"COST-EFFECTIVENESS ANALYSIS OF CERTAIN AIR TO SURFACE MISSILE SYSTEMS"

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This paper treats the problem of attrition of U. S. aircraft in Southeast Asia (SEA). This attrition is due to the extremely heavy concentration of enemy AAA fire from conventional tube-artillery as well as more modern surface to air missile systems (SAM's). Tactical targets in SEA are often defended by such combinations of these weapons as to create what has been described by several observers as the most intense, well coordinated, and sophisticated air defense network ever assembled in the history of modern warfare. The severity of this environment, when coupled to the very expensive aircraft and weapons currently in use, tend to produce very inefficient systems when measured from a cost-effectiveness standpoint.

Several methods of countering the threat of enemy AAA activity are possible, one of which is to neutralize the personnel associated with these AAA sites rather than the equipment itself. Neutralization, it should be pointed out, does not necessarily involve killing people. One such system involves the use of an air-launched tactical missile which will deliver a warhead to the general area of the target, as shown in Figures 1 and 2. The missile warhead will then detonate at a pre-determined altitude where the ordnance is dispersed over a sufficiently large area to cover all elements of the target. After successful delivery of the missile, the pilot of the aircraft which launched the missile returns to his base. Using this technique, targets such as antiaircraft guns and vulnerable SAM sites may be rendered ineffective for a sufficiently long period of time to permit the main strike force to proceed to the now undefended primary target area, unopposed by AAA deterrents. The success of such an endeavor is, of course, dependent upon such parameters as type of warhead used, range at which the missile is launched, the accuracy of the guidance system (if any), the skill of the pilot, and many other variables. The cost of such a system is determined by the unit cost of the missile, operational and maintenance costs of the aircraft and pilot, design and development costs incurred in placing the missile system in the inventory, replacement costs of the aircraft and pilots which are preempted by the defending AAA sites, and other costs.

When the total costs are coupled to the expected performance of the system, measures of cost-effectiveness may be generated which may take the form of:

(a) kills per dollar
(b) costs per N missions
(c) sites killed per M missiles

and many others.

The significant feature of the problem is that events are occurring simultaneously; several aircraft are delivering missiles against many AAA sites which are at the same time firing at the attacking aircraft. This dual or war game is very difficult to analyze from a deterministic viewpoint, particularly if sensitivities to the various parameters are required. The relative cost-effectiveness of many candidate systems is best determined through the use of discrete digital simulation. Of the several special purpose simulation languages available, we chose GPSS-360 to solve this problem.

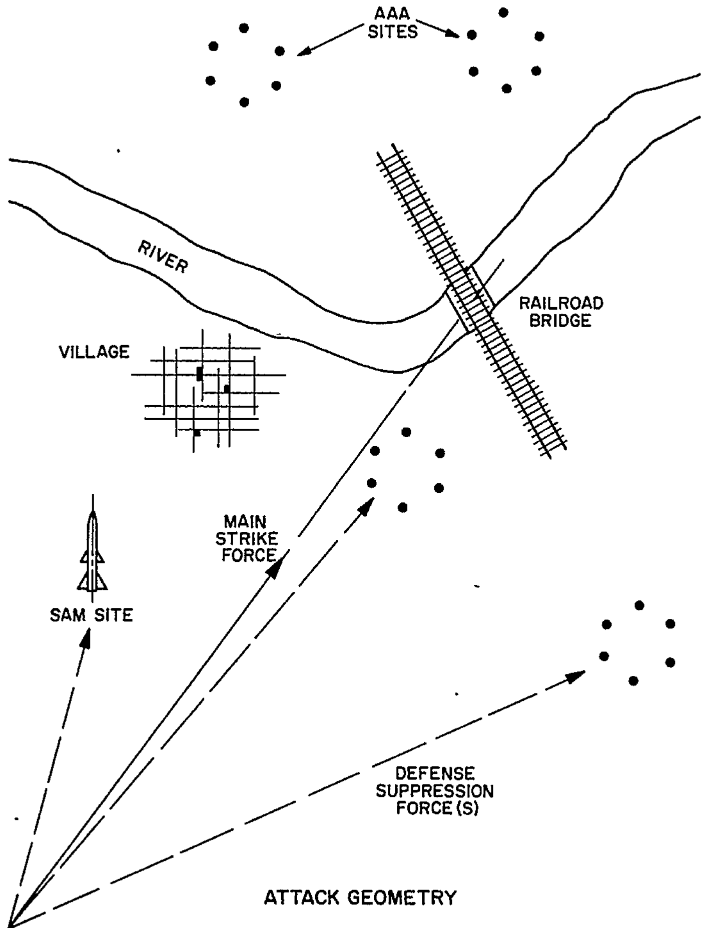
The targets for this problem consisted of groups of AAA guns ranging from medium to heavy calibers, as well as several SAM sites. Two flights of flak suppression aircraft were provided as the offensive force, and each side was presented with a set of "operating ground rules," which took the form of constraints such as gun reaction time, aircraft stabilization time, definitions of what constituted a kill, basic loads for the SAM sites, and so on. The simulation or game began at the time that the lead aircraft detected the target area and was over when any of the following conditions were met:

1. All aircraft are either killed or have have successfully escaped the effective envelopes of the nearest gun or SAM, or

2. All guns at all sites are out and SAM's are ineffective of action, or

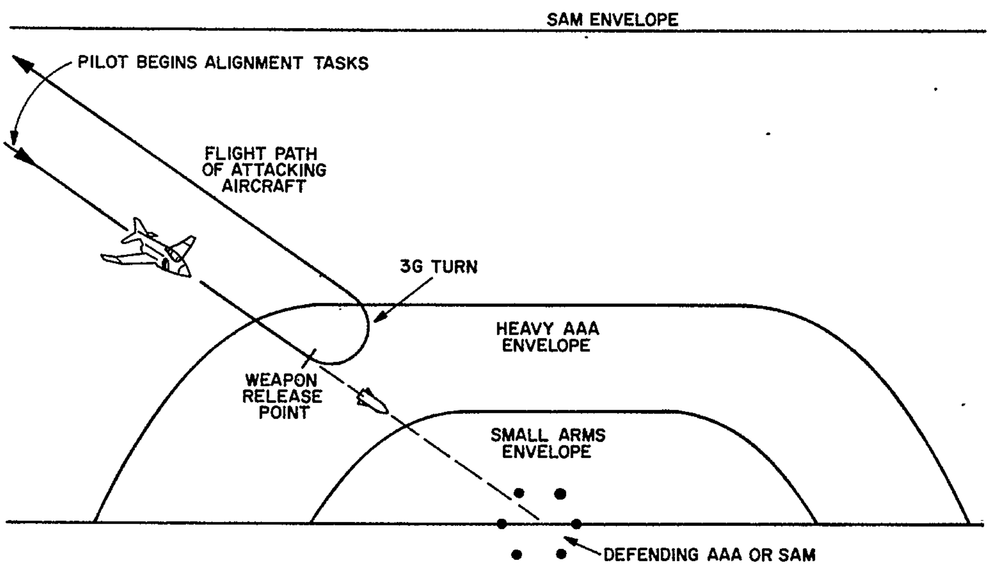
3. All guns are out of range and SAM's are out of missiles.

Several special problems arose during the course of the simulation. The first and most serious was the abnormally long run times required on the IBM 360-50. This was due to the inherent inability of GPSS to do extensive computations. The equations describing the path of the aircraft in the turn and the missile after launch required trigonometric functions and non-integer exponentation, both of which are not included in the GPSS-360 version. The inability to use continuation cards and the dependence on graphic inputs caused the computational aspects of the simulation to take on mammoth proportions. Nevertheless, several candidate systems were successfully evaluated and significantly different measures of cost-effectiveness were calculated, thereby enabling us to determine which of the potential systems was most worthy of additional time and money for further study.



ATTACK GEOMETRY

Fig. 1



DELIVERY PROFILE

Fig. 2