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Computer-Assisted Planning for Low-Intensity Conflict at Strategic National Facilities

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COMPUTER-ASSISTED PLANNING FOR LOW-INTENSITY CONFLICT AT STRATEGIC NATIONAL FACILITIES

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ABSTRACT

This report assesses the feasibility of using computer simulation methodologies to improve the planning and execution of defense at strategic national facilities. The influences of event timing, force level, insider help, passive-vs-active security, invader air support, and defender air defense are among the factors that are explored and quantified in terms of the likelihood of overall defense success.

1. INTRODUCTION

Computer-assisted analytical techniques, sometimes termed operations research or systems analysis, are being developed worldwide to aid military authorities in preparing and implementing optimum courses of action for countering armed enemy forces. Depending upon the scale of action, the tools address conflict at appropriate levels of resolution from broad, full-blown theater combat to detailed, low-intensity limited engagement in areas as small as one or two buildings. Simulation methodologies track and clarify the sequencing of events in an action scenario and calculate casualties and consumption of materiel. The tools may thus assist in planning the strategy, tactics, logistics, and timing of offensive and defensive actions and provide for systematic evaluation and comparison of alternative courses of action, with quantitative measures of effectiveness. Setting up a particular computerized scenario may assist planners in thinking through all aspects of an operation and may be a useful part of commander and troop training. The financial and human casualty costs of alternatives may be included.

2. APPLICATION AT STRATEGIC NATIONAL FACILITIES

These methodologies may be useful in planning the protection of defended national installations. An important difference in application, compared with typical military simulations, is the smaller scale of combat operations. Other notable differences may exist. Potential areas of application include

1. Rapid, interactive, force-on-force evaluation of alternative strategies for dealing with a contingency situation, prior to or possibly during the event.

2. Financial cost-vs-benefit analysis of alternative strategies.

3. Sensitivity analysis of the relative importance of factors that affect a contingency study. The procedure varies each of the parameters on which outcome depends and provides quantification of the relative importance of each. Such an analysis may identify those factors most important to lowering costs or increasing benefits.

4. The reliability of the outcome predicted by contingency analysis is a function of the uncertainties in the data used. Uncertainties may exist, for example, in the size of a force attacking a facility, in the type or effectiveness of its weapons and in its skills in using them, in the timing of the attack, and in the readiness and capability of defending units. These uncertainties may be input to the analysis in the form of parameter range probability distributions. The simulation then performs a stochastic (Monte Carlo) analysis of the contingency and provides a quantitative description of the uncertainty of the outcome. Such an analysis may aid in placing confidence bounds on an expected outcome.

An important aspect of these methodologies is that they are not computer run-time intensive. Once the basic data have been prepared and input, a run typically takes one analyst less than 5 min. Thus, many alternative courses of action and variations of parameters may be explored in a short period of time. A detailed description of the methodologies is provided in ref. 1.

3. DEMONSTRATION MODEL

To assist in the initial assessment of the applicability of these methods to conflict at strategic facilities, a simulation model was developed that incorporates many of the important aspects of security that are treated by planners. These include, for both sides of the conflict, the size and structure of forces; the types and capabilities of weapons, transportation vehicles, and other materiel; the layout of the site; land and air routes; route speeds; barriers and methods of thwarting them; targets of (enemy) action; and several types of command options that may be exercised at various stages of conflict. The demonstration is based upon generic, unclassified information and invented data and does not purport to reflect security factors at any actual site.

3.1 CONTINGENCY FACTORS CONSIDERED

Potentially important factors to be investigated for both sides of an engagement fall into the following categories:

A. Combat manpower and weapons

Number and size of units
Composition of units
Quantity of weapons carried and delivered
Strength and effectiveness of weapons for purpose

B. Event timing

Relative location of units
Detection of units
Route selection for maneuver
Travel rates on route segments
Delays
Tactics

3.2 CONTINGENCY ANALYSIS

The simulation treats a generic installation with invading (Red) and defending (Blue) forces. The analysis first postulates a reference scenario with nominal values for system parameters. Then five series of cases vary important parameters of the reference case to determine their impact on contingency outcome and hence to identify possibly better defense strategies for the Blue forces. Case series A will examine a spectrum of temporal factors that control the timing and sequencing of events and lead to a particular conclusion, factors such as Blue mobilization time and delays introduced by Red interdiction of facility transportation routes. Case series B will examine the impact of insider help on the mission. Series C examines the effects of differing levels of dedicated security at the target building entrance and at the target itself. Series D and E examine the impact of the presence vs absence of various levels of air support for the Red mission.

3.2.1 Reference Case

Figure 1 is a black-and-white rendering of the multicolor interactive computer terminal screen on which the analysis is performed. The screen consists of three basic areas. The FIELD OF BATTLE window consists of a background map of the site and an overlay that highlights important features such as roads, buildings and tactical units. The optimum map usually is an aerial photograph or equivalent; in the demonstration case, a simple atlas map is used. The facility site is the clear central area with a bold outline. Several buildings are outlined; the target building is labeled V1. Transportation links are shown as dashed lines. Significant points in the transportation network are marked by node numbers: node 17 is a road barricade, node 19 is at the perimeter fence where Red penetration occurs, node 20 is the target building entrance, and node 21 is at the target. A bar over a node indicates an inherent delay at that node. In the black-and-white rendering, Red flags are distinguished by small triangles; other flags are Blue units. Numbers within the flags are the unit numbers, and letters indicate unit posture: A is attack, D is defend. A bar under a flag indicates a ground unit; a bar over a flag indicates an air unit. The site's manned (or intermittently manned) observation towers are shown in Fig. 2 by outlines, cross-hatching, and larger numbers. These symbols are not included in the other figures for visual clarity. The screen has enlargement capability; Fig. 3 is a blowup of the target building and vicinity.

The second major section of the screen is the BATTLE PROGRESS window on the right side. Here, unit status is displayed. Bar graphs will continuously show the attrition of forces, as combat occurs, in terms of casualties of each type of weapon in each unit as a percentage of the starting values. The display can show ammunition losses as well. The upper portion of the window reports the Blue status, and the lower half reports the Red status.

Finally, the bottom section of the screen, marked C3I, is the user interface and provides numerous options (not shown) for manipulating and analyzing a scenario. This section also contains the battle clock, registering minutes (MN).

The reference scenario is as follows. In a surprise attack, the three small Red squads in Fig. 1 intend to remove the target at node 21. The five Blue units attempt to thwart removal. The structure of these units is summarized in Table 1. Blue 1 and 2 are armored squads, each consisting of five men with automatic M16 rifles, one man with an M79 grenade gun and high-explosive (HE) grenades, and a V150 armored vehicle with a driver and a gunner for the 20-mm cannon. Blue 3 and 4 are motorized infantry squads, each consisting of five men with rifles and two men with grenade guns. Blue 5 is a single guard with an M16 rifle.

