playing field in regard to Baron Services, Inc. request to George Wheeler, and summarize the results of our investigation into the Pentagon's request for us to perform an interference analysis. The highlights of what has happened in the previous weeks follow in rough chronological order. First we need to bring everyone to a general understanding for our reasoning:

1. Baron Services has been investigating the possibilities of building a completely new Doppler Weather Radar System for commercial use throughout the world for the scientific studies of the atmosphere, warning of the civilian population that dangerous weather conditions exist, and a tool for hydrological or Flood Forecasting.
2. The reasons for using this 3500MHz – 3650MHz frequency of the S-band instead of the conventional 2700MHz – 2900MHz frequency of the S-band is mainly to reduce the price of the system and thus make it appealing to potential customers.
3. A list of the cost reduction features is included below:
   a. Use of a 20ft diameter dish for a 1 degree beamwidth, instead of a 27ft diameter dish for the lower frequency
   b. Use of a 22ft radome instead of a 41ft radome
   c. Use of a smaller antenna positioner
   d. Use of a smaller and lighter weight tower.

Mr. George Wheeler – is our FCC Attorney and the person we chose to investigate the possibilities of using the 3500MHz – 3650MHz frequency band.

Mr. Puckett's Office – in the Pentagon was contacted by Mr. Wheeler and Baron provided some general documentation regarding our preliminary specifications for the new radar system, and Mr. Puckett's Office obliged by sending us a list of additional questions he would like for us to answer. Baron responded in kind to Mr. Puckett's questions through Mr. Wheeler. After a couple of question and answer periods, someone in Mr. Puckett's Office requested that we perform a survey in accordance with ITU-R M.1461-1 documents. That brings the readers of this document to the current timeframe.

Documents Used to Analyze the Potential for Interference Included:

1. ITU-R M.1461-1, Annex 1
2. FCC Document 05-56, Released March 16, 2005
3. NTIA TR-99-361, Department of Commerce, December 1999

Investigation of Potential Interference with Existing Radiodetermination and Communications Systems

Firstly, it was determined that the frequency range of 3100MHz – 3700MHz are set aside for radiodetermination and communications. It was determined that the 3650MHz – 3700MHz frequency band which the FCC has assigned for shared use licensed wireless communications in ET Dkt No 04-151.

Secondly, it was determined that with proper microwave filters installed in the Baron "land based" Radar System, the only radar systems that appear to have any potential for generating or receiving interference are listed as "Shipboard Radar A"[1] and operate in the 3500 – 3650MHz frequency range, and for which we are seeking permission to use this frequency range for commercial Doppler weather radar systems.

In addition to being located on the Aircraft Carriers for "Carrier Air Traffic Control" these Shipboard A Systems include three land based radar systems that are listed as being located at: 1) Pensacola, Florida, 2) Pascagoula, MS, and 3) St. Inigoes, MD. It is noted that location of a radar with the capability to potentially interfere with these 3 land based radar sites must have special approval for installation/use within 80km of each site[2]. Baron agrees with this regulation requiring approval from the FCC before attempting to locate any radar transmitting equipment within these boundaries.

Methods of Planned Interference Reduction

Baron Radar Services' approach to elimination of interference is twofold. First, Baron's radar systems will employ a contiguous, but overlapping waveguide bandpass filter bank, designed to provide a minimum of 100dB out of band rejection to all signals, and having a very narrow, approximately 50MHz wide, passband for operation of the radar system. In addition, our signal processor software contains a de-fruiter that is designed to remove unwanted interference, extraneous pulses, from other sources with attenuation of approximately 50dB. At a separation of 5000 feet, the free space loss is approximately 105dB. The combination of these techniques will provide isolation between the two radar signals of greater than 250dB.

