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

In the Matter of	)	
	)	
Amendment of the Commission's Rules	)	WT Docket No. 11-202
to Permit Radiolocation Operations in	)	
the 78-81 GHz Band	)	

REPLY COMMENTS OF TREX ENTERPRISES CORPORATION

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Trex Enterprises Corporation (Trex), by its attorneys, hereby replies to the comments submitted in response to the *Notice of Proposed Rulemaking* (*NPRM*) released in the above-captioned proceeding.[1] Commenters agree that FOD radar detection systems should be able to operate at airports on a licensed basis under Part 90, provided that technical compatibility among the systems is demonstrated and applications are coordinated with NTIA to protect radio astronomy services (RAS) observatories (as proposed in the *NPRM*). In these reply comments, Trex provides additional technical information to demonstrate the compatibility between its FOD detection radar systems and automotive collision avoidance SRR systems. Trex also continues to seek to maximize use of the band for the provision of other services. To achieve that objective, it urges the Commission to ensure that parties proposing other uses of the band demonstrate that they have adopted stringent receiver design standards before the Commission adopts limits on other conforming uses of the band.

[1] *Amendment to the Commission's Rules to Permit Radiolocations Operations in the 78-81 GHz Band*, Notice of Proposed Rulemaking and Order, WT Docket No. 11-202, FCC 11-185 (rel. Dec. 20, 2011).

I. TREX'S FOD DETECTION RADAR SYSTEM OPERATES AT AIRPORTS WITHOUT CAUSING HARMFUL INTERFERENCE TO AUTOMOTIVE SRR AND CAN BE SUITABLY COORDINATED WITH RADIO ASTRONOMY SITES

Both the Strategic Automotive Radar Frequency Allocation Group ("SARA") and Robert Bosch, GmbH ("Bosch") agree that licensed FOD detection radar systems should be able to co-exist with automotive short range radar (SRR) equipment operating in the 78-81 GHz band without causing harmful interference.[2] Likewise, the National Radio Astronomy Observatory (NRAO) supports Trex's request, provided there is suitable coordination with the small number of potentially-affected radio astronomy sites.[3]

SARA and Bosch want to confirm that the technical parameters specified in the waiver order that granted authority to certify, manufacture, license and use the Trex FOD radar detection equipment at airports are sufficient to fully protect automotive SRR equipment operating in the 77-81 GHz band on public roadways near airports. In addition, SARA asks the Commission to require Trex to provide additional information "to justify why it requires such high power levels to operate FOD radar systems, including the distance that Trex desires the FOD radar systems to cover, the minimum metal target size that the FOD radar systems are expected to detect, and related information."[4]

In response to SARA's request, Trex herein provides additional information about its system (in addition to the technical information provided in Trex's opening comments). The FOD radar detection technology developed by Trex, known as "FOD Finder™," uses a low-power, 3-D imaging, frequency-modulated continuous wave (FMCW) radar system that can be

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2 SARA comments at 2; Bosch at 6 ("it is not suggested that there cannot be compatible sharing between licensed FOD radars at airports and automotive SRRs on motor vehicles, even in close proximity to FOD-equipped airports").

3 NRAO comments at 2 (¶ 4).

4 SARA comments at 4.

mounted on a vehicle to provide mobility. The technology is designed to detect and classify the presence of FOD in the airport environment. The radar detection system incorporates a 78-81 GHz sensor mounted on a reciprocating platform that allows scanning a field approximately 80 degrees in front of the vehicle. The antenna tilt is fixed in relation to the vehicle, scanning at the rate of 30 scans per minute and providing a detection distance in front of the vehicle of approximately 200 meters with a detection "cell" of approximately 1 meter by 1 meter. The radar detection system sweeps the frequency range between 78 and 81 GHz to affect an electronic scan in elevation, along with a rotary stage to produce an azimuth scan, which together detects, classifies and logs the location of small debris items against the flat surface of the airport runway, taxiways, hangar and gate environments.