Red 1 is an infantry unit consisting of two men with automatic AK47 rifles, one man with an RPG7 antitank weapon with rockets, and one man with napalm bombs for interdiction. Red 2 is an infantry unit of three men with AK47s and one with an RPG7. Red 3 is an air support unit consisting of a light, noncombat helicopter to transport the target off-site; the pilot is armed with an AK47.

In the model, weapon effectiveness and the resulting attrition of forces are determined using generalized heterogeneous Lanchester methodology,[2] with options for area or point fire weapons and variable timestep. Four key process parameters are input:

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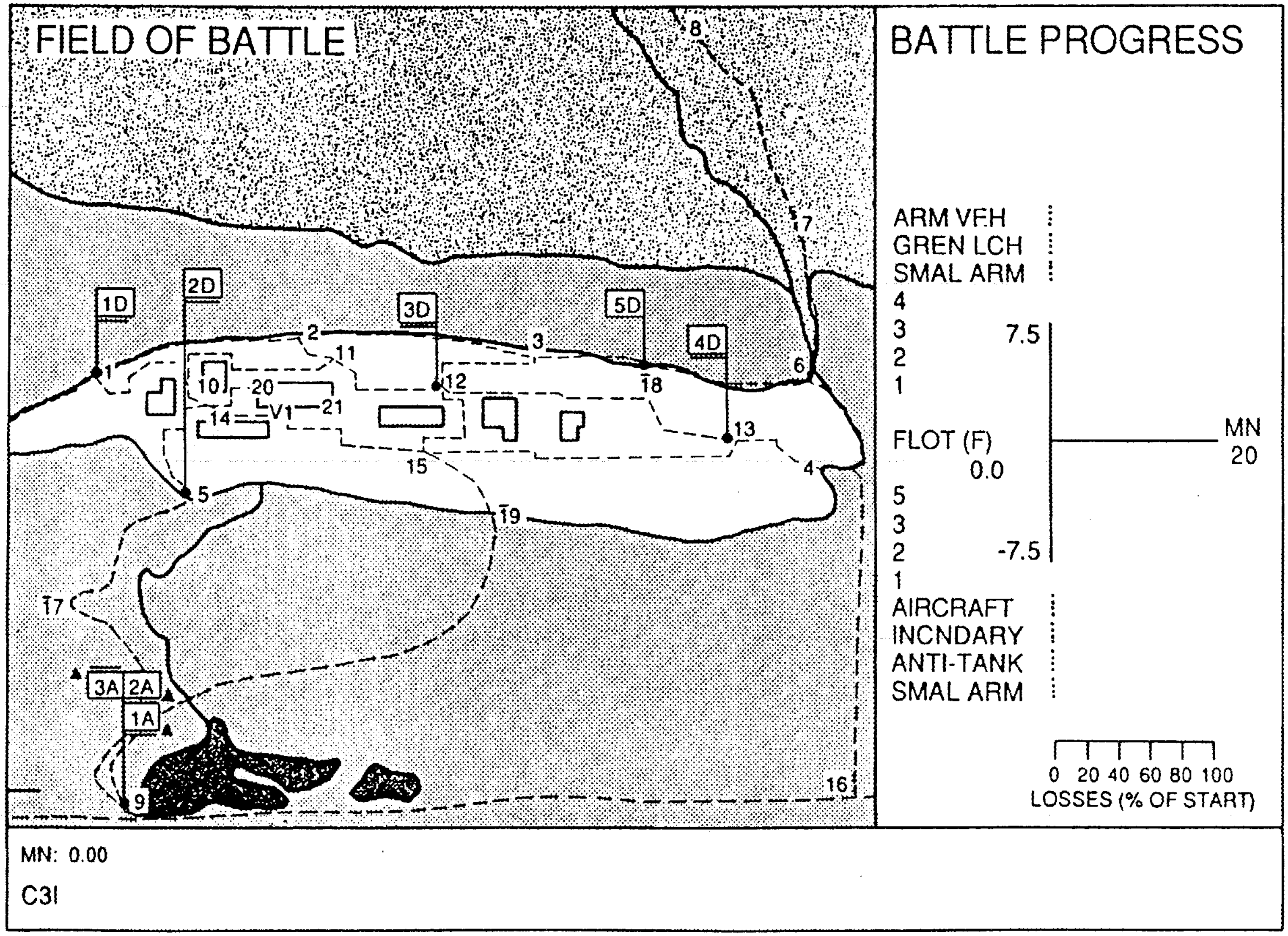

Fig. 1. Interactive terminal display for contingency analysis.

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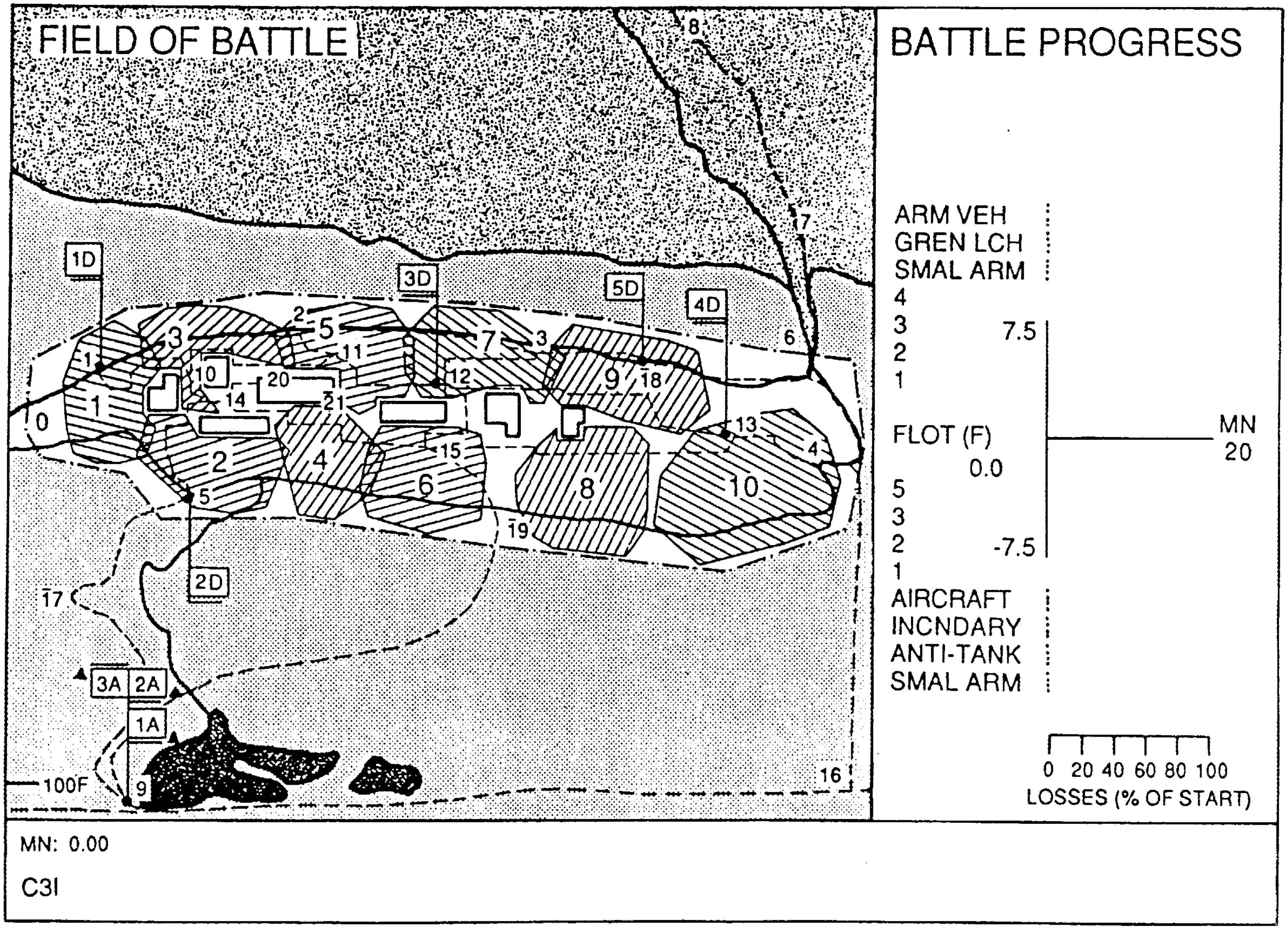