When one calculates the overall radar system gain for the purpose of interference determination between two Baron radar systems of equal performance, we add 90dBm for the transmitter, 115dBm for the receiver, and the gain of both the receiving and transmitting antenna of 44dB and 44dB, we find the sum of 293dB. So it is sufficient to say that with only 250dB of isolation there remains a strong possibility of interference between the two radar systems, even with 50 – 100MHz frequency separation.

In the case of a 44dB gain antenna, the conical beamwidth is approximately one (1) degree. This means that for all of the above gains to add, the antennas must be pointed directly at each other in a straight line, or they must have a line of sight (LOS). At any other time during operation except for LOS, the gains will be much lower, probably by a factor of at least 44dB. Thus during these times, 250dB of isolation is sufficient to prevent interference.

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1 Taken from the Department of Commerce - NTIA Report, page 11 of NTIA Document, TR-99-361.

2 See FCC 05-56, page 4, paragraph 7, Footnote 12.

Operational Antenna Scanning - The normal operation of the Baron weather radar system is for the antenna to scan continuously for location, detection and observation of hydrometeor phenomena in the atmosphere. The majority of the time, Baron's radar system will operate in one of 4 modes.

> ***PPI Scanning –*** In this scan the radar antenna turns 360 degrees continuously in azimuth with the elevation pointed at a fixed angle. As a worst case, the antenna elevation normally points ½ beamwidth above the horizon, so with a one (1) degree beamwidth, the center of the elevation beam is never below ½ degree. This means we will never look directly (LOS) into adjacent radar systems antenna as long as there are several miles of separation between radar systems. The only other condition for PPI operation is for the antenna to be elevated at an even higher angle.
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> ***RHI Scanning –*** RHI is accomplished at any of the fixed azimuth intervals between 0 degrees and 359.9 degrees, with the elevation scanning between 0.5 and 90 degrees. In most cases the elevation scan upper limit is set to 15 degrees or less. However, we still avoid pointing LOS with another antenna.
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> ***Sector Scanning –*** Sector scanning is similar to PPI scanning with the exception that the antenna moves back and forth in azimuth over a sector prescribed by the operator. Again the antenna elevation is set to a fixed preset angle as described above.
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> ***Volumetric Scanning –*** Volume scanning is accomplished in a near "corkscrew" fashion and is employed to sample the complete hemisphere within range of the radar system. The scan begins with the antenna positioned ½ beamwidth above the horizon and with each 360 degree revolution of the antenna, the elevation angle is increased by one beamwidth, in this case 1 degree, until the volume scan is completed.

Summary – We believe that, all things above being considered, there is very little chance of interference with the Shipboard A type radar systems...since there are only three (3) of these systems located in the continental United States and the remainder are at sea. Furthermore, every system will be installed at a location that has undergone a "radar site survey" in which the potential for interference will be examined thoroughly and documented evidence of non-interference shall be provided prior to installation. The only foreseen areas that we consider a potential problem in the CONUS are St. Inigoes, MD, Pensacola, FL, and Pascagoula, MS. Outside the CONUS, we have potential for sales in San Juan, PR, but the system would be located on the back side of a mountain peak that would be both higher altitude (3000ft) and shielded from the test range by the peak of the mountain. As for Military systems on board vessels at sea, most of these systems have appropriate ECCM devices that should further reduce the possibilities of interference by our radar system.

As far as International sales are concerned, we are hopeful that this design would be acceptable to those clients also, but we have no known database on what types of emitters in this frequency range are in use overseas. We would appreciate any guidance that the Department of Defense might provide us in this area.

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Finally, since this is considered a commercial Internal Research & Development (IR&D) Project within our company, we are interested in the shared use of the upper portion of the S-Band for commercial weather radar operations ... 3500-3650 MHz portion of the S-Band. In particular we want to work together to determine whether there might be portions of the S-Band which would be preferable for non-government operations of weather radar systems and whether you have comments or questions about aspects of the design of or frequency coordination procedures for these new weather radar systems which can be worked out in advance while this product is still under development to enhance opportunities for successful spectrum sharing.

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