Justification for consideration of the use of D-Block bands

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Summary:

IMSAR LLC operates a wide-band UHF synthetic aperture radar for imaging the surface of the Earth. Best performance is achieved when operating across an uninterrupted frequency band, since interruptions can cause artifacts in the imagery and decreased resolution. The IMSAR radar operates from an altitude of 2500 feet or more above the ground. This range to the ground, coupled with the low power transmitter and the wide band of operation, results in undetectable power levels for ground-based, narrow-band receivers such as those which will be used for the FirstNet system. Additionally, we are requesting use of these bands at only three locations, two of which are remote military sites. The FirstNet network is still in the early development stages and it is likely that there will not be geographic conflict between FirstNet and IMSAR tests until a much later date.

Details:

Company and Technology Background

IMSAR LLC has technology that is able to track moving targets, image the surface of the earth, create digital elevation maps, assist in search and rescue operations, and detect small changes in a scene, such as the movement of a vehicle. The US Navy, Army, and Air Force have expressed interest in this technology. The size, weight, power, and cost of IMSAR's Synthetic Aperture Radar (SAR) system, known as NanoSAR, are an order of magnitude less than similar systems. The radical change in weight and power consumption enables tactical use of the radar, which in turn gives surveillance capabilities to small sets of soldiers that were previously unavailable. With the new surveillance capabilities, dangerous and life threatening situations can be further reduced.

IMSAR performs SAR tests from a small aircraft typically flying between 2,000 and 10,000 feet in altitude (above ground level). Directional transmit and receive antennas are nominally pointed toward the earth. Reflected signals are collected and processed to create images of the ground. Transmission is a linear frequency modulated continuous wave (LFM-CW) with the frequency being swept from the minimum to the maximum frequency 1000 times per second. Because the transmission power is low and the frequency sweeps very rapid, the average power at a given frequency is extremely low.

UHF frequencies are employed to enable ground penetration and observation of specific targets where UHF reduces the clutter of the background. A continuous frequency band of operation is desired to reduce artifacts in the SAR imagery and to maintain high resolution. The transmit signal is directed perpendicular to the direction of travel and towards the ground using a directional antenna. The antenna radiation pattern is approximately 120° in elevation and 70° in azimuth. The back lobes of the antenna are attenuated significantly. The peak of the antenna pattern has a 45° incident angle to the ground. The return signal is received by the same antenna. Data collections occur primarily over rural areas of Utah and remote government owned lands to test the functionality and demonstrate the utility of the radar as a tool for both commercial and military applications. Sites of interest to be imaged will be terrains of interest to potential customers, including urban and rural scenes. Additional locations are used for further testing and demonstrating the product to customers.

Locations of Operation

1. Springville, UT (100 km radius), in Utah County, IMSAR offices
2. China Lake, CA (64 km radius), in Kern County, military base
3. Dugway, UT (16 km radius), in Tooele County, military base

Non-interference – Mathematical

IMSAR's UHF band radar has a very low probability of interfering with other systems operating in the same frequency band, because the low-power signals are transmitted from a considerable range and are spread out over a large bandwidth.

The radar signal is a linear frequency modulated (LFM) "chirp" whose instantaneous frequency increases linearly throughout the duration of the radar pulse, beginning at the smallest frequency and ending at the largest. This is repeated 1000 times per second. Since each individual frequency is only transmitted for a very short duration, the power in each frequency bin is considerably less than it would be with a continuous wave (CW) signal transmitting at that single frequency. This is known as a spread spectrum signal.

As a microwave signal radiates from an antenna it spreads out as the distance from the antenna increases. This is in contrast to a laser beam, which is highly focused and maintains all of its power in the pointed direction. The power density (in units of Watts per square meter) of a microwave signal radiated from an isotropic source decreases by a factor of $4\pi R^2$, where R is the distance from the antenna. For a directional antenna, the transmitted power is first multiplied by the gain of the antenna before dividing by the R^2 term. Even still the R^2 term becomes large very quickly and greatly reduces the power incident on the distant target.

The IMSAR UHF radar transmits 1 Watt of power through an antenna that has about 6 dB of gain, currently operates over 510 MHz of bandwidth (from 450-960 MHz), and typically operates at a range of 3000 feet or more from the intended target. So the 1 Watt gets spread out over the band and then the power density is reduced by the distance that it must travel before reaching the ground. The end result is that the transmitted radar signal is indistinguishable from noise once it reaches another device or system operating in a sub-band, such as the 11 MHz-wide bands used by the FirstNet network (power levels are on the order of picowatts). (IMSAR is able to detect this signal from out of the noise with the use of a broadband receiver and appropriate signal processing techniques.)

Non-interference – Experience

IMSAR has had an FCC experimental license covering portions of the UHF band since November 2008, when the license allowed for transmissions between 405-450 MHz. This was expanded to be 405-650 MHz in September 2010, and expanded further to 405-960 MHz in December 2012. During this time there has not been any reported incident of interference caused by our radar system.

During 2013 we had some testing planned near Atlanta, GA, and there was concern that our system would interfere with various broadcast and communication systems in the vicinity of this busy city. As a result, we notified about 40 different agencies to let them know what we were doing and when we were doing it. We told them that we didn't anticipate any problems but for them to call us if they encountered anything at all, and we would immediately shut down our transmitter. We successfully completed our experiments without any complaints from any of the organizations that were notified.

On another occasion, we were flying at just 500 feet above ground level at a military facility. Some members of the military wanted to prove that they could detect our signal. They brought out their expensive RF equipment and pointed it in the direction of our transmitter as it flew by on the aircraft. Even knowing where to look, the band we were transmitting at, and having sensitive equipment, they were unable to distinguish our signal from the noise floor of the equipment.