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WING-IN-GROUND (WIG) EFFECT VEHICLE MISSION ANALYSIS: *METRIC COMBAT SIMULATIONS*



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WING-IN-GROUND (WIG)
EFFECT VEHICLE MISSION ANALYSIS:
METRIC COMBAT SIMULATIONS

A. ANALYTICAL OBJECTIVES

In assessing potential military applications for Wing-in-Ground (WIG) effect vehicles, it is important to expand the analysis beyond technical feasibility assessments. It is essential to also measure the impact mission-capable WIGs could have on combat outcomes. The emphasis of this analysis is to provide preliminary answers to some of the "so what" questions surrounding WIG performance; i.e., what return on investment in terms of improved U.S. combat capabilities may be realized by developing and employing WIGs. Consequently, BDM has incorporated several potential WIG combat missions into the simulation of a broader Southwest Asia (SWA) scenario involving U.S. early entry forces. A base case scenario (non-WIG) is compared with three excursions in which WIG technology is simulated to perform various combat and lift missions. The simulation results support assessments of the impact that WIG technology could have on disrupting threat offensive operations and preserving U.S. forces in a single scenario, as well as inferences about other possible military roles.

This analysis is intended to provide a basis for continuing assessments of potentially valuable military missions for WIG technology. The analysis is not comprehensive with respect to all potential missions, but it does provide insights into the operational significance of several WIG combat and lift roles. While the selected missions emphasize the speed, range, endurance, and capacity of WIG applications, further study will be needed to determine whether other existing or projected combat systems would be capable of performing the same missions more effectively and/or at lower cost. In addition, the application of WIG technology in other theater scenarios and combat intensities is vital before final conclusions can be drawn concerning the potential operational utility of WIG craft.

B. THE METRIC MODEL

The METRIC simulation was chosen to conduct WIG operational analysis. METRIC is a key component of the FOCUS family of tools which support a wide range of operational analyses at varying levels of resolution (see *Figure 1*). FOCUS includes worldwide order of battle and equipment data bases; simulation models for mobilization, transportation, and combat analysis; a geographic information system (GIS); and graphics workstations.

The METRIC model is an advanced joint warfare simulation which incorporates a robust representation of command, control, communications, computers and intelligence (C4I) architectures to support analysis of "force multiplier" technologies and employment concepts. As depicted in *Figure 2*, METRIC is used to model joint warfare, including combat and non-combat missions (such as logistics). METRIC's modules include artificial intelligence (AI) routines to automatically provide dynamic battle management within the simulation, or the model can be run with humans-in-the-loop (see *Figure 3*). In support of the WIG analysis, most U.S. and threat tactical operations were run under computer control. WIG employment concepts were input by players and executed by existing AI routines based on perceptions of tactical situations.

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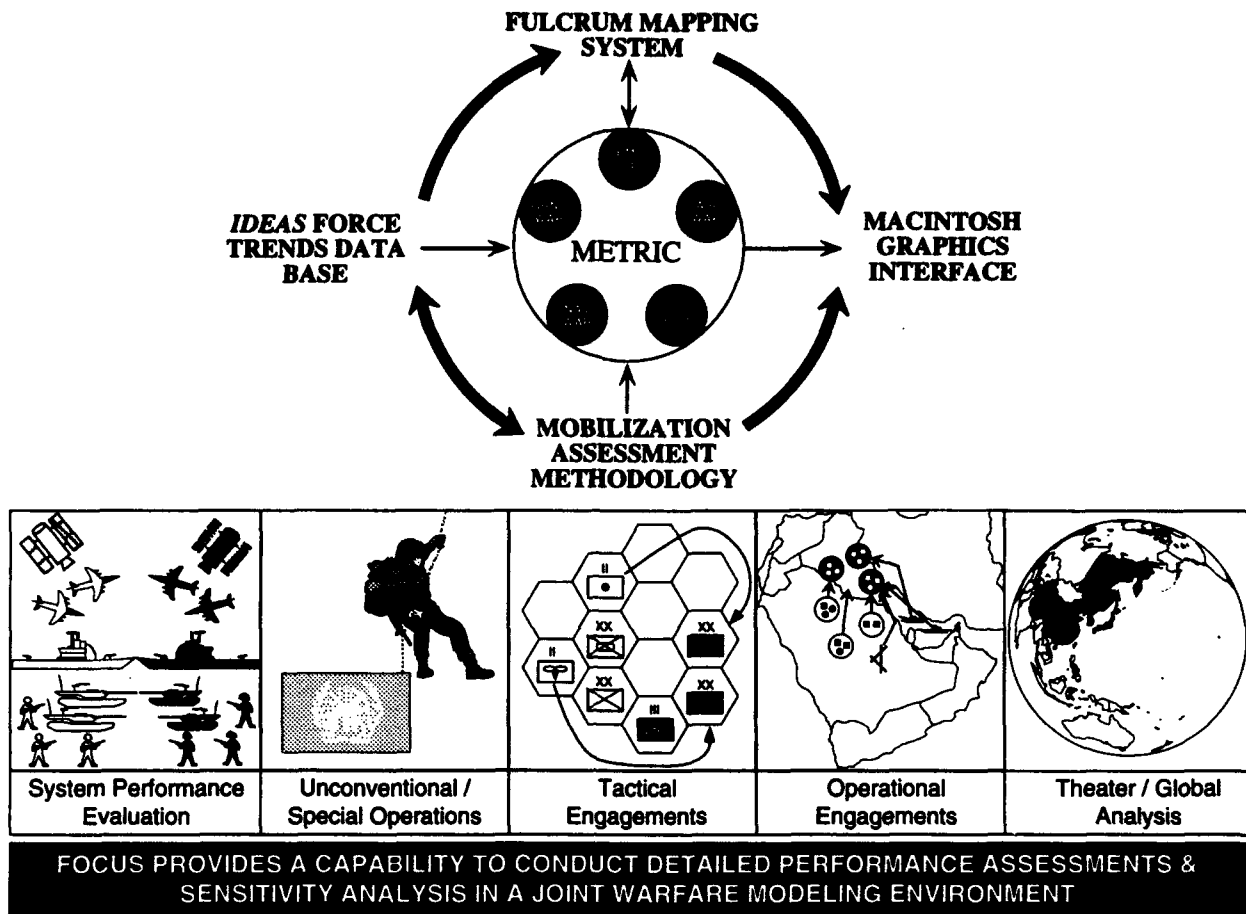


