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Radar interference into LTE base stations in the 3.5 GHz band

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ABSTRACT

We study the interference from a rotating shipborne radar system that spectrally and spatially coexists with a Long Term Evolution (LTE) cellular communications network in the 3.5 GHz band to investigate the feasibility of LTE deployment in the United States coastal metropolitan cities in that band. First, we simulate the radar systems with realistic operational parameters. Furthermore, we leverage a detailed 3GPP-compliant LTE simulation with a sophisticated air interface modeling and investigate sensitivity of LTE to radar interference in macro cell, outdoor small cell, and indoor small cell scenarios. We simulate the propagation conditions between the radar and LTE system by adopting the Free Space Path Loss and Irregular Terrain Model commonly leveraged by National Telecommunications and Information Administration (NTIA), to account for propagation, diffraction, and troposcatter losses that the radar pulses undergo before they reach the LTE system. As a performance metric, we evaluate the throughput of the LTE system in the uplink direction for various distances between the radar and the cellular system. Our simulation results indicate an LTE link will remain operational even in severe interference conditions. In fact, the LTE system as close as 100 km away from the radar undergoes less than 10% throughput loss from the LTE total throughput, and the throughput loss is less than 30% when the radar is only 50 km away from the LTE.

1. Introduction

One additional tool available to Mobile Network Operators (MNOs) and other spectrum users in order to satisfy the mobile broadband communications data traffic increase [1] is spectrum sharing. Concerning this subject matter, the Presidents Council of Advisers on Science and Technology (PCAST) suggested leveraging government-held spectrum for mobile broadband needs. PCAST's proposal spurred the issuance of a Notice of Proposed Rulemaking (NPRM) [2] followed by rules by the Federal Communications Commission (FCC) proffering the 3550–3700 MHz, abbreviated as the 3.5 GHz band, for mobile broadband purposes. The 3.5 GHz band is used by Department of Defense (DoD) radar systems which are entitled to full protection for their operations within their deployed areas. Soon after, the NTIA led a measurement campaign indicating the under-utilization of the 3.5 GHz band by the incumbents; this study revealed the untapped potential of the aforementioned band to be shared with non-federal communications.

A successful spectrum sharing precludes any destructive interference amongst the incumbent and entrant. Concerning this, NTIA performed a link budget analysis to investigate the interference between radar and commercial systems [3] in the 3.5 GHz band and provided with exclusion zones in its 2010 Fast Track Report [4], extending until 557 km inland and covering 60% of the United States (US) population as depicted by the yellow line in Fig. 1 based on technical assumptions available at the time.

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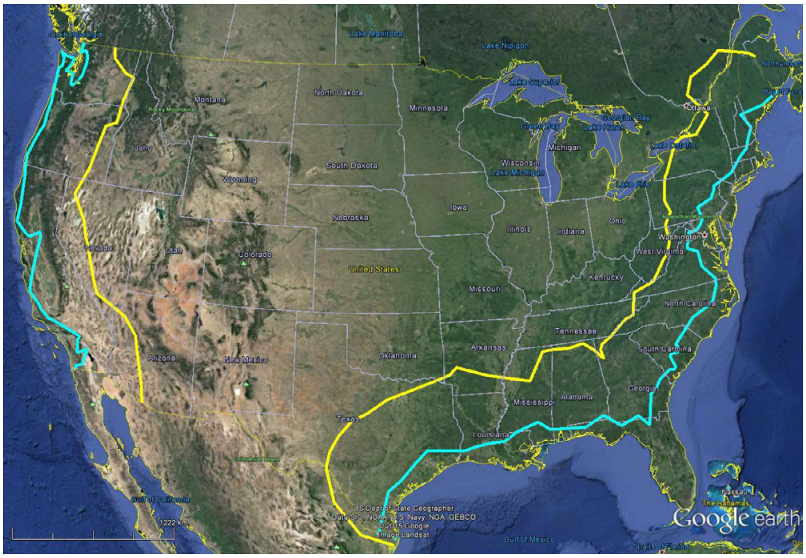

Fig. 1. NTIA simulations have proposed exclusion zones, Yellow Line—2010 Fast Track Exclusion Zones [4] and Blue Line—2015 Revised Exclusion Zones [5]. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

On March 24, 2015, NTIA filed a letter with the US spectrum regulator, FCC, recommending a framework that would reduce the geographic area of the zones by approximately 77% as depicted by the blue line in Fig. 1, based on new analysis of potential interference from commercial systems into incumbent radar systems which need to be protected. However, the reduced exclusion zones still translate into 40% of the US population being impacted.

Moreover, in its Report and Order [6] released on April 21, 2015, the FCC rightfully noted that NTIAs latest analysis effort to reduce the exclusion zones did not consider the potential interference impact to commercial systems from federal radar systems and encouraged commercial device and infrastructure manufacturers to study the issue and design equipment that overcomes or avoids harmful interference from federal radar systems. This paper presents such an analysis of interference from radar into commercial systems.

Because LTE is expected to be the prevalent cellular tech- nology in the 3.5 GHz band, we studied the effect of interference from Federal radar systems into LTE. We concentrated on the UL direction because uplink interference could disturb the base station (BS) receiver, leading to degradation of service of the sites entire service area while downlink interference which is interference to the User Equipment receiver could have more limited impact on the communication quality of the whole system. Also, we concentrated on the performance of Time Division Duplex (TDD) LTE Systems that are expected to be deployed in this band.

In the course of our investigation, we simulated macro cell, outdoor small cell, and indoor small cell LTE deployments at the system level and compliant to the 3rd Generation Partnership Project (3GPP) [7]. Furthermore, the radar system simulation includes rotation, antenna pattern, dwell time, and other technical parameters for radar data sheets. Moreover, free space path loss (FSPL) [8], and irregular terrain model (ITM) diffraction and troposcatter losses [9] are simulated using the parameters from the NTIA [4]. Our simulation results show that under the assumptions made in our study, LTE is very robust to radar interference even when LTE is experiencing extremely low signal-to-interference-plus-noise ratio (SINR) conditions. The current generation of military ship-borne radar operating in 3550–3650 MHz is used on only 17 ships deployed around the world. About 75% of this total are home-ported in Norfolk, VA, San Diego, CA, and Seattle, WA. Even if on exceptional occasions, multiple ship-borne radars are deployed near a given coastal area, it is unlikely that they will be using the same channels. Therefore, the probability of multiple radars around a given coastal location using the same channels as or adjacent channels to the LTE system is low. As such, it is reasonable to assume that the most likely scenario is that of one ship-borne radar interfering with the LTE system.

In the next section, we present the state-of-the art literature about the spectrum sharing between radar and mobile broadband systems.

2. Related work

In [4], NTIA investigated the interference between WiMAX and radar systems in the 3.5 GHz band by means of link budget analyses done on ecosystems containing radars on one side and WiMAX on the other side. The authors concluded that large geographic separations, reaching 577 km inland, between the two systems are required to allow for their operation. In [5], NTIA refined their analysis which led to a reduction of 77% of the exclusion zones but still hindered extending 3.5 GHz mobile broadband to the metropolitan areas in the US coastal areas. However, only a precise simulation of the involved technologies via simulating their protocol details can yield in relevant performance impact metrics due to interference between the systems. Next, Cotton et al. [10]