Fig. 2. Display of site observation towers.

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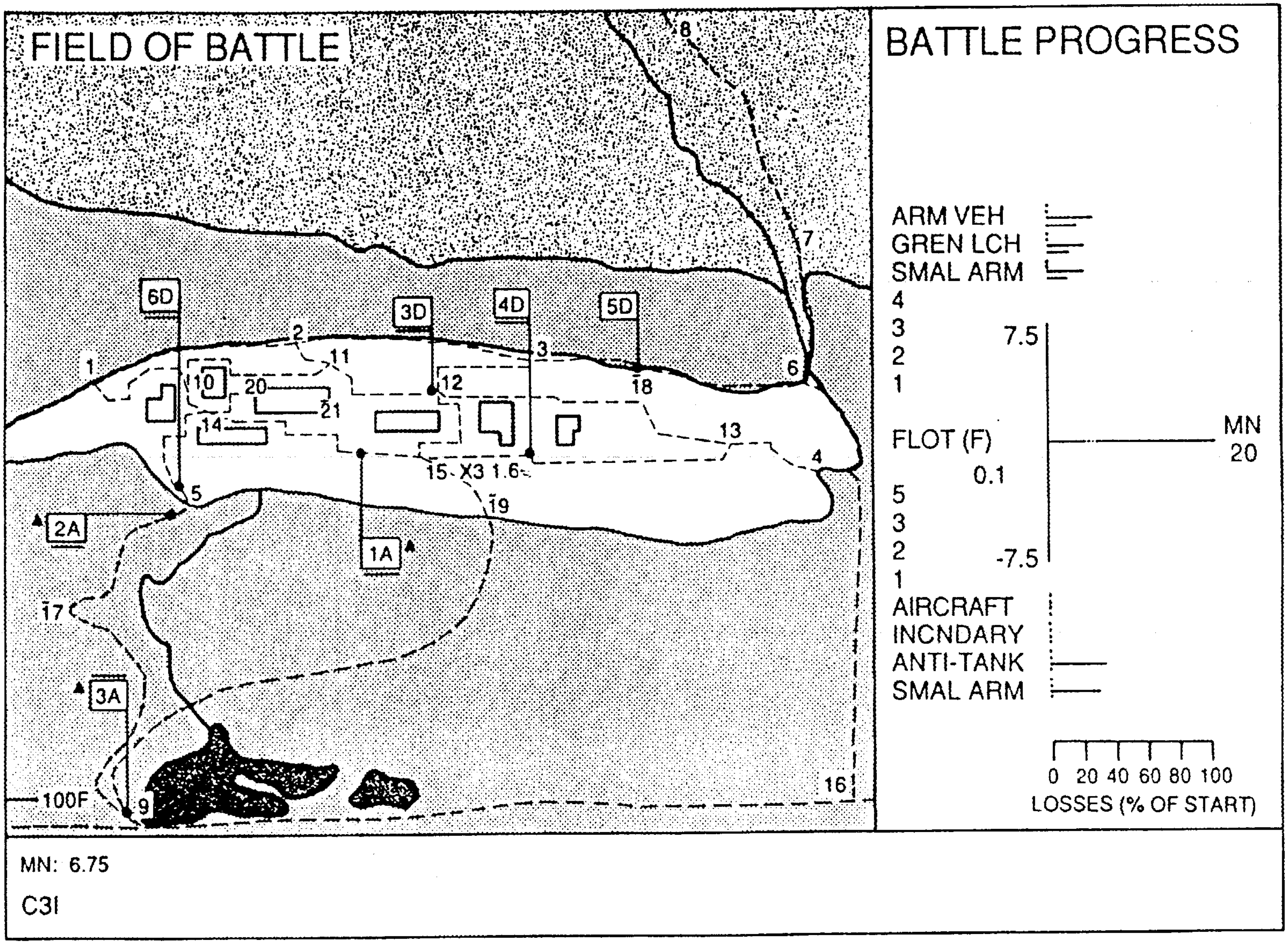

Fig. 3. Enlargement of target building and surroundings. Red 1 acquiring target at node 21 while Blue 3 and 4 are delayed by interdiction at node 14.

Table 1. Size and composition of Blue and Red units

Unit	Weapon	Quantity	Ammunition	Quantity
Blue 1	M16 rifle	5	Standard	1500
& Blue 2	M79 grenade launcher	1	HE grenades	6
	V150 armored vehicle	1	20-mm cannon fire	400
Blue 3	M16 rifle	5	Standard	1500
& Blue 4	M79 grenade launcher	2	HE grenades	6
Blue 5	M16 rifle	1	Standard	600
Red 1	AK47 rifle	2	Standard	400
	RPG7 antitank	1	Rocket	3
	Incendiary	1	Napalm bomb	6
Red 2	AK47 rifle	3	Standard	600
	RPG7 antitank	1	Rocket	3
Red 3	Light helicopter	1	AK47 rifle fire	400

the rate d_{ij} at which a weapon (operator) of type i detects opposing weapons of type j, the volume of fire per detection f_{ij}, the hit probability per fire h_{ij}, and the level of destruction per hit m_{ij}. The parameters represent average values under expected combat conditions. Rate of detection is per minute when opposing forces are in proximity (i.e., within combat range). Reference values are listed in Tables 2 and 3.