Figure 1. FOCUS Model Family.

Outputs from METRIC include combat results by side, by unit, and by system (both as shooter and as target); communications statistics by radio, by network, and by sender or receiver; intelligence reports by side, by unit, and by sensor; map overlays depicting the progress of combat in either real-time or replay mode; and a variety of other statistics and reports describing system performance and engagement results. Several of these report types are used to support this analysis.

C. SCENARIO OVERVIEW

To support the goal of focusing on modeling and analysis rather than scenario development, an existing scenario from another recent ARPA study was chosen for the WIG analysis. In this scenario, a light U.S. early entry force on the ground near Al Jubayl, Saudi Arabia conducts joint operations with U.S. air and naval forces against a mechanized Iraqi incursion into Saudi Arabia. The breakthrough force employs two avenues of advance, one along the coast and the other approximately 100 kilometers inland, in a north-south movement. The Iraqi objective is to overrun the U.S. positions and capture the reinforcement and staging areas at Al Jubayl and Dhahran. The scenario involves attacks by Iraqi forces on U.S., coalition and indigenous Saudi units both along the Saudi Arabian Persian Gulf coastline and inland against King Khalid Military City (see Figure 4). This analysis focuses on a pre-supposed, corps-sized Iraqi breakthrough force advancing through Kuwait and into Saudi Arabia. Other threat and friendly activities unrelated to the breakthrough are not depicted (although some diversion of total available assets is assumed).

