TACTICAL AIR WAR: A SIMSCRIPT MODEL

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ABSTRACT

Missile systems must acquire and intercept high performance aircraft over wide ranges of velocity, altitude and angle of attack. This paper puts forward a SIMSCRIPT simulation model for an aircraft and SAM (surface to air missile) encounter. Since SAM locks onto its target, aircraft evasive actions such as Electronic Counter Measures (ECM), and aerobatic maneuvers may not be effective; however an aircraft may evade destruction by exhausting the missile's fuel supply. It is demonstrated by the simulation that as aircraft speed increases, the mean kill time is increased and the number of aircraft which escape also increases. Aircraft treated here may conform to the specifications of SR-71 Black Bird and F-14A Fighter.

INTRODUCTION

An important and persistent family of applications in simulation modeling and game theory involves air defense problems. A general statement given by Dresher is: (1) the tactical air war campaign consists of a series of strikes, each of which consists of simultaneous couter air, air defense and ground support operations by each side undertaken to accomplish a given mission, (2) like most battle situations, the attacker seeks the greatest possible gains in the form of the destruction of targets, and the defender wishes to make these gains as small as possible, (3) an important decision of the defender in a battle situation is the distribution of his total defense resources among his targets. The attacker's decision is the distribution of his total attacking force among those targets.

Other air war problems are concerned with the selection and attacking of a target from a set of possible targets, or more generally with the problem of how to distribute one's available resources between a number of possible targets. The enemy will also have resources to deploy in defense of these missiles and the effectiveness of one's attack will depend partly on chance, partly on the way one's forces are distributed between various possible targets, and partly on enemy deployment (3,4).

The performance of missile systems can be determined by actual flight tests, laboratory tests, and computer simulations. Flight tests examine the entire missile system and are characterized by a set of flight conditions such as speed, range, altitude, type of target, environmental factors, and type of maneuvers (6-10). Laboratory tests examine and determine the performance characteristics of missile systems hardware. Computer simulations, however, can integrate the laboratory and flight test, and provide data on missile performance at an economical cost.

Many simulations languages, techniques and models have been developed in recent years. However, the simulation language best suited for a particular simulation study depends upon the characteristic of the system and upon the programming skill of the individual conducting the study. As a general rule, an increase in the flexibility of a simulation program is obtained at the cost of requiring more understanding of programming techniques. Similarly reductions in programming time achieved through the use of simulation languages are associated with increases in computer running times and computer costs. The decision whether to use a particular simulation language may be influenced by the following, 1. characteristics of the problem, 2. availability of computer hardware, 3. availability of programmer knowledge in particular computer languages, 4. cost of programming, and 5. cost of computer time (5). The language used here is SIMSCRIPT.

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SIMSCRIPT is a statement-level, event-oriented simulation language. The static structure of SIMSCRIPT is described by permanent entities, their attributes and membership in sets; while the dynamic structure is modeled by events which are changes of state which may take place simultaneously at discrete points in simulated time, and are initiated by the execution of event routines. Simulated time is controlled by the self generated main routine which schedules events by means of a set of temporary entities called event notices. Each activity is represented by two events which specify its start and finish.

THE MODEL

The three dimensional trajectory is designed with the aircraft having an (x, y, z) co-ordinate axis with the SAM co-ordinates of (0, 0, 0) at all times. The initial co-ordinates of the aircraft are randomly generated. If these generated numbers are not within the SAM's range, a missile will not be launched and a new set of random co-ordinates will be generated. When an aircraft enters the missile range, a probability of launch and kill is determined, where this probability is a function of the ratio of the missile to aircraft range to the missiles range. If a missile is launched, a chase event is scheduled and data related to aircraft speed, and distance traveled by missile are computed every second. Once a chase is initiated, the aircraft maintains it's altitude and y coordinate while moving away in the x direction at constant velocity. If SAM has exhausted its fuel or if aircraft has been destroyed, a new case is scheduled and a new search for another aircraft begins. The time is then reset to a start status. The model variables are:

1 - Aircraft x - co-ordinate - search
2 - Aircraft y - co-ordinate - search
3 - Aircraft z - co-ordinate - search
4 - Aircraft x - co-ordinate - chase
5 - Aircraft y - co-ordinate - chase
6 - Aircraft z - co-ordinate - chase
7 - Aircraft - missile range - search
8 - Aircraft - missile range - chase
9 - Missile probability of kill
10 - Maximum aircraft contact range
11 - Minimum aircraft contact range
12 - Maximum aircraft altitude
13 - Minimum aircraft altitude
14 - Aircraft velocity
15 - Missile velocity
16 - Aircraft-missile range of kill
17 - Missile range
18 - Total distance traveled by missile

SIMULATION PROCEDURE

Parameters of the aircraft used in this simulation are similar to those of the Black Bird SR-71 or F-14A fighter. The aircraft speed was varied between Mach 0.5 (545 ft/sec.) to Mach 3.5 (3815 ft./sec.) while the missile speed was kept constant. 150 simulation runs were carried out for each case. Various missile speeds were also simulated with ranges from Mach 1.5 to Mach 3.5. Table 1 shows the results of aircraft-missile encounter at various speeds and gives the number of simulated cases, number of aircraft chased, number of aircraft killed, number of aircraft escaped, the mean kill time and standard error of kill time. Fig. 1 shows the results of aircraft-missile encounter at constant missile speed of Mach 2 and various aircraft speeds (Mach 0.5 to Mach 3.5), and Fig. 2 shows 95% confidence interval for mean kill time at missile speed of Mach 2 and various aircraft speeds (Mach 0.5 to Mach 3.5).

CONCLUSION

The F-14 is a high performance fighter possessing the world's most advanced weapons systems (AWG-9 Phoenix and side winder). The F-14 can launch six missiles simultaneously from over 100 miles away, at six separate targets and still monitor 24 more. Its speed ranges from Mach 0.5 to Mach 3.5 at altitudes of 100,000 feet (2). The SR-71 Black Bird travels at more than triple the speed of sound at altitudes of 100,000 feet or more. The range of SAM is about 25 to 30 miles.

The number of cases generated are 150 for a given aircraft and missile speed. Since the missile locks onto the target, aircraft evasive actions such as Electronic Counter Measures (ECM), aerobatic maneuvers, etc. were not included in the model. It can be seen that as aircraft speed increases the mean kill time is increased and the number of escaped aircraft is also increased. This is the basis for developing very fast aircraft for intelligence purposes such as the SR-71 Black Bird.

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