Blue units are initially stationed at nodes 1, 5, 12, 13, and 18 (Fig. 1). All Red units deploy from a staging area at node 9. Red squad 1 (Red 1) plans to secretly penetrate the fenced facility at node 19 (out of view of towers), while Red 2 creates a diversion by engaging Blue 2 at node 5 and luring in Blue 1. Red 2's scheduled route is by road from the staging area at node 9 to node 17 and then to node 5 on two-wheeled motorized vehicles that can be maneuvered around the in-road barricade at node 17. The Red mission is postulated to occur after midnight when the barricade is routinely erected; hence a 1-min delay of Red 2 at node 17 occurs.

Red 1's scheduled route is on foot from node 9 across open fields to the facility fence at node 19, where a 1-min penetration delay occurs. It is assumed that tower 6 detects Red 1 immediately upon its entrance into the observation range.

After passing the fence, Red 1 goes cross-country to the road junction at node 15 by road through junction 14, to the target building entrance at node 20, and through the building to the target at the opposite end at node 21. After taking the target, Red 1 egresses to the entrance where Red 3 (a light helicopter) rendezvouses at a prescheduled time, receives the target, and exits. Blue has no tactical air defense except rifle fire. Red 1 will sacrifice itself (die or be captured) in the operation.

Standard rates of movement on transportation links are shown in Table 4, together with factors that modify these values for a particular unit that may move slower or faster on a link. In particular, invading Red 1 is assumed to be on foot within the facility and

Table 2. Weapon effectiveness and attrition parameters for Blue assault of Red

	AK47 rifle	RPG7 antitank	Incendiary	Light helicopter
		Blue rate of detection of Red		
M16 rifle	0.5	0.5	0.5	0.8
M79 grenade launcher	0.5	0.5	0.5	0.8
V150 armored vehicle	0.25	0.25	0.25	0.4
		Blue volume of fire at Red per detection		
M16 rifle	15	15	15	15
M79 grenade launcher	2	2	2	
V150 armored vehicle	6	8	6	
		Blue probability of hit Red per fire		
M16 rifle	0.002	0.002	0.002	0.0005
M79 grenade launcher	0.006	0.006	0.006	
V150 armored vehicle	0.01	0.01	0.01	
		Blue quantity of Red kill per hit		
M16 rifle	1	1	1	1
M79 grenade launcher	2	2	2	
V150 armored vehicle	1	1	1	

hence travels at only 0.2 times the nominal 30-mph (vehicular) speed on the intrasite roads between nodes 15 and 14 and between nodes 14 and 20.

Red 1 is equipped with napalm bombs to temporarily interdict the site's road network with open flame at strategic points and delay Blue units. The length of delay created is a programmed function of the topography at the interdiction point and the quantity of ordnance (napalm) expended on it. The algorithm postulates increasing delay with increasing ordnance up to a saturation level, beyond which no further disruption is achieved. The time required by Red to perform the interdiction is a delay of Red itself and is a function of the quantity of ordnance expended. The interdictions are made as Red 1 passes through the selected points to create delays behind it as it advances to the target building. In the reference case, Red 1 spends 15 s to establish a delay of 1.6 min at node 15 to detain Blue 4. This is shown in Fig. 4 by the nomenclature "X3 1.6," which means that this is a type 3 interdiction point and that the level of interdiction created by Red will take Blue 1.6 min to circumvent. Figure 4 also shows Blue 1 and 2 joined as Blue 6 in the diversionary engagement with Red 2. As indicated by the horizontal graphs in the BATTLE PROGRESS window, Blue 2 and Red 2 have thus far sustained ~30% casualties; Blue 1 has ~15% casualties.

Table 3. Weapon effectiveness and attrition parameters for Red assault of Blue

	M16 rifle	M79 grenade launcher	V150 armored vehicle
		Red rate of detection of Blue	
AK47 rifle	0.6	0.6	0.9
RPG7 anti-tank	0.6	0.6	0.9
Incendiary	0.6	0.6	0.9
Light helicopter	0.2	0.2	0.4
		Red volume of fire at Blue per detection	
AK47 rifle	8	8	4
RPG7 anti-tank	0.2	0.2	2
Incendiary			
Light helicopter	2	2	6
		Red probability of hit Blue per fire	
AK47 rifle	0.007	0.007	0.02
RPG7 anti-tank	0.01	0.01	0.04
Incendiary			
Light helicopter	0.002	0.002	0.003
		Red quantity of Blue kill per hit	
AK47 rifle	1	1	0.01
RPG7 anti-tank	3	3	1
Incendiary			
Light helicopter	1	1	0.01

Subsequently, Red 1 spends 52 s creating a delay of 7 min at node 14 to detain Blue 3 and Blue 4. As will be seen, the delay at node 14, from which the only road link to the target building entrance originates, is particularly critical to the success of the Red mission.

Red 1 is assumed to receive passive insider aid in the form of a floor plan of the building with a marked route to the target (Fig. 3). Although there is no searching for the target, Red does traverse the building at a slower rate than would persons familiar with the building. Movement through the building has a normal rate of 176 ft/min for foot traffic; the Red unit is assumed to travel at only half that rate.

The building entrance and target are both alarmed. Neither is provided armed guards. There is no delay in penetrating the building, but a 60-s delay is postulated for acquisition of the target itself.

The time needed to mobilize Blue units once the need for action is recognized by surveillance (e.g., observation towers) or called for by Blue headquarters is set at 60 s.

Table 4. Reference rates of movement on roads, fields, and in buildings for links between listed node pairs. Values are miles per hour except for the intrabuilding link of node pair 20,21, for which units are feet per minute

Node pair	Normal speed	Red unit modifier	Node pair	Normal speed	Red unit modifier
1,2	50	0	1,10	30	0
2,3	50	0	2,11	30	0
3,18	50	0	3,12	30	0
4,6	50	0	4,13	30	0
4,16	50	0	5,17	20	0
5,14	20	0	6,7	50	0
6,18	50	0	7,8	50	0
9,17	20	0	10,11	30	0
10,14	30	0	11,12	30	0
12,13	30	0	12,15	30	0
13,15	30	0	14,15	30	0.2
9,16	60	0	9,19	3	0
14,20	30	0.2	15,19	3	0
20,21	176	0.5			

In the reference case, timing of events is such that Red 1 acquires the target, transfers it to Red 3, and Red 3 escapes by air with a margin of 35 s before Blue units can penetrate the delay at node 14 and reach the target building. Red 1 is captured by Blue 3 and 4 at the building entrance where the transfer occurred. Red 2 largely sacrifices itself, suffering 80% casualties in creating the diversion of Blue 1 and 2 at node 5.