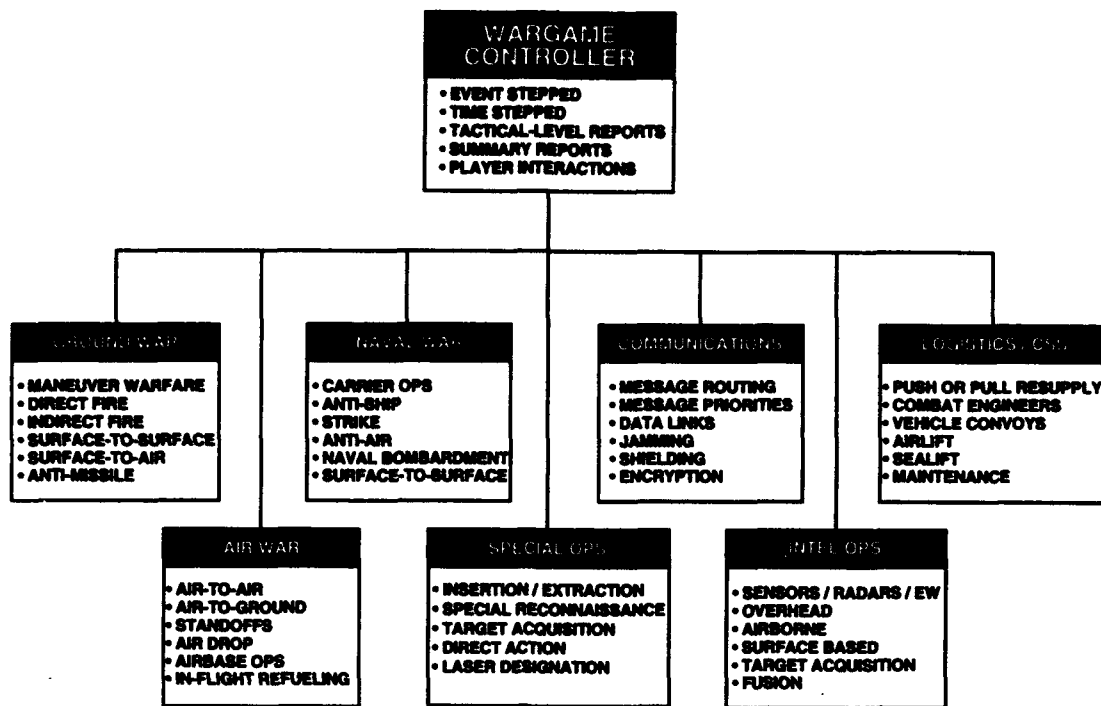


Figure 2. METRIC Gameset.

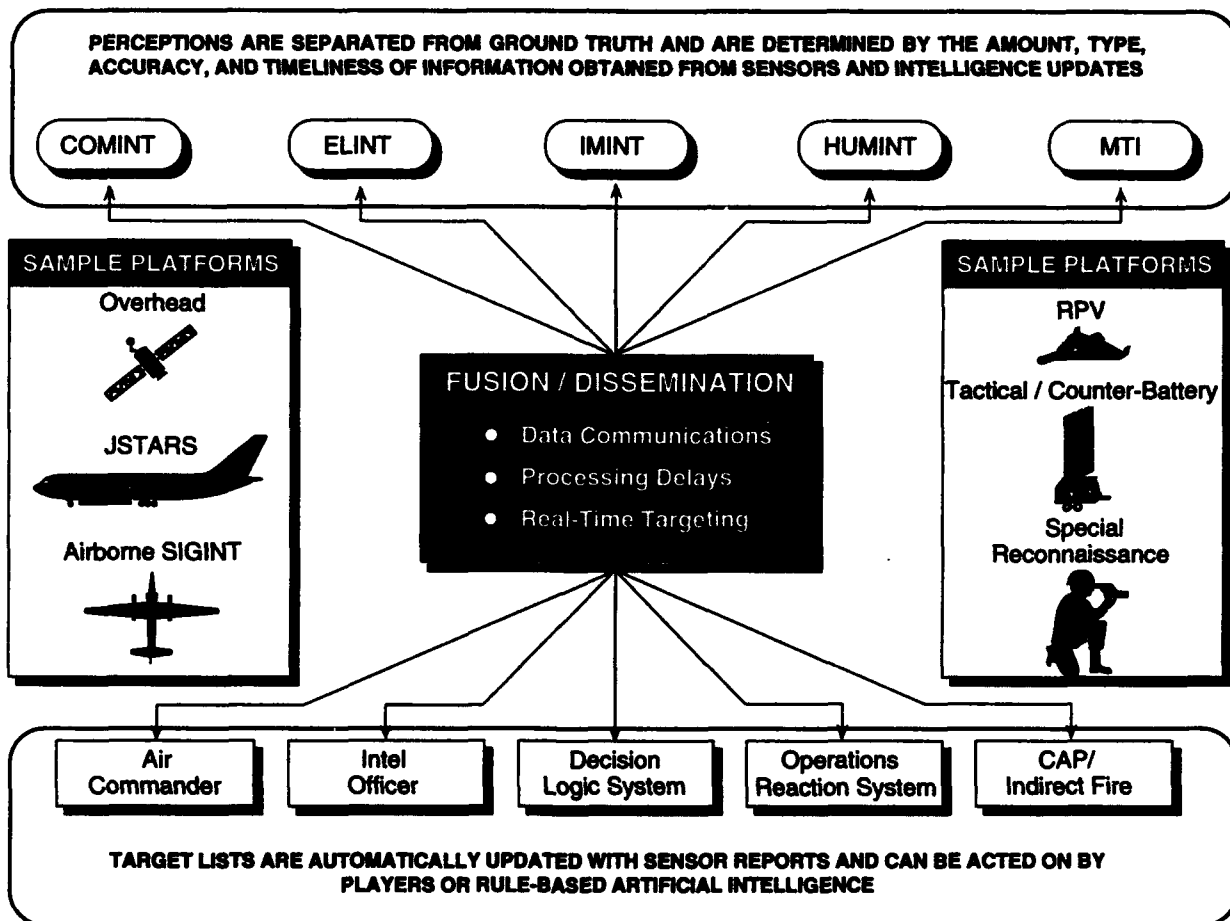


Figure 3. Automated Exploitation of Intelligence in METRIC.