The Trex FOD Finder radar detection system is designed to drive down a runway at a speed of 30 mph (44 ft/sec) collecting debris that is potentially damaging to an aircraft engine. For reference, a quarter inch (0.25") diameter ball bearing can cause measurable damage to the turbine blades in a jet engine, as depicted in the picture below, and is chosen to represent the minimum size detection threshold.

The Trex FOD Finder radar performs an azimuthal scan sweeping the runway from left to right in 2 seconds, and then from right to left in another 2 seconds to begin its sweep again. Thus the time between scans of a single point on the ground can be as long as 4 seconds, or a travel speed of 176 feet. In order to avoid false negatives and false positives, the FOD Finder is designed to scan each point on the ground at least three times, setting the FOD detection range requirement at about 200 meters.

The received power from the radar's antenna is given by the standard radar formula:

$$P_r = P_t\left(\frac{G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4}\right) > (kTB)(NF)(S/N).$$

The Trex FOD Finder antenna gains G_t and G_r are each 45 dBi. The wavelength λ of operation is 3.8mm (-24dB(meters)), and the detection range R required, as explained above, is 200 meters (23dB(meters)). The cross-section σ of a 0.25" ball bearing is -45dB (square meters), the numerical factor in the denominator is equivalent to -33dB and the FOD radar's transmit power P_t is 100 milliWatts (20 dBm). This sets the received return power level (from a quarter-inch diameter ball bearing at 200 meters distance) at 20 + 45 + 45 – 48 – 45 – 33 -4(23) = -108 dBm.

The FMCW receiver noise bandwidth is 1 kHz (kTB = -144 dBm noise floor), the receiver noise figure noise floor (NF) is 3dB (which is state of the art for millimeter wave frequencies), and the FOD detection threshold is set at a 12dB signal-to-noise (S/N) ratio as a balance between limiting transmit power and limiting false alarms. Sensitivity of the FOD radar is often limited by the clutter caused by signal reflections from the ground, which can produce a

noise-like spectral sensitivity floor up to 20dB higher than the noise floor due to the thermal noise. The clutter level is different for different runway surface conditions and the above 20dB sensitivity reduction has been observed for rough surfaces representing the worst case. This sets the receiver detection threshold at -144 + 3 + 12 + 20 = -108 dBm, the same as the return power from a quarter-inch diameter ball bearing at 200 meters distance, consistent with reliable detection of FOD at the size threshold necessary for aircraft and traveler safety. The ground clutter signal varies proportional to the transmit power, which allows for adjustment to the transmit power within a 20dB range and with minimum impact on the FOD detection capability under the worst case conditions. Detection of the same target at the maximum range of 300 meters distance requires an additional 7dB in system sensitivity (as compared to the range of 200 meters distance) and given the available transmit power, the system can operate at longer ranges when the clutter level is not too high.

SARA and Bosch also raise a potential concern that when the main antenna beamwidth of the FOD detection radar system is in use, it could potentially illuminate a public roadway near the airport and cause harmful interference to automotive SRR systems installed on automobiles traveling on such roadways.[5] In addition, SARA asserts that, based on the technical parameters specified by Trex for its FOD radar detection system and set forth as operating conditions in the waiver order, interference to SRR equipment "is likely because Trex proposes to operate FOD radar systems at 65 dBm e.i.r.p. – more than 38dB higher than the power at which SRR systems are authorized to operate under European standards governing vehicular radar."[6] The following explanation of how the FOD Finder radar system operates responds to

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5 SARA comments at 3; Bosch comments at 2.

6 SARA comments at 3 (referencing ETSI EN 302 264-1 (V1.1.1) (2009-06), *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Short Range Radar equipment*

SARA's specific concern about the FOD Finder power level potential concerns and demonstrates that the FOD radar detection system will not illuminate public roadways near airports to cause harmful interference to automotive SRR systems.