Many of the values and assumptions of this scenario will be systematically investigated in the following analysis to establish critical items and to identify ways to improve Blue (and Red) operations. Important parameters that will be treated are listed in Table 5.

3.2.2 Temporal Parameters: Event Timing

The first parametric study will examine the importance and interrelationships of key temporal parameters in Table 5 that control the sequencing and cumulative outcome of events in the reference scenario. The fates of Red 1 and 2 are not significantly affected by the parameters of this series of cases, but the consequence for Red 3, and hence the mission, will change from escape to capture, depending upon the particular variations. The study approach is one of progressively tightening the timing, a parameter at a time, to establish (among other things) how Blue may more effectively respond and thwart the escape under a range of conditions. Recognizing that absolute prediction of event times is difficult at best, the most significant information to be derived from such analysis may be relative trends and importances. Results are summarized in Table 6; in each case, only the altered parameters from Table 5 are shown. The first four cases explore tactical timing actions that both sides may improve, namely, the competing effects of (a) shorter Blue mobilization time (60 s in the reference case) and (b) more

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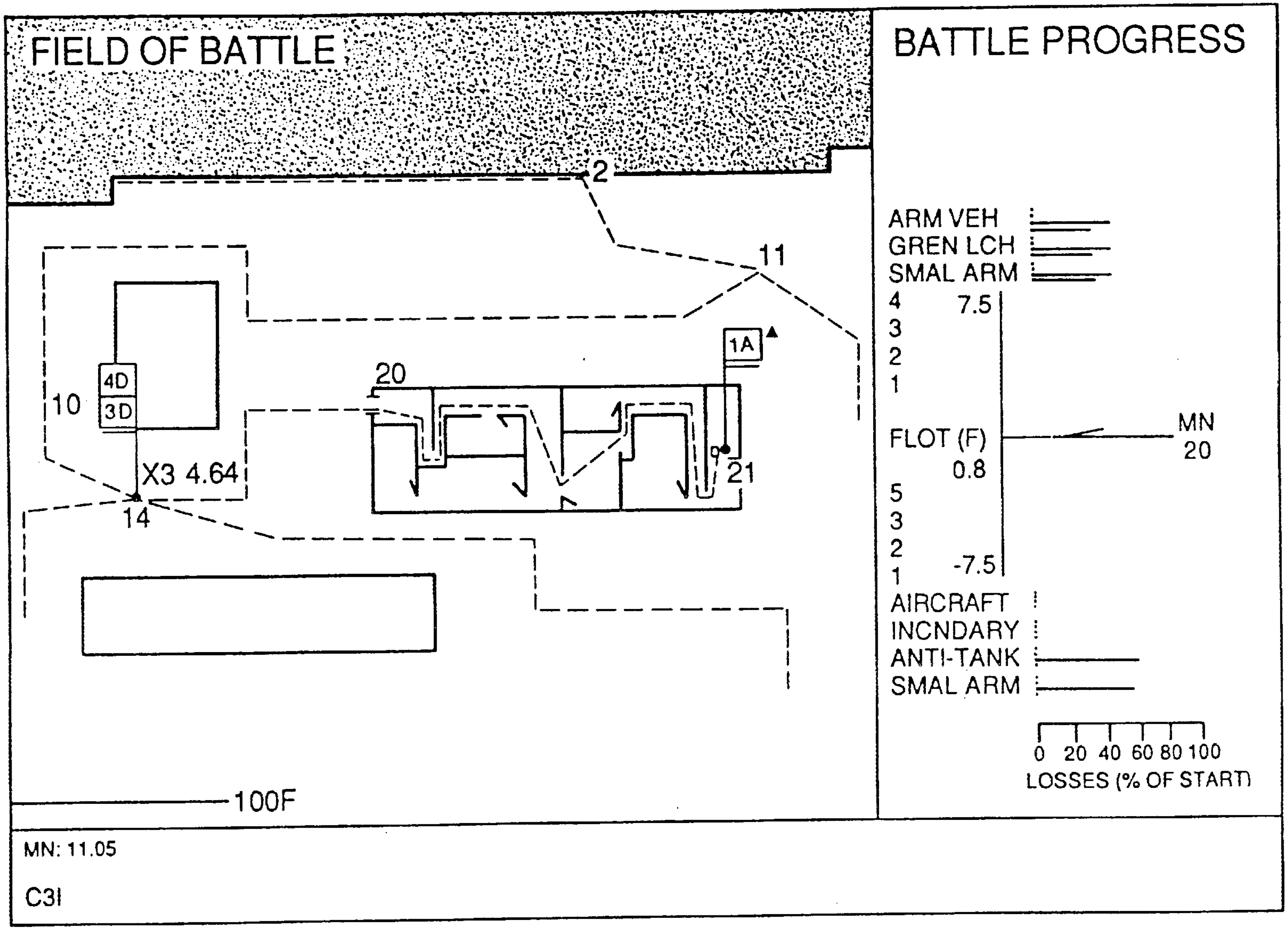

Fig. 4. Penetration of facility by Red 1 while Red 2 provides diversionary engagement of Blue 1 and 2 (designated Blue 6) at node 5.

Table 5. Investigated parameters of reference case

Parameter	Value
Observation towers detect Red 1	Yes
Blue mobilization time	60 s
Red 1 time to create delay at node 15	15 s
Delay of Blue 4 at node 15	96 s
Red 1 time to create delay at node 14	52 s
Delay of Blue at node 14	420 s
Red 1 speed factor on site roads	0.2
Security at target building entrance	Alarm
Security at target	Alarm
Insider aid	Passive
Red 1 speed factor on target building ingress	0.5
Red 1 speed factor on target building egress	0.5
Red air support	Target transport
Blue air defense	No
Delay of Red in transferring target into helicopter	30 s
Red 3 escape margin (minus = intercepted by Blue)	35 s

rapid route interdiction by Red, particularly at node 14 (52 s in the reference case). Improvements will be examined sequentially.

Since Red 3 escaped with the target in the reference case, Blue mobilization time is reduced from 60 s to 45 s, and the reference case is repeated (Table 6, case A1). With this improvement in Blue operations, Red 1 is intercepted and neutralized by Blue 3 and then Blue 4 at node 14 while Red 1 is in the process of interdicting that node, 27 s before the interdiction can be completed. In Table 6 the nomenclature >−27 s means interception by Blue more than 27 s before Red mission success.