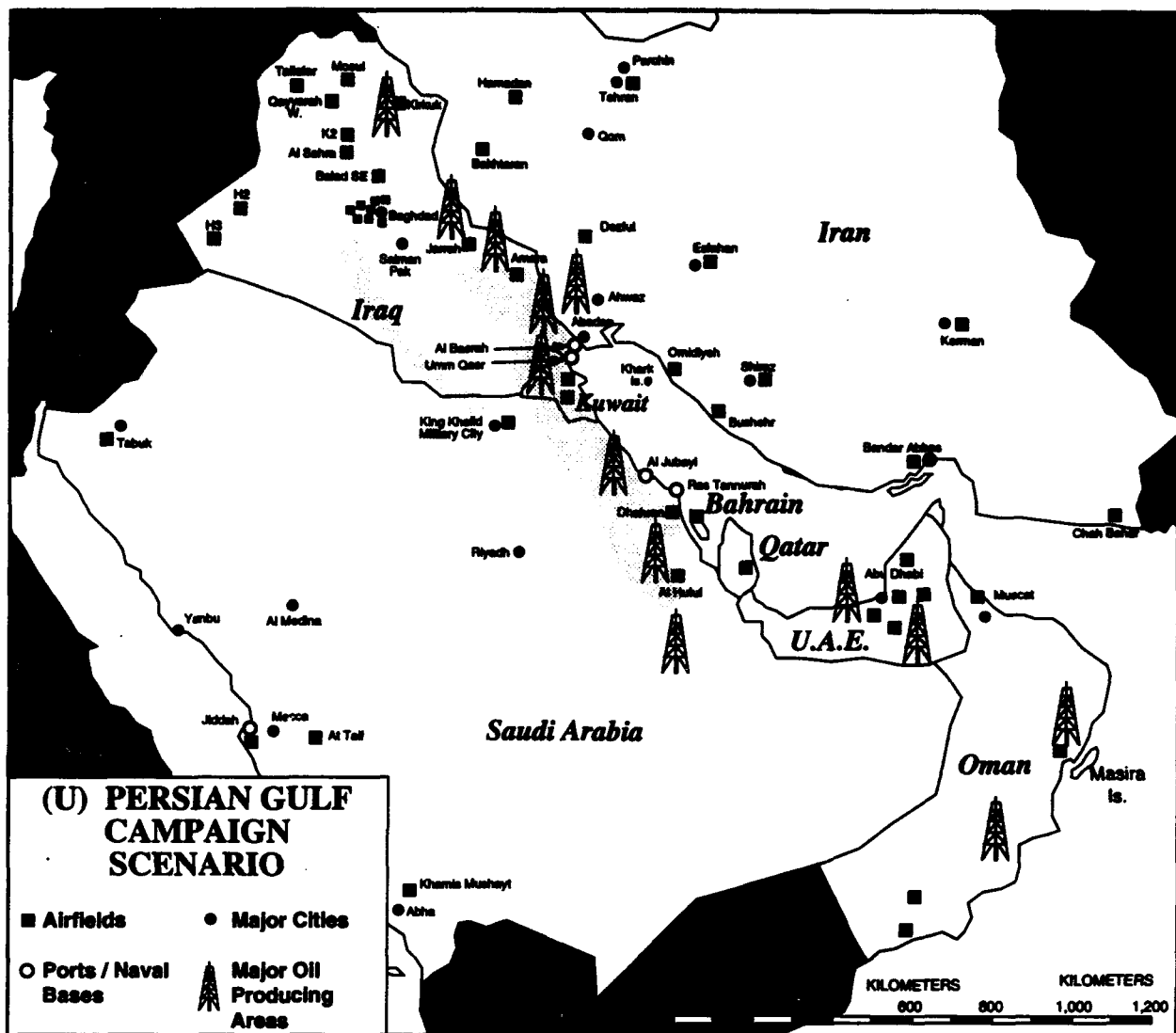


Figure 4. Scenario Overview.

