

## THE VULNERABILITY OF LASER WARNING SYSTEMS AGAINST GUIDED WEAPONS BASED ON LOW-POWER LASERS—PART I

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**Abstract.** Laser-assisted weapons, such as laser-guided bombs, laser-guided missiles and laser beamriding missiles pose a significant threat to military assets in the modern battlefield. Laser beamriding missiles are particularly hard to detect because they use low power lasers. They are even harder to defeat because current countermeasures are not designed to work against this threat [1]. The aim of this project is to examine the vulnerability of laser warning systems to guided weapons, to build an evaluation tool for laser warning receivers (LWRs) and seekers, and try to find suitable countermeasures for laser beamriding missiles that use low power lasers in their guidance systems. The project comes about because of the unexpected results obtained from extensive field trails carried out on various LWRs in the United Arab Emirates desert, where severe weather conditions may be experienced. In order to approach the subject, a computer model has been developed to enable the assessment of all phases of a laser warning receiver and missile seeker. MATLAB & SIMULINK software have been used to build the model. During this process experimentation and field trials have been carried out to verify the reliability of the model. This project enables both the evaluation and design of any generic laser warning receiver or missile seeker and specific systems if various parameters are known. Moreover, this model will be used as a guide to the development of reliable countermeasures for laser beamriding missiles. This paper (Part I of a four-part series of papers) outlines the theory required to construct a computer model for a laser beamriding missile engagement.

### NOMENCLATURE

- $P_{out}$ —output power of laser irradiator;
- $\tau_i$ —impulse length;
- $\theta$ —angle of divergence of laser irradiator;
- $\lambda_0$ —wavelength of irradiation;
- $a$ —diameter of transmitter aperture;
- $R$ —distance from irradiator to receiver;
- $P_{in}$ —power of laser irradiation on receiver input;
- $x$ —size of laser beam in receiving objective plane;
- $D$ —diameter of receiving aperture;
- $\ell$ —size of photodetector sensing area;
- $f$ —focal length of receiving objective;
- $\omega$ —field of view of receiver;
- $P_{thr}$ —threshold power;
- $k_{opt}$ —loss coefficient on optical elements;
- $T_{abs}$ —atmospheric absorption attenuation;
- $T_{sct}$ —atmospheric scattering attenuation;
- $B$ —bandwidth;
- $T$ —temperature;
- $\Delta\lambda$ —optical bandpass filter; and
- PD—photodetector.

### INTRODUCTION

The laser warning sensor engagement model introduced here is capable of simulating all aspects of a laser beamriding missile engagement and laser warning receiver scenario. It simulates all the factors that may affect the laser beam propagation through the atmosphere until it hits the target (missile seeker or LWR).

The model is designed to simulate the effect various weather conditions that may be faced by laser warning receivers and laser missile seekers in typical desert environments and is the first Laser Warning Sensor (LWS) model capable of simulating the weather conditions of United Arab Emirates (UAE) using Matlab & Simulink software and the LOWTRAN VII atmospheric computer code. Moreover, the model is designed to simulate the effects of any solar

interaction on the warning system and to generate the background clutter as might be expected of the UAE desert.

Finally, it demonstrates the capability of detecting weak optical signals at the maximum ranges of anti-tank missiles in the severe weather condition of the desert.

### BASIC METHODOLOGY

The model is written as a combination of Simulink blocks and Matlab code in a modular fashion. The basic methodology can be seen in Figures 1a and 1b, which depict the whole system from the laser source where the signal is generated, through to the receiver which represents the laser warning receiver and/or the laser missile seeker.

### LASER SENSOR FUNCTIONING MATHEMATICAL MODEL

Knowing the general picture of the laser sensor, we need to introduce the mathematical formulae that are the basis for the model and analysis. Figure 2 shows the functioning mathematical model of the laser sensor.

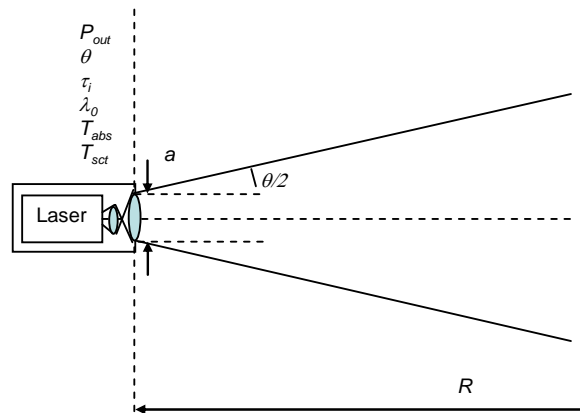


Figure 1a. Laser source.

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