ELECTRO-OPTICAL SYSTEMS ANALYSIS—PART 2

Mark A. Richardson[1]

Abstract. This paper is the second in a series of short tutorial articles loosely based on tutorial sessions given at the Royal Military College of Science to Masters of Science (MSc) students who are studying on defence technology courses. The purpose of the tutorials is to enable students to do first-pass (rough) calculations on various aspects of electro-optical systems. This type of analysis is typical of that which they may carry out in their potential future role as defence analysts. This second paper looks at calculating the power received at a detector from a target that may be considered to be either a point source or an extended source. Such calculations enable the estimation of, for example, the lock-on range of an infrared (IR) homing missile.

INTRODUCTION

In any theatre of conflict or potential conflict the shear number of infrared homing missiles available is quite bewildering. These missiles range in complexity and cost from the simple hot-spot trackers such as SA7 to the complex fully imaging systems such as IR Maverick or the Advanced Short Range Air to Air Missile (ASRAAM). The success of these missiles is also very impressive with IR missile systems accounting for approximately 55% of worldwide combat aircraft losses in the past 20 years. It is necessary in some instances, for example in defence analysis, to make rough calculations on the feasibility of the operation of such systems in various conditions with little or practically no data available on the systems to be used. In some circumstances the data may simply be a report that an IR missile was used against a particular target and a poor quality photograph of the alleged missile. Under these circumstances it is therefore appropriate to undertake a process of very low-fidelity modelling to enable a decision of the probability of successful utilisation. This paper looks at such a low-fidelity model for IR homing missile systems.

DETECTOR PROJECTED AREA

To calculate the lock-on range of an IR missile it is first necessary to ascertain if the target is a point source or an extended source. This is achieved by determining the *projected area* of the detector A_P in *object space* as depicted in Figure 1 where a and b are the dimensions of a single detector element in the IR missile seeker, f is the focal length of the seeker optics and R is the range to the target, and hence the projected area is derived as follows:

$$A_P = a' . b' = \frac{a . b . R^2}{f^2} \qquad (1)$$

The target is then considered to be a point source if the area of the target A_T is smaller than the projected area A_P (this is also known as a sub-pixel target) and conversely the target is considered to be an extended source if A_T is bigger than A_P.

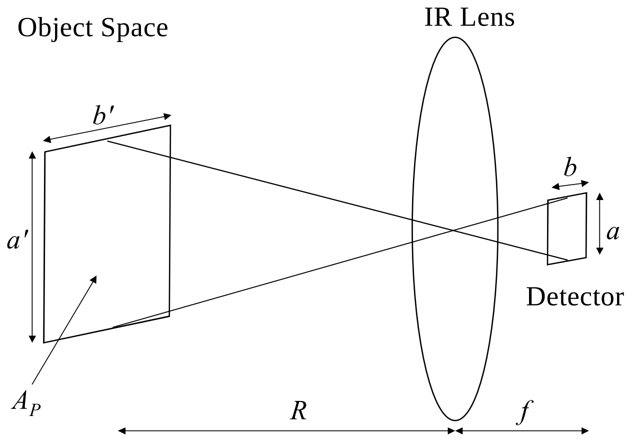

Figure 1. Projected area of the IR missile detector.

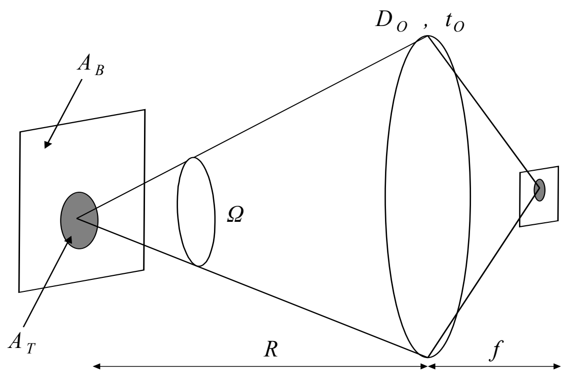

Figure 2. Point source geometry.

POINT SOURCE TARGET

When the target is present in the projected area the power that falls on the detector will consist of two components, one from the target itself and the other from the background, which is also present in the projected area. When the target is not present in the projected area the power on the detector will

[1] Head Electro-optics Group, School of Engineering and Applied Science, Cranfield University, Royal Military College of Science, Shrivenham, Swindon, WILTS SN6 8LA, United Kingdom.