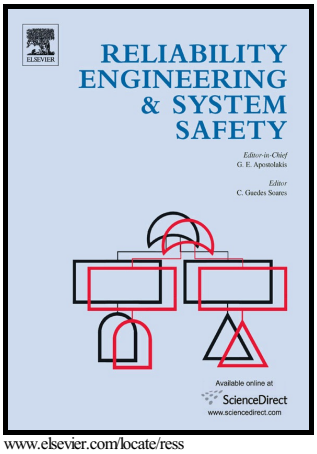
Modeling Cumulative Defensive Resource Allocation Against A Strategic Attacker In A Multi-period Multi-target Sequential Game

Xiaojun Shan



www.elsevier.com/locate/ress

PII: S0951-8320(17)30342-3
DOI: http://dx.doi.org/10.1016/j.ress.2017.03.022
Reference: RESS5782

To appear in: *Reliability Engineering and System Safety*

Received date: 29 November 2015
Revised date: 13 February 2017
Accepted date: 20 March 2017

Cite this article as: Xiaojun Shan, Modeling Cumulative Defensive Resourc Allocation Against A Strategic Attacker In A Multi-period Multi-target Sequential Game, *Reliability Engineering and System Safety* http://dx.doi.org/10.1016/j.ress.2017.03.022

Modeling Cumulative Defensive Resource Allocation Against A Strategic Attacker In A Multi-period Multi-target Sequential Game

Abstract

This paper fills a literature gap by investigating the strategic interactions between an attacker and a defender with a multi-period multi-target game. At each period, the defender allocates a limited amount of defensive resources over multiple targets, and the attacker assigns some attack probabilities to those targets. We consider four scenarios where the defender could be either myopic or long-sighted, and the defense could be carried over to future periods or not. Our analyses characterize the defender's optimal allocations in these four scenarios and develop an algorithm to identify the optimal allocations. We find that increases in defense carryover could lead to less allocation to defended targets from the second period at equilibrium, and lead to defending more targets. To gather empirical evidence regarding one key function of the model - success probability of attack, we conduct statistical analysis based on datasets from Global Terrorism Database, which is provided by National Consortium for the Study of Terrorism and Responses to Terrorism (START) and the Urban Area Security Initiative (UASI) grant allocations from FY 2004 to FY 2012. We conclude that in general, effects of defense resources on reducing success probability of attack are mixed due to scarcity of terrorism data.

1 Introduction

In order to enhance national security, the annual budget requests for the U. S. Department of Homeland Security (DHS) has increased from $22.1 billion in the year of 2002 to $65 billion in the year of 2016 (Figure 1). Although hundreds of billions of dollars are at the DHS's disposal, they are limited considering the large number of potential targets to be defended. Moreover, in light of continuous defense grant allocations from the federal government for multiple years, how to efficiently allocate limited defensive resources over the years becomes a significant challenge.

Dresher (1961) was among the first to apply game-theoretic analysis to military conflicts. Recently, homeland security arises as an important and urgent issue demanding significant research efforts. Game theory has been widely applied in risk analysis for homeland security (see Sandler and Siqueira (2009) for a survey of research on game theory and counter-terrorism). Defending multiple targets within a single-period game-theoretic model has been studied in the literature