The defending U.S. force consists primarily of two battalions of the 82nd Airborne Division supported by other elements of the XVIII Airborne Corps; elements of a Marine Expeditionary Brigade (MEB), including an armored battalion and a mechanized company; a carrier battle group (CVBG) in the Persian Gulf; and Air Force units based at Riyadh and Dhahran. The primary lethal assets of the light U.S. ground forces are 18 AH-64D Apache/Longbow helicopters, 18 AH-1 Cobra helicopters, and 9 multiple launch rocket systems (MLRS) using ATACMs Block I and II rounds. Fixed wing aircraft devoted to stopping the breakthrough include 48 F-15Es, 10 A-6s, and 24 F/A-18s. Air launched standoff munitions include Tri-Service Stand-Off Attack Missile (TSSAM), Joint Stand-Off Weapon (JSOW), High-Speed Anti-Radiation Missile Block IV (HARM IV), Stand-Off Land Attack Missile (SLAM) and Hellfire/Longbow. Riyadh and Dhahran are defended by Patriot and theater high-altitude air defense (THAAD) anti-missile systems, as well as point air defense assets. U.S. reconnaissance, surveillance and target acquisition (RSTA) architecture includes AWACS, JSTARS, U2-R with ASARS, Rivet Joint, and overhead satellites.

The threat forces advancing along the coast consist of one heavy (double-size) armored division equipped with T-72 main battle tanks and a variety of maneuver and support assets. Advancing approximately 100 kms inland, is a second similarly equipped force consisting of an armored and a mechanized division. These ground forces are supported by 1,000 kilometer ballistic missiles fired from fixed sites in southern Iraq and mobile SCUD launchers; 45 MiG-29 Fulcrum air defense aircraft; 45 SU-22 Fitter ground attack aircraft; 40 Mi-25 Hind-D ground attack helicopters; and long-range, heavy artillery. The Hinds are forward-deployed to a Forward Area Rearmament and Refueling Point (FARP) outside the range of U.S. MLRS/ATACMs; likewise, the ballistic missile launchers cannot be reached by any ground systems. Threat air defense systems include SA-10s, SA-15s, and various hand-held SAMs and air defense artillery. The threat RSTA architecture includes a Mainstay-type AWACs, Gazelle reconnaissance helicopters, and tactical assets. This order of battle was deliberately modernized to present the U.S. force with a robust threat of the type anticipated in many Third World countries after the turn of the century.

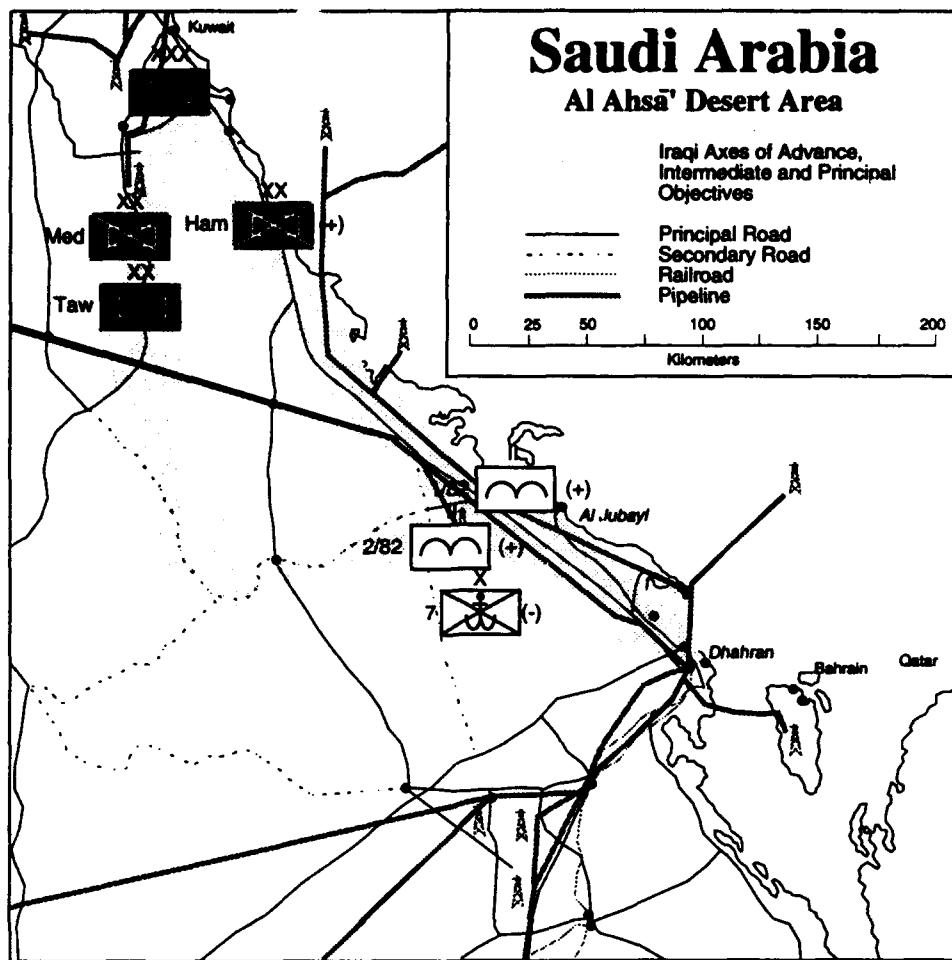
Deployment of major ground units is depicted on *Figure 5*. As the threat units begin to advance southward toward the U.S. ground positions, U.S. fixed wing aircraft begin interdiction strikes (although they are hampered by a low cloud ceiling and the limited number of ground attack aircraft available). The U.S. force supplements fixed wing operations with attack helicopters, and ATACMs as the threat units move within range. Meanwhile, Iraq targets U.S. air bases in Saudi Arabia and ground forces with combinations of fixed wing aircraft and ballistic missile attacks. Early on Day 1, Hinds also begin ground attack missions, principally against MLRS units and the helicopter base near Al Jubayl. The U.S. responds to the threat helicopter attacks with Apache strikes, but not until the night of Day 1/Day 2 when the mission can be accomplished under cover of darkness. Throughout Days 2 and 3, the air war continues with targeting priorities modified by each sides' situation awareness of battlefield conditions. Threat ground units continue to advance toward contact with the defending U.S. force by late in Day 3.

