

Aircraft Vulnerability Analysis by Modelling and Simulation

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Abstract

Infrared missiles pose a significant threat to civilian and military aviation. ManPADS missiles are especially dangerous in the hands of rogue and undisciplined forces. Yet, not all the launched missiles hit their targets; the miss being either attributable to misuse of the weapon or to missile performance restrictions. This paper analyses some of the factors affecting aircraft vulnerability and demonstrates a structured analysis of the risk and aircraft vulnerability problem. The aircraft-missile engagement is a complex series of events, many of which are only partially understood. Aircraft and missile designers focus on the optimal design and performance of their respective systems, often testing only in a limited set of scenarios. Most missiles react to the contrast intensity, but the variability of the background is rarely considered. Finally, the vulnerability of the aircraft depends jointly on the missile's performance and the doctrine governing the missile's launch. These factors are considered in a holistic investigation. The view direction, altitude, time of day, sun position, latitude/longitude and terrain determine the background against which the aircraft is observed. Especially high gradients in sky radiance occur around the sun and on the horizon. This paper considers uncluttered background scenes (uniform terrain and clear sky) and presents examples of background radiance at all view angles across a sphere around the sensor. A detailed geometrical and spatially distributed radiometric model is used to model the aircraft. This model provides the signature at all possible view angles across the sphere around the aircraft. The signature is determined in absolute terms (no background) and in contrast terms (with background). It is shown that the background significantly affects the contrast signature as observed by the missile sensor. A simplified missile model is constructed by defining the thrust and mass profiles, maximum seeker tracking rate, maximum guidance acceleration and seeker sensitivity. For the purpose of this investigation the aircraft is equipped with conventional pyrotechnic decoy flares and the missile has no counter-countermeasure means (security restrictions on open publication). This complete simulation is used to calculate the missile miss distance, when the missile is launched from different locations around the aircraft. The miss distance data is then graphically presented showing miss distance (aircraft vulnerability) as a function of launch direction and range. The aircraft vulnerability graph accounts for aircraft and missile characteristics, but does not account for missile deployment doctrine. A Bayesian network is constructed to fuse the

doctrinal rules with the aircraft vulnerability data. The Bayesian network now provides the capability to evaluate the combined risk of missile launch and aircraft vulnerability. It is shown in this paper that it is indeed possible to predict the aircraft vulnerability to missile attack in a comprehensive modelling and a holistic process. By using the appropriate real-world models, this approach is used to evaluate the effectiveness of specific countermeasure techniques against specific missile threats. The use of a Bayesian network provides the means to fuse simulated performance data with more abstract doctrinal rules to provide a realistic assessment of the aircraft vulnerability.

Keywords: aircraft vulnerability, infrared simulation, missile-aircraft engagement, missile threat, Bayesian network

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