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The Safety of WiMAX Insolid Propellant Rocket Production

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Abstract**—**With the advance in wireless networking, IEEE 802.16 WiMAX technology has been widely deployed for several applications such as "last mile" broadband service, cellular back-haul, and high-speed enterprise connectivity. As a result, military employed WiMAX as a high-speed wireless connection for data-link because of its point to multi-point and non-line-of-sight (NLOS) capability for many years. However, the risk of using WiMAX is a critical factor in some sensitive area of military applications especially in ammunition manufacturing such as solid propellant rocket production. The US DoD policy states that the following certification requirements are met for WiMAX: electromagnetic effects on the environment (E3) and Hazards of Electromagnetic Radiation to Ordnance (HERO). This paper discuses the Recommended Power Densities and Safe Separation Distance (SSD) for HERO on WiMAX systems deployed on solid propellant rocket production. The result of this research found that WiMAX is safe to operate at close proximity distances to the rocket production based on AF Guidance Memorandum immediately changing AFMAN 91-201.

Keywords**—**WiMAX, ammunition, explosive, munition, solidpropellant, safety, rocket, missile

I. Introduction

In thepastdecade, WiMAX 802.16 high-speedwirelessbroadbandtechnologyhasbeenutilizedin a numberofaspectsandapplications.The term "WiMAX" (WorldwideInteroperabilityforMicrowaveAccess)createdbyWiMAXforumisbasedon,802.16,standarddesignedbytheInstituteofElectricalandElectronicsEngineers(IEEE).These,twoorganization sare in fact different (similarto IEEE 802.11 andWiFioverlap)[1].IEEEisthetechnicalprofessionalsocietythat developsinternationalstandardssupportingmanyoftoday'stelecommunications,informationtechnologyandpowergenerationproductsandservices [2]. Ontheotherhand, the WiMAX Forumis a nonprofitorganizationformedtopromotetheadoptionofWiMAX compatibleproductsandservices.Majorroleofthisorganizationistocertifytheinteroperability of WiMAXproducts [3].WiMAX networks are becoming a preferable means for military communication because of its outstanding functionality. The most significant benefit of WiMax is the long-range capability.It covers more area and range of military operations than traditional WiFi system. In addition, the high bandwidth is also another advantage of WiMax. It provides data rate up to 75 Mbps, which supplies better service of military applications over the network. Finally, a WiMax system supports in non-line-of-sight (NLOS) and line-of-sight (LOS) services depended on the situations. Therefore, WiMAX has been deployed in several military operations. The rest of the paper is organized as follows. Section II gives an overview of WiMAX system and its spectrum. Section III provides the background of solid propellant rocket production and how WiMAX is utilized in the rocket manufacturing. Section IV presents the analysis of using WiMAX for solid propellant rocket production and the result of the experiment. Finally, conclusion is provided in Section V.

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II. WiMAX System

A. WiMAX Standard

Several colloquial names of WiMAX such as "Mobile WiMAX", "Fixed WiMAX" or "802.16e" can be basically clarified as follow:

1) Fixed WiMAX (802.16d) is 802.16-2004 standard that has no support for mobility.

2) Mobile WiMAX (802.16e) implemented a number of enhancements to 802.16-2004, including better support for Quality of Service and the use of Scalable OFDMA, and supporting to the mobility functionality.

The most popular 802.16 standard deployments is Mobile WiMAX, which is implemented as a high-speed Internet broadband. The in progress 802.16 standard referred as 802.16m (Mobile WiMAX Release 2 or WirelessMAN-Advanced) is an advanced Air Interface with expected data rates up to 100 Mbit/s for mobile and 1 Gbit/s for fixed station. WiMAX Forum operates a certification program while the IEEE only sets specifications but does not test equipment for compliance with them. WiMAX certification by WiMAX Forum is intended to guarantee compliance with the standard and interoperability with equipment from other manufacturers.