Next, since the time required by Red 1 to set the delay at node 14 is limiting in the previous case, Red 1 is postulated to improve this time by a factor of 2 (case A2). The Red mission once again becomes successful; Red 3 escapes with a margin of 15 s before Blue reaches the target building.

Blue mobilization time is further reduced to 30 s, the postulated minimum for units at this facility (case A3). Red 1 is intercepted at node 14 and neutralized 20 s before interdiction of node 14 can be accomplished.

Finally, the times for Red 1 to set the delays at nodes 14 and 15 are reduced to postulated minimum values of 9 and 2 s respectively (case A4). The Red mission narrowly succeeds; Red 3 escapes 3 s before Blue can reach the target building.

The next five cases retain the minimum mobilization time and maximum route interdiction efficiency of case A4 and examine two other competing parameters: (a) the length of delay to Blue at node 14 and (b) the length of time Red 1 spends traversing the target building while Blue is delayed. These cases provide an indication of the maximum delay that Blue can tolerate. Again, the parameters will be altered sequentially.

First, the delay of Blue at node 14 is reduced from 7 min to 6 min (case A5). Red 1 acquires the target but is intercepted by Blue at the entrance to the target building (node 20) 48 s before transfer of target to Red 3 can be accomplished.

Table 6. Effects of varying key reference temporal parameters
(only the changed parameters are shown)

Case	Parameter	Value
A1	Blue mobilization time	45 s
	Red 3 escape margin (minus = intercepted)	>−27 s
A2	Blue mobilization time	45 s
	Red 1 time to create delay at node 15	7 s
	Red 1 time to create delay at node 14	26 s
	Red 3 escape margin (minus = intercepted)	15 s
A3	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	7 s
	Red 1 time to create delay at node 14	26 s
	Red 3 escape margin (minus = intercepted)	>−20 s
A4	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	9 s
	Red 3 escape margin (minus = intercepted)	3 s
A5	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	8 s
	Delay of Blue at node 14	360 s
	Red 3 escape margin (minus = intercepted)	−48 s
A6	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	8 s
	Delay of Blue at node 14	360 s
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	3 s
A7	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	6 s
	Delay of Blue at node 14	300 s
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	−30 s
A8	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	6 s
	Delay of Blue at node 14	300 s
	Insider aid	Active
	Red 1 speed factor on target building ingress	1.0
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	45 s

Table 6. (continued)

Case	Parameter	Value
A9	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	5 s
	Delay of Blue at node 14	240 s
	Insider aid	Active
	Red 1 speed factor on target building ingress	1.0
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)*	−6 s

*Escapes under fire.

Next, postulating a compensating improvement in Red movement on retracing its route through the building resulting from acquired familiarity, the Red 1 speed factor is increased from 0.5 to 1.0 on egress only (case A6). Because of the lengthy route through the building, this parameter has a major impact on mission outcome. Whereas in case A5 Red 1 was intercepted 48 s before mission success, the timing is now very close. The target is transferred to Red 3 with a 3-s margin before Blue reaches the building.

The delay of Blue at node 14 is reduced to 5 min (case A7). Red 3 is intercepted by Blue at the building entrance 30 s before transfer of the target to Red 3 can be accomplished.

Now assuming active insider help in the form of guidance through the building, the Red 1 speed factor on building ingress (as well as egress) is raised from 0.5 to 1.0 (case A8). Again, because of the long route through the building, a major impact on mission outcome occurs. Red 3 escapes with 45 s to spare.

Finally, delay of Blue at node 14 is reduced to 4 min (case A9). Red 3 is intercepted by Blue at the building entrance 6 s before transfer of the target from Red 1 is complete. For these few seconds, Red 3 is engaged by Blue. The attrition calculation shows negligible damage to Red 3 aircraft during this interval since the Blue units lack effective air defense capability. Red 3 escapes under fire with the target.

Cases A5 to A9 indicate that with the most efficient Red 1 operation postulated, Blue cannot tolerate a delay of more than 4 min at node 14. A somewhat longer delay may be acceptable if Blue approached the site with air defense capability such as Stinger weapons. The allowable delay probably could not be shortened extensively, however, since Blue would likely be out of viewing range of Red earlier in the operation.

These cases underscore the value of passive defense, namely, locating the target such that access is retarded by unavoidable delay to intruders. Here, the target is in the far reaches of a long building that must be traversed even though the mission is aided by an insider. The delay is the controlling factor in several cases of Table 6, providing Blue with the time necessary to reach the site and thwart the mission. Short of violently breaching the building walls, this defense mechanism appears undefeatable.

Case A9 highlights the desirability of suitable air defense against Red tactics of this type.

3.2.3 Insider Help

In the previous analysis, insider help was postulated either as a building floor plan or active guidance to the target. The next cases investigate circumstances under which the Red mission may be accomplished without insider help. Blue mobilization and Red interdiction efficiency are taken to be optimum as established in case A4. With active insider help, the time spent by Red 1 in the target building is 1.3 min each way on ingress and egress, plus 1 min in target acquisition, for a cumulative total of 3.6 min in the building. Without insider help, the building must be searched by Red 1 to find the target. The amount of time for, and the success of, such a search will depend on many factors involving the size and complexity of the building and the manner in which the target is secured. Typical search time may be established experimentally using personnel unfamiliar with the site. For the current study, it is assumed that an additional 5 min is required to locate the target; this delay is simulated by reducing Red 1's rate of travel on ingress (speed factor = 0.21). Without insider aid, Red 1's time in the building is 8.6 min. When Blue is delayed the reference 7 min at node 14, Red 1 is intercepted in the building by Blue 2.5 min before the mission succeeds (Table 7, case B1).

If Red 1 avoids detection by the observation towers and is not noticed until tripping the alarm at the target building entrance, it gains the time required by Blue 3 and 4 to mobilize for the alarm (30 s) plus the time for Blue to reach the building (~30 s), a total of 60 s. Blue's margin of safety is reduced to 1.5 min (case B2).

Red 1 penetrates the site with six incendiary bombs for interdiction. In the reference scenario, these are apportioned sequentially between nodes 15 and 14 to affect interdictions of 1.6 and 7 min respectively. Postulated absence of detection by observation towers will obviate the expenditure on node 15, and the bombs may be concentrated to increase the delay at node 14. With the interdiction capability of napalm as programmed, expending all bombs at node 14 may create an interdiction of 8.5 min, the maximum possible for node 14 based on its postulated topography and vulnerability to napalm. With this peak level of interdiction, Red 1 completes transfer of the target to Red 3 just as Blue reaches the scene. Because of inadequate Blue air defense, Red 3 escapes under fire (case B3).