The Trex FOD Finder radar system operates significantly different from the collision avoidance SRR systems in that it forms very narrow, pencil-like beams that point downward and rapidly scans in both the horizontal and vertical directions the flat surface of the airport runway. Under typical operating conditions, the pencil-like beam scans 90 degrees horizontally and 5 degrees vertically. Given the radar antenna dimensions and illumination taper, its angular beam size as measured between first zeros in the beam pattern is 0.45 degrees horizontally and 1.3 degrees vertically. The full 90 degrees wide horizontal scan takes 4 seconds. Considering these system parameters, the time dwell on any target is 4 sec * (0.45/90) * (1.3/5) = 3 milliseconds. Due to such short duration of potential interference exposure, Trex submits that the most accurate and useful way to evaluate the FOD radar's potential impact on automotive SRR is by using the maximum transmitted peak power criterion, which is defined by ETSI for SRR systems at 55 dBm e.i.r.p. when measured within a 50 MHz bandwidth.[7]

At peak transmit power, the FOD Finder radar is capable of producing up to a 65 dBm (e.i.r.p.) power level. But for the typical short range distance (defined as 300 meters or less) mobile operating version of the FOD Finder radar, the actual transmit power operates at 10-20dB lower than the 65 dBm maximum, as the radar sensitivity is mostly limited by the ground clutter. Using the lower actual transmit power for mobile operations, the corresponding e.i.r.p. level is below the 55 dBm e.i.r.p. ETSI limit. The FOD Finder is also capable of operating in a

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operating in the 77 GHz to 81 GHz band; Part 1: Technical requirements and methods of measurement, Annex D at 36) (*ETSI EN 302 264-1*).

7 *See ETSI EN 302 264-1* § 7.1.3 Maximum radiated peak power (e.i.r.p.)

fixed (*i.e.*, stationary) position for longer range distances (defined as greater than 300 meters). For the long range fixed operations, the full 65 dBm transmit power is preferred.

Because the beam of the radar is always pointed downward to the ground for debris detection and the runways are set back considerable distances from public roads that are located near airports, the only potential impact that the FOD Finder radar could have on automotive collision avoidance SRR radar equipment operating on the pubic roadways nearby would result from ground reflections and from the scattering of the FOD Finder beam. But the RF attenuation that results from the interaction of ground reflection and beam scattering would considerably reduce the e.i.r.p. power. Accordingly, the downward beam orientation of the FOD Finder radar ensures that it will be able to operate within the maximum e.i.r.p. power limits and not adversely affect SRR equipped automobiles traveling on public roadways in the areas outside the airport environment even at full available transmit power. In addition, the first sidelobe level of the antenna is lower than -18 dBi relative to the center of the main beam which ensures that the power transmitted through the sidelobe even in the case of the direct hit of the SSR radar antenna will be well below the 55 dBm e.i.r.p. limit.

Moreover, Bosch's own observation effectively disposes of the concern that when the main antenna beamwidth of the FOD detection radar system is in use, it could potentially illuminate a public roadway near the airport and cause harmful interference to automotive SRR systems installed on automobiles traveling on such roadways. Bosch states –

> If FOD radars at airports utilize directional antennas, aimed in a generally downward direction toward an airport runway, that configuration, despite the mounting of the radar on a motorized vehicle moving the FOD radar back and forth along airport runways, will likely minimize interference on public roadways adjacent to airports. The operating configuration of the radar, coupled with the limited propagation characteristics of the 77-81

> GHz band, could provide sufficient protection for SRR operation in the 78-81 GHz band.[8]

To ensure FOD radars use downward directed antennas, SARA and Bosch ask whether a licensing regime that regulates the siting of FOD radars may be needed.[9]

As explained above, Trex's FOD Finder antenna is highly directional and because it points at a small point on the runway, it will not illuminate a public roadway. Accordingly, Trex is not opposed to the Commission adopting the licensing condition proposed by Bosch that the applicant certify that the FOD radar will be mounted and utilized so that when in use it does not, within the main beamwidth of the antenna (azimuth or elevation), illuminate a public roadway near the airport.[10]

Bosch notes that it has recently participated in cooperative testing of the potential interaction between automotive radar systems and millimeter-wave Radioastronomy observatories, and proposes that similar testing should be done to determine the compatibility between FOD radars and automotive radars.[11] Trex submits that such testing is not necessary because unlike SRRs, which radiate in multiple directions from a motorized vehicle, FOD radars utilize highly directional antennas, aimed in a downward direction. Bosch itself confirms that such operating characteristics "could provide sufficient protection for SRR operation in the 78-81 GHz band."[12]

Finally, NRAO states that the fixed-location operation of devices with the same operating parameters as described in paragraph 18 of the *NPRM* could cause serious interference

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8 Bosch comments at 9.