D. DESCRIPTION OF SIMULATED WIG MISSIONS

1. Summary

As a result of the initial threat advantage in combat power, the U.S. strategy is to employ long-range systems to interdict ground forces and neutralize the significant enemy direct fire advantage. Consequently, one of the best potential combat applications identified for WIGs was interdiction of threat forces beyond the effective range of U.S. attack helicopters and ATACMs. Other opportunities were identified, as well, for the use of WIGs in the northern Persian Gulf against targets requiring extreme forward deployments.

After evaluating a broad range of possible WIG combat missions, four combat applications were selected for analysis in the excursion case: air defense, navalized variants of ATACMS (henceforth NTACMs), theater missile defense (TMD), and sea-landed cruise missiles (SLCMs). The four applications were designed such that the WIG's range, mobility, and endurance would be important factors to successful accomplishment of the missions. A total of six combat WIGs were deployed to the Persian Gulf. Five WIGs were equipped with vertical launch systems (VLS) capable of accommodating any of the missiles associated with the chosen missions. Throughout the scenario, two WIGs were dedicated to NTACMs missions and one WIG each to the air defense, TMD and SLCM roles. The sixth WIG played a combat support role and was equipped with a three-dimensional, phased array radar to provide aircraft and missile acquisition and tracking data to the other WIGs and ground stations at Riyadh and Dhahran.



Threat concept of operations based on combined arms corps moving south in two axes with coordinated air and missile support

- **Continuous air support throughout three day offensive**
 - Air cover provided by MiG-29 aircraft based in Iraq
 - Early fighter-bomber attacks to destroy / suppress MLRS units
 - Close air support available from helicopter forward area refueling and rearming point (FARP) established along inland road march
- **Surface-to-surface missile strikes on U.S. forces from launchers in Iraq and mobile SCUDs**
 - Small number of 1,000 km missiles launched at U.S. air facilities
 - SCUDs target long-range U.S. artillery and ground forces
- **Long-range artillery suppression and counter-battery fires prior to initiating close combat**
- **Overwhelming massed attacks on U.S. defensive positions**

Figure 5. Threat Operational Concepts.

BDM also assessed the potential impact on combat outcomes of two WIG lift scenarios in which additional assets were made available to the U.S. ground forces. Similar to the combat mission selection process, a variety of lift possibilities were considered, including deployment of: a heavy corps; an armored cavalry regiment (ACR); and, small (below battalion-size) tailored force packages designed to address specific U.S. in-theater force deficiencies. As will be discussed later in this report, the lift modeling and analysis focused on the lower end of the spectrum of unit deployment possibilities. The purpose of the lift scenario analysis was to support an evaluation of the operational impact WIG technology could have by providing a high speed heavy lift capability to rapidly supplement the other forces in the scenario.