3.2.4 Security at Target Building and at Target

The reference case postulates that security at the target building entrance and at the target itself consists of alarms linked to command headquarters. The next series of cases investigates the incremental effects of alternative levels of security at these points, ranging from no security to a dedicated squad.

If the target building entrance is not protected by an alarm (or the alarm is defeated by insiders) and if Red 1 has not been detected prior to entering the building, then Red 1 will gain the transit time through the building (1.3 min with passive insider aid) before tripping the target alarm (Table 8, case C1).

If both the target building entrance and the target lack operating alarms, Red 1 may gain at least the entire time in the building before detection, 3.6 min (case C2).

In the next case (C3), a single guard with minor fortification (walls, etc.) is posted at the target, and defensive engagement occurs when Red 1 is proximate. Using the combat parameters of Tables 1 to 3, the attrition calculation for the high-intensity

Table 7. Effects on mission outcome of not having insider aid

Case No.	Parameter	Value
B1	Blue mobilization time	30 s
	Red 1 time to create delay at node 15	2 s
	Red 1 time to create delay at node 14	9 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	−150 s
B2	Observation towers detect Red 1	No
	Blue mobilization time	30 s
	Red 1 time to create delay at node 14	9 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	−90 s
B3	Observation towers detect Red 1	No
	Blue mobilization time	30 s
	Red 1 time to create delay at node 14	11 s
	Red 1 delay of Blue at node 14	510 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red 1 speed factor on target building egress	1.0
	Red 3 escape margin (minus = intercepted)	0 s

skirmish with automatic rifles shows that there is a 50% probability of the outnumbered guard being disabled in 1 min and a 70% probability in 2 min. Red loses one man. Thus, a conventional guard at the target may provide a delay to Red of about 1 min.

The incremental times associated with variations in the security level in these three cases are substantial compared with the tight timing of some of the scenarios examined previously and could reverse the outcomes of those scenarios.

In the final case (C4), squad Blue 3 is dedicated to the target. Blue now outnumbers Red 7 to 4 in the skirmish at the target, and the outcome is as expected. After 1 min, Red 1 experiences 50% casualties of its riflemen; this rises to 65% in 2 min and to 80% in 4 min. Maximum loss for Blue is 40%. The squad security level appears to provide near assurance of defeat of the Red mission. Sustaining this level of dedicated security is, of course, often prohibitively costly.

Table 8. Incremental effects of alternative security levels at target building entrance and at target

C1	Security at target building entrance	No
	Potential time gain for Red 1	78 s
C2	Security at target building entrance	No
	Security at target	No
	Potential time gain for Red 1	216 s
C3	Security at target	Guard Blue 5
	Potential time gain for Red 1	−60 s
C4	Security at target	Squad Blue 3
	Potential time gain for Red 1	Defeat Red 1

3.2.5 Red Air Support and Blue Air Defense

The next study examines consequences of alternative levels of Red air support: (a) no air support and (b) air attack capability. Also considered is Blue air defense capability.

The results of the B cases indicate that without insider help to avoid the long delay in searching the building for the target, the Red mission is doomed to failure unless air support is available to promptly transport the acquired target from the site. A logical next study is to determine whether there are circumstances under which the Red mission may, with insider help, succeed without air support. The altered scenario may be played many ways; the following is one example. It is postulated that Red 1 adopts modified tactics. Instead of six incendiary bombs, Red 1 carries a mix of four incendiaries and two high-explosive devices. Up to the point of target acquisition, the scenario is the same as the reference case except that the delay of Blue at node 14 is reduced to 3 min to conserve incendiary ordnance for subsequent interdiction use. After traversing the building with passive insider aid (a floor plan) and acquiring the target, Red 1 uses the high explosives to breach the building wall near the target and then exits directly across a small field to node 15 (Figs. 1 and 2). Tower 11 observes Red 1 crossing the field. Blue 4 is on the near side of the interdiction at node 14 and is ordered to intercept Red 1. Allowing a 30-s response time to initiate this action, Blue advances upon Red 1 in the process of setting a new delay at node 15 with the remaining incendiary bombs. Red 1 is fired on for 5 s. The attrition calculation shows negligible Red casualties during this brief encounter. The interdiction is completed, providing a 6-min delay of Blue. The target is sufficiently maneuverable to transport across fields to the staging area, and Red 1 retraces its original route to node 9.

The final outcome of this scenario now depends upon Blue's assessment of Red 1 tactics. In the worst case for Blue (Table 9, D1), Blue does not perceive the location of the staging area, and Red 1 escapes without contest.

In a better but still ineffective response (case D2), Blue perceives Red 1's escape route, and Blue 4 attempts to intercept at the staging area after completing the delay at node 14. It should be noted that for a time, Blue 4 is boxed in by interdictions at nodes

Table 9. Effects on mission outcome without air transport of target from site

	Parameter	Value
D1	Blue mobilization time	30 s
	Red 1 time to create delay at node 14	4 s
	Delay of Blue at node 14	180 s
	Red 1 time to create second delay at node 15	8 s
	Second delay of Blue 4 at node 15	360 s
	Insider aid	Passive
	Air support	No
	Blue unit sent to intercept at Red stage area	No
	Red 3 escape margin (minus = intercepted)	>300 s
D2	Blue mobilization time	30 s
	Red 1 time to create delay at node 14	4 s
	Delay of Blue at node 14	180 s
	Red 1 time to create second delay at node 15	8 s
	Second delay of Blue 4 at node 15	360 s
	Insider aid	Passive
	Air support	No
	Blue unit sent to intercept at Red stage area	Blue 4
	Red 3 escape margin (minus = intercepted)	50 s
D3	Blue mobilization time	30 s
	Red 1 time to create delay at node 14	4 s
	Delay of Blue at node 14	180 s
	Red 1 time to create second delay at node 15	8 s
	Second delay of Blue 4 at node 15	360 s
	Insider aid	Passive
	Air support	No
	Blue unit sent to intercept at Red stage area	Blue 3
	Red 3 escape margin (minus = intercepted)	−280 s

15 and 14. The fastest route for Blue 4, when free, is via roads out of and around the site to the staging area (i.e., through node 16). In this case, Blue 4 reaches the staging area 50 s after Red 1 reaches the staging area and escapes.

In the best response (case D3), Blue perceives the location of the staging area and promptly dispatches Blue 3 (which is not boxed in by interdictions) to intercept. Blue uses an optimum-time-of-travel route, which the model finds, through nodes 10, 11, 12, 13, 4, 16, and 9. In this case, Blue reaches the staging area nearly 5 min ahead of Red 1 and defeats the mission.

