Chapter 7
Attrition Models and Applications

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ABSTRACT

Frederick W. Lanchester proposed simple ordinary differential equations that plainly model the attrition of fighting forces in a battlefield. With this insight, researchers studied extensions of these equations to model various battles for years. Novel studies include the application of these equations to miscellaneous field apart from battles that comprise reciprocal contention of opponents. If well-defined, these models can assist decision makers in revealing the shortcomings of a war strategy and discovering the bottlenecks that should be optimized. The recent studies prove that the insights gained from these models can also be utilized in other fields such as economy, biology, engineering, etc. This chapter includes the classic Lanchester equations, significant extensions of classical models, and a number of important application examples.

INTRODUCTION

During the planning and execution phases of a war, decision makers are mostly concentrated on achieving the victory. Obviously, winning a battle may not be simply based on the amount of friendly or enemy forces. Many parameters, such as morale, maneuver, C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) capability, weapon technology, crew training level etc. have significant effect on trajectory of the battle states. Even in today's world, defense industries intensified their work on game-changing technologies. Stealth technologies avoid detection of fighting units. A laser gun becomes a source of a continuous destruction. Unmanned vehicles are

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expendable units that may accomplish critical tasks like detecting a key enemy unit or destruction of a critical facility. Therefore, the fusion of these parameters complicates the simple modeling process of a war. To overcome this challenge, a number of high-level mathematical models have been developed and those models are stochastically solved by simulation softwares.

The state of a victory is mostly correlated with the number of remaining friendly and enemy forces and their potential capabilities. Since WWI, researchers and military authorities tried to build simple models to observe the fluctuation of fighting forces. This descriptive information involved the crucial interpretation of the course of the action. The most commonly acknowledged models are proposed by Frederick W. Lanchester during WWI. He proposed ordinary differential equations that simulate the flow the war deterministically and/or stochastically until a defined end state. These models are concentrated on the loss of force and have a large set of assumptions to keep the models easy. Hence, a complete war may be easily simulated with any spreadsheet.

This chapter will include preliminary information on the attrition models that explain a war holistically with differential equations and their extensions that are proposed by researchers in course of time. In addition to land operations, these models may also be applied to naval and air operations. Some important examples of attrition model applications include the Battle of Britain and the Battle of Atlantic. Even in recent studies, the equations developed for attrition models are applied to any competitive field such as market share, public goods game, manufacturing strategies, etc. The aim of the chapter is to provide insight for attrition models, describe the origin and the idea behind models, exemplify the types of the models and refer to substantial studies and applications.

BACKGROUND

A war (or a combat) may be modeled for various purposes. Regardless of its purpose, a combat model is expected to produce the required output to decision-makers to assist them in analyzing the performance of both sides of the war. Tactical warfare models can be grouped under three category as follows (Bonder, 1981):

- War Games
- Simulations
- Analytical Models

Each category possesses its own pros and cons in dimensions of realism, simplicity, accessibility etc. War games are common frameworks for a broad class of applications that encapsulate the games that progress upon the decisions of the opposing decision-makers. The decision-makers conclude their decisions according to the information that is derived from the domain of the game. War games are played for centuries even only for relaxation (Shephard,1963). Chess is a valuable worldwide example. However, war gaming services especially to military tacticians for boosting their capability to achieve crucial decisions, analyze their tactics, practice the war environment etc. Kriegsspiel is a tangible domain for war games that is developed and heavily practiced in 18^{th} and 19^{th} centuries. With the aid of computers, complex war games may be played through smart systems. Simulations are realistic runs of human reasoning and behavior by actions of automated and/or semi-automated forces (Ilachinski, 2004). They provide a collective output of reactions provided by consistently partitioned event or agents.

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