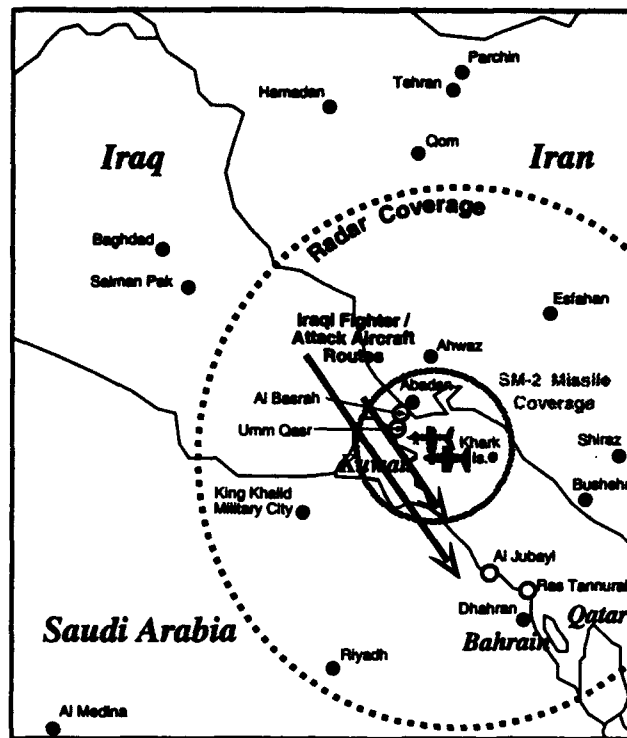
A notional 800 ton gross take-off-weight (GTW) wingship was used for all combat missions, with only slight changes in configuration. A payload fraction of 0.2 (160 tons) was used for this wingship, and a fuel fraction of 0.36 (288 tons). The range for this WIG design has been estimated to be 2900 nms (5370 km), with a speed of 330 knots (611 kms/hour). The WIG was configured with a VLS containing 48 missile cells capable of handling any of the types of missiles required for the simulated combat missions (in some cases, multiple missiles can be loaded into a single cell). For two of the missions (NTACMs and SLCMs) the missile load was somewhat less than the theoretical capacity of the VLS due to WIG weight constraints. The heavy lift WIG was assumed to be a 3,000 GTW design with a payload fraction of 0.2 (600 tons), and at fuel fraction of 0.41 (1,230 tons). The range of this craft is estimated to be 4600 nautical miles, with a speed of 320 knots.

2. Air Defense Application

The air defense mission was performed in the northern Persian Gulf where it was feasible to intercept both Fulcrums and the Fitters en route to their targets from air bases in central Iraq (see *Figure 6*). The missile load for the air defense WIG was 48 standard missile-2 block IV (SM-2 IV). Targeting information was provided by a second WIG equipped with a three dimensional, phased array (Aegis-type) radar (although relay of AWACS information to the air defense WIG was also considered). The missile load proved sufficient to keep an air defense WIG on station for approximately four hours during the high-intensity Day 1 conditions of this threat scenario. The WIG then returned to Ad Daman for resupply (3-1/2 hours to reload missiles plus approximately 1/2 hour transit time to and from station). Subsequent to Day 1, resupply of the air defense WIG was discontinued.

3. NTACM Application

Two wingships were employed in the NTACMs role, each equipped with 32 NTACMs (one per cell) as their primary missile, and 32 advanced medium-range air-to-air missiles (AMRAAMs); (configured for vertical launch, four per cell) for their secondary air defense mission (see *Figure 7*). Both NTACMs wingships performed two interdiction missions against threat ground units early on Day 1. One WIG was assigned a primary mission of destroying the threat FARP. This WIG also had a secondary mission to attack SCUD launchers as real-time targeting information became available. The other WIG was dedicated against maneuver units. Subsequent sorties of both WIGS (after resupply) targeted threat maneuver units. The WIGs moved to approximately 50 kms off-shore for these missions, changing locations rapidly in between launches. NTACM Block I submunition warheads were used against the FARP and the SCUD launchers, while NTACM Block II was used against maneuver targets.



OBJECTIVES

To assess the advantages of deploying high speed, sea-based air defenses in coastal areas to acquire/destroy aircraft at distances far removed from friendly ports/ troop positions.