The next cases investigate the effects of an increased level of air support that includes air assault of Blue units. The scenario proceeds as in the reference case up to the time that Red 1 reaches node 14; that is, Red 2 engages Blue 1 and 2 at node 5 for diversion, and Red 1 delays Blue 4 at node 14 to allow Red 1 time to reach the target building. Red 1 does not use interdiction at node 14 to delay Blue 3 and 4. Instead, the Red 3 aircraft, now postulated to be tactically armed, engages Blue 3 and 4 outside the target building and holds them off until Red 1 acquires the target and delivers it to Red 3 for air transport off-site.

A key question is, how effective may the helicopter actually be? Clearly, this depends on the type of helicopter, the weapons installed, and the operator's skill. The question is addressed here by investigating a plausible range of effectiveness. The reference case aircraft is a standard light helicopter and a pilot equipped with an AK47 rifle. At the opposite limit of attack capability, a military assault helicopter such as the AH-64A may be equipped with (among other armaments) an automatic 30-mm cannon with 1200 rounds of high-explosive ammunition and laser tracking that may, in the present case, execute an airborne delaying mission for Red 1 during the time interval the target is being acquired and transferred. The effectiveness of the Red 3 attack helicopter, as specified by the combat process parameters of Table 3, is investigated over a range 10 to 1000 times that of the airborne rifle of the reference case.

These cases assume no insider help. Hence, Red 1 will spend nearly 9 min inside the building acquiring the target. For the case in which the Red 3 air attack capability is only 10 times that of the reference helicopter, Blue 3 and 4 sustain less than 10% casualties from helicopter fire (Table 10, case E1). Because of the comparatively long interval of engagement, the helicopter is calculated to have a 45% probability of being brought down by Blue rifle fire. The strength of Blue 3 and 4 is greater than 90% when Red 1 emerges from the building. Successful transfer of the target appears unlikely under the circumstances, and the Red mission fails.

When Red 3 air assault effectiveness is 100 times that of the reference case (case E2), Blue casualties increase to 40% and the probability of the Red aircraft being downed by rifle fire while Red 1 is acquiring the target drops to 38%. With Blue 3 and 4 so weakened by the time Red 1 emerges from the building, Red mission success appears likely.

When the air attack effectiveness is 1000 times that of the reference case (case E3), Blue casualties are greater than 60% after only 3 min of engagement, and Blue is effectively annihilated by the time Red 1 emerges from the building. Red 3 sustains only a 10% probability of being shot down, and chances of mission success are high.

These cases indicate that relatively modest but effective Red air attack capability may substantially increase the probability of Red mission success even without insider help when Blue lacks appropriate air defense.

Blue may counter the air threat with suitable air defense weapons such as Stinger ground-to-air missiles. In the next case (E4), Blue 3 is equipped with one Stinger-type weapon and six missiles. Combat parameters describing the interaction between the Red attack helicopter and the Blue air defense weapon are given in Table 11. On the basis of these parameters, Blue air defense is nearly three times as effective against Red air as Red air is against Blue air defense, largely because of the high visibility (measured by rate of detection) of the air unit in comparison with air defense and because of the inherent accuracy of the air defense weapon (measured by hit probability). In this case (Table 10, E4), the attrition calculation for engagement between Red 3 and Blue 3 shows a 75% probability that the Red aircraft will be shot down within 20 s; there is a

Table 10. Effect of air attack support for Red mission

E1	Red 1 delay of Blue at node 14	0 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red air support	Attack; target transport
	Red 3 aircraft relative attack capability	10X
	Blue air defense	No
	Blue 3 and 4 casualties	10%
	Red 3 probability of being shot down	45%
	Red mission success	No
E2	Red 1 delay of Blue at node 14	0 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red air support	Attack; target transport
	Red 3 aircraft relative attack capability	100X
	Blue air defense	No
	Blue 3 and 4 casualties	40%
	Red 3 probability of being shot down	38%
	Red mission success	Likely
E3	Red 1 delay of Blue at node 14	0 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red air support	Attack; target transport
	Red 3 aircraft relative attack capability	1000X
	Blue air defense	No
	Blue 3 and 4 casualties	Annihilated
	Red 3 probability of being shot down	<10%
	Red mission success	Yes
E4	Red 1 delay of Blue at node 14	0 s
	Insider aid	No
	Red 1 speed factor on target building ingress	0.21
	Red air support	Attack; target transport
	Red 3 aircraft relative attack capability	1000X
	Blue air defense	Yes
	Blue 3 probability of air defense being killed	15%
	Red 3 probability of being shot down	~100%
	Red mission success	No

15% probability of Blue air defense being killed during that time. This level of air defense appears capable of defeating any of the investigated Red operations that depend upon air support (transport and/or attack) for success.

Table 11. Weapon effectiveness and attrition parameters for engagement of Red air and Blue air defense

Parameter	Value
Blue rate of detection of Red	1.0
Blue volume of fire at Red per detection	3.0
Blue probability of hit Red per fire	0.9
Blue quantity of Red kill per hit	1.0
Red rate of detection of Blue	0.1
Red volume of fire at Blue per detection	100.0
Red probability of hit Blue per fire	0.1
Red quantity of Blue kill per hit	1.0

4. CONCLUSIONS

For the postulated facility, offensive and defensive forces, and their missions, the preceding analyses identify contingency controlling parameters and interrelationships that may be useful in improving security at the facility. In addition, the results provide quantification of these broad conclusions:

1. The likelihood of Red success is critically reduced by maintaining a high level of Blue response readiness as measured by unit mobilization time and other factors.

2. Placing a dedicated guard at the target provides additional delaying action that prevents the success of all investigated cases with or without air transport, with or without insider help, and not involving explosives to breach the target building and defeat the important passive delay the building passages provide.

3. For the scenarios in which Red uses explosives to escape from the target building and then exits the facility on foot, Blue must correctly perceive Red withdrawal tactics, that is, recognize where the staging area is located and move quickly to intercept there. This perception may be based on tracking by the towers until Red leaves the observation range and on previous knowledge of the region and the escape options it affords.

4. Air defense is necessary to protect against Red air-attack support. This capability also defeats certain Red air-transport missions that otherwise may succeed.

5. RECOMMENDATIONS FOR FUTURE RESEARCH AND DEVELOPMENT

The demonstration model and analysis appear to confirm the potential benefits in applying the methodologies to analyze contingencies at strategically important national facilities. The following four-phase program of additional work is suggested to fully develop the techniques reported here.

1. Expand and refine the simulation to treat all security characteristics that need consideration, including economics.

2. Particularize the full model to an actual facility and validate it against expected or known results. Field exercises at the installation of interest may be useful in the validation.

3. Transform the model into a production version that may be used at a variety of facilities.

4. Adapt the model to a two-player format that permits running it as a combat training simulator.

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