9 SARA comments at 2; Bosch comments at 7.

10 Bosch comment at 10.

11 Bosch comments at 12.

12 Bosch comments at 9.

to radio astronomy operations and therefore should not be allowed within line of sight of radio astronomy stations except after suitable coordination (as has been proposed in the *NPRM*).[13] Trex notes that because its antenna is highly directional and is pointed at a small point on the runway, the possibility of causing harmful interference to radio astronomy operations is virtually non-existent. Nevertheless, Trex understands NRAO's concerns and does not oppose coordination of applications that are within line of sight of radio astronomy stations. As noted in the *NPRM*, because the 78-81 GHz band is shared with Federal operations, as a matter of course applications would be coordinated with NTIA in any event.[14]

II. TO MAXIMIZE USE OF THE BAND, THE COMMISSION SHOULD INSIST ON STRINGENT RECEIVER DESIGN STANDARDS TO MINIMIZE UNNECESSARY LIMITS ON OTHER CONFORMING USES OF THE 78-81 GHz BAND

Consistent with the public interest, in this rulemaking proceeding the Commission should enable the greatest use of the various safety-related technologies already proposed for this band – FOD radar detection systems, automotive short range radar (SRR) systems, and tank level proving radar (TLPR) devices – while at the same time ensuring that the 78-81 GHz band is utilized efficiently, flexibly, and not unnecessarily inhibited. This obligation is particularly important given that the spectrum is limited and in high demand.

With this understanding, Trex urges the Commission to refrain from adopting any rule provision for the 78-81 GHz band that would inadvertently and unnecessarily restrict additional and future use of the band in any way not already restricted under the existing band allocation. Instead of adopting restrictions, Trex urges the Commission to ensure that the receiver performance of prospective uses of the 78-81 GHz band utilizes high performance

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13 NRAO comments at ¶¶ 6-10.

14 *NPRM* ¶ 13.

technical innovations so that equipment that may be susceptible to harmful interference are sufficiently engineered to function with and accommodate other operations. This includes ensuring that manufacturers have efficiently engineered their receivers utilizing the most current best practices so that they are not so sensitive as to not tolerate, and thereby effectively prohibit, other use or operations, whether on a licensed or unlicensed basis. In no way should Trex's recommendation here be construed to suggest that it believes that any manufacturer designing equipment to be used in the other proposed services have not adopted sound and stringent engineering standards. Trex merely urges the Commission and others to insist on the adoption of the absolute best and sound engineering practices to ensure that the introduction of a new service or technology is not hindered.

III. THE ORDER ALREADY CONDITIONS ANY LICENSE GRANTED UNDER THE WAIVER ORDER ON THE RESOLUTION OF THE RULEMAKING PROCEEDING

SARA and Bosch request that any licenses issued pursuant to the waiver order be expressly conditioned on the resolution of this proceeding.[15] But the waiver order already imposes such condition. Trex's request for a waiver to permit certification, manufacture, licensing, and use of its FOD detection radar equipment is already subject to certain requirements and is expressly conditioned on the resolution of the rulemaking proceeding.[16] Trex is in the process of certifying it FOD radar detection equipment so that licenses can be obtained and operations of this critical safety device can commence in accordance with the conditions established by the Commission.[17]

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15 SARA comments at 4; Bosch comments at n.2.

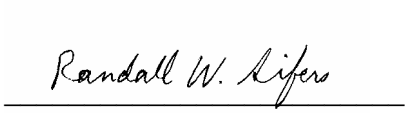
16 *Order* at 18.

17 See para 18.

IV. CONCLUSION

For the foregoing reasons, Trex respectfully urges the Commission to resolve this proceeding in a manner that permits use of the 78-81 GHz band for its FOD radar detection equipment and maximizes overall use of the band.

Respectfully submitted,



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