B. RadioFrequencySpectrum

On a global scale, the radio frequency interface varies by region. That is where Spectrum-governing authorities, such as Federal Communication Commission (FCC) plays a key role in determining useable spectrum for various, and sometimes competing service. However part of the spectrum in most country is specifically controlled by military or public safety. Those spectrum bands are identified as either licensed or unlicensed. Carriers that have paid for the use of these bands currently possess licensed bands. On the other hands, unlicensed bands are freely available for any experimental or enterprise application. There is no uniform global licensed spectrum for WiMAX, nevertheless in an effort to drive WiMAX standardization the WiMAX Forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz [2].

C. WiMAXforMilitary

In the arena of military tactics, WiMAX can be used to establish a secure link between multiple sites. The connection to and from command center to remote sites can be rapidly created which consequently benefits the military operations that require real-time situation awareness. WiMAX can be integrated into mobile command units, combined with tactical radio and satellite systems. In addition, WiMAX is a perfect candidate for the implementation of the military tactical data link due to its versatile strong network characteristics. However, some sensitive area of military operations related to ammunition or explosive devices require intensive study before deploying WiMAX into the system.

III. WiMAX in Solid Propellant Rocket Production

A. Scenario

The ammunition-manufacturing site is usually situated in the remote area that considered low casualty. The suitable site is usually near the mountains or earth mounds so they act as a blast barrier, blocking the explosion in the case of accident. In most cases, the data link between each plants is required in order to remotely control the machine in hazardous area or access explosion proof security network camera. In solid propellant rocket production, the connection from the office center to several plants can be simply established by deploying WiMAX. A point-to-multipoint WiMAX tower can rapidly create secure high-speed connectivity among plants which overcomes the difficulty of wiring fiber optics in mountainous region (see Figure 1).

Fig. 1 The WiMAX system scenario for Solid Propellant Rocket Production

B. SolidPropellantRocketProduction

Several high risks processes of solid propellant production are categorized in 3 parts: material preparation, motor charging and assembling, and rocket storing. The chemicals used in the material preparation are substantially hazardous such as Ammonium Perchlorate (NH4CIO4). The powdery particles of AP can simply cause the explosion from electrostatic discharges. The propellant casting in motor charging and assembling process is susceptible to the detonation. The devices used in this step require explosion proof certified equipments. Finally, the finish rocket model stored in the warehouse is the most dangerous area, which required special protection because this rocket can be detonated by itself. Therefore, the use of all electronic equipments and radio frequency must compel to the safety standard since the radio frequency fields represent real hazard to Electroexplosive devices (EED) [5].

C. WiMAX for Rocket Manufacturing

Since WiMAX offers long range secure connection either NLOS or LOS functionality, it is a perfect network infrastructure candidate in the manufacturing of solid propellant rocket. The terrain layout of plants is difficult to set up wired network hence wireless network is a preferable method of connection. Unlike WiFi, WiMAX is intended to work outdoors over long distances. Nevertheless, in order to use WiMAX in solid propellant rocket manufactures, the effect from radio frequency have to be carefully studied.

IV. The Optimal Solution and Safety of WiMAX Systems

To deploy WiMAX system in to the ammunition production, it is required to meet the certification for electromagnetic effects on the environment (E3) and hazards of electromagnetic radiation to ordnance (HERO). In the experiment, the outdoor integrated flat panel antenna WiMAX unit with 4.920 GHz 23 dBi gain and 40 watts power is analyzed.

TABLE 1
RECOMMENDED POWER DENSITIES AND SSDS FOR HERO SUSCEPTIBLE MUNITIONS

Condition	MaximumAllowable Power Density	Safe Separation Distance
Worst Case 32000MHz < f	P_0=100 $\frac{W}{m^2}$	$D = 0.0925\sqrt{P_t G_t}\, ft.$
Exposed EED 4850MHz < f		
In Storage/ Transport 1533.7MHz < f		
In Metallic Container All Frequencies		

A. Calculation

There are 4 cases of rocket condition: the worst case, exposed EED, in storage or ground transportation and in metallic container. The allowable maximum power in all cases is 100 watt. The safe separation distance is calculated by Eq. 1 from Table 1.

$$D = 0.0925\sqrt{P_t G_t}\,\text{ft.} \quad (1)$$

The sample WiMAX device operates (PtGt) at 40 watts (e.r.i.p.).

$$D = 0.0925\sqrt{40}\,\text{ft.}$$

Thus

D = 0.585 ft. (0.1783 meters)

B. Experiment

From the calculation, the safety distance for tested WiMAX device is 0.1783 meters. The power consumption is 40 watts which is much lower than the maximum allowable. These parameters are required to design the rocket static test.The actual power evaluated by Electromagnetic Radiation (logarithmic periodic antenna) is normally lower than the calculated power [6]. As a result, the experiment is designed according to calculated parameter above. In the static test, the solid propellant is casted in the metal rocket case. The igniter is in the core of propellant connected to the electric initiator. WiMAX antenna is tested in the length of 0 and 0.18 meters from the static rocket (see Figure 2). The rocket chamber is located inside the blast wall for safety precaution. The static test is designed to see if the radio frequency from WiMAX antenna can detonate the igniter inside the solid propellant.

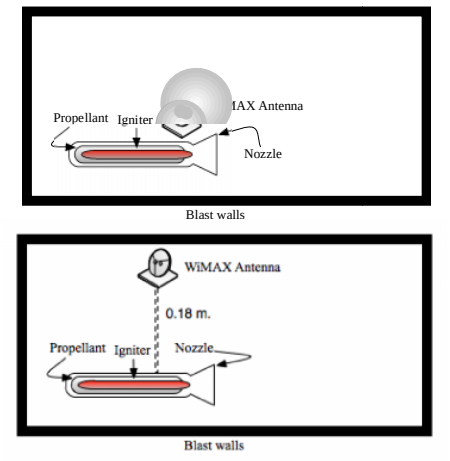

Fig. 3Two configuration of static test for WiMAX radio frequency

C. Result

The static test is planned to inspect the effect ofWiMAX frequency wave to the ignitor inside the solid propellant. The test shows that the radio frequency from WiMAX antenna at 40 watts power cannot ignite the ignition from the length of 0 and 0.18 meters. The igniter inside the solid propellant does not get any effect from the WiMAX radio frequency.

IV. Conclusion

The 4.9 GHz WiMAX system with the power of 40 watts can be safely operate in the solid propellant rocket production in the proximity of at least 0.1783 meters. The maximum allowable power density for 4.9 GHz frequency is 100 watts based on AF Guidance Memorandum immediately changing AFMAN 91-201. In this paper, the test deploys the high power of WiMAX devices. As a result, the lower power and frequency of commercial WiMAX system be operated in a close proximity of ammunition as well.

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References

[1] White Paper, *RF Spectrum Utilization in WiMAX*, Fujitsu Microelectronics America, Inc. , Nov 2004
[2] Joon Ho Park; Mingji Ban; Sung Ho Cho, *A design of a mobile WiMAX system for military applications and its performance in fading channels*, Advanced Technologies for Communications, 2008. ATC 2008. International Conference on , vol., no., pp.185-188, 6-9 Oct. 2008
[3] Pentagon,*AFMAN91-201_AFGM1*, Oct 2009
[4] Defense Update,*Wimax Ieee-802.16 Military Applications*, December 2010 [http://defense-update.com/products/w/wimax.htm]
[5] Einstein, H.B.; Warner, H.B.;, Mathematical Evaluation of Radio Frequency Hazards to Resistive Devices, Electromagnetic Compatibility, IEEE Transaction on, vol. 7, no. 3, pp. 287-296, Sept 1965
[6] Jiradett K., Ornin S., Teeranun S., *The use of RFID in solid propellant rocket production management system* , World Academy of Science, Engineering and Technology, July 2010

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