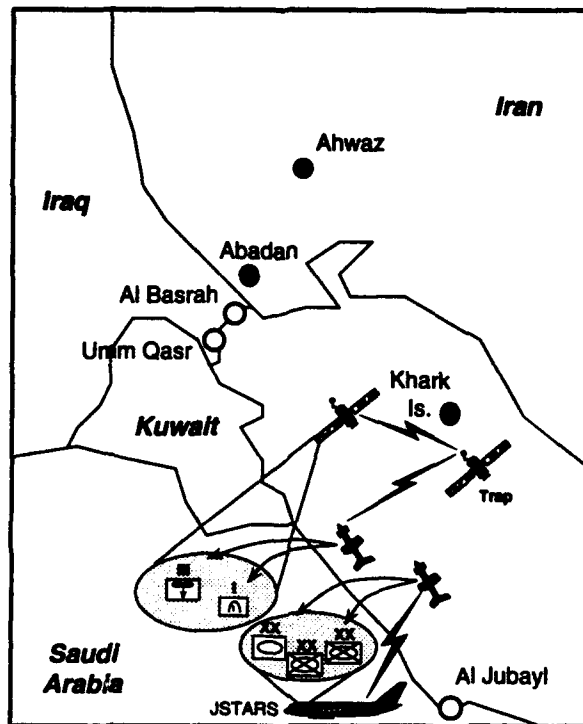
CONCEPT OF OPERATIONS

- Air Defense Missile Wingship and Air Defense Radar Wingship deploy along over-water flight paths used by Iraqi fighter and attack aircraft
- Radar Wingship acquires ingressing hostile aircraft and directs Missile Wingship to destroy targets

SYSTEM CHARACTERISTICS

- Air Defense Missile Wingship
 - 48 missile launch cells loaded with 48 SM-2 Blk IVA missiles (range: 167 km)
- Air Defense Radar Wingship
 - 3-dimensional, phased array (Aegis/GBR-type) radar (acquisition range: 500 km)
 - 8 missile launch cells loaded with 32 AMRAAM for self defense

Figure 6. Air Defense Mission Summary.



OBJECTIVES

To assess the advantages of deploying high speed, sea-based tactical fire support missile systems against massed armored formations, critical mobile targets, and forward aerial refueling points (FARPs).

CONCEPT OF OPERATIONS

- NTACMS Missile Wingships deploy to conduct interdiction of massed armored formations, Scud missile launchers, and FARPs
- Targeting data passed from JSTARS, WIG-launched UAV and/or tactical intelligence sources

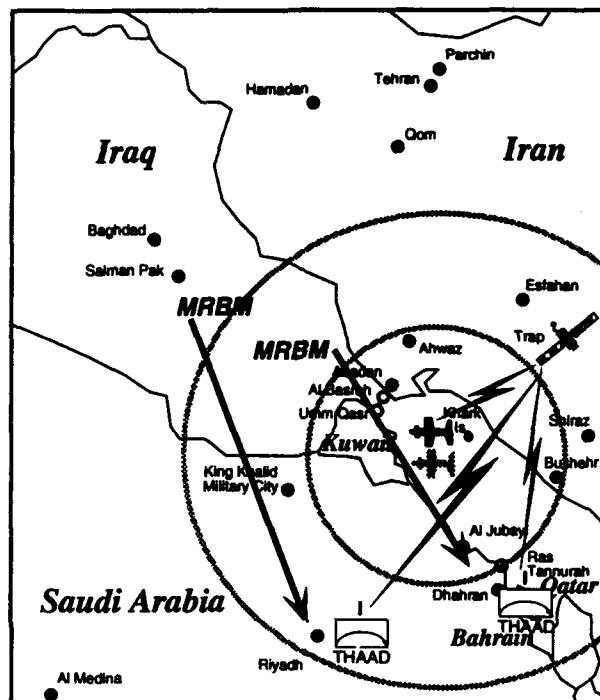
SYSTEM CHARACTERISTICS

- NTACMS Missile Wingship
 - 32 missile launch cells loaded with 32 NTACMS Block I and Block II missiles (range: 160 km)
 - 8 missile launch cells loaded with 32 AMRAAM for self defense

Figure 7. NTACMS Mission Summary.

4. TMD Application

The WIG equipped to perform TMD missions operated in tandem with the forward-based radar WIG, much like the air defense variant (see *Figure 8*). The TMD WIG was equipped with 40 SM-2/low exoatmospheric projectile (LEAP) missiles (one per cell), and 32 AMRAAMs (four per cell) for a secondary self-defense/air defense mission. The radar platform WIG passed acquisition targeting data to both the LEAP WIG and to ground-based THAAD launchers around Riyadh and Dhahran.



OBJECTIVES

To assess the advantages of forward deployment of theater missile defense assets using a high speed, sea-based acquisition, tracking and launch platform to counter SSM launches.

CONCEPT OF OPERATIONS

- Deployment to the far northern region of the Persian Gulf to counter SSM threat posed by Iraqi SCUD/ MRBMs.
- WIG will acquire/destroy airborne SSMs.
- Acquisition and tracking data on unengaged missiles will be passed back to ground-based TMD.

SYSTEM CHARACTERISTICS

TMD Wingship:

- 40 missile launch cells loaded with 40 SM-2 / LEAP (range 167 km)
- 8 missile launch cells loaded with 32 AMRAAM for self-defense

Figure 8. TMD Mission.

The TMD WIG was deployed to the northern Persian Gulf, with its primary mission to intercept launches of the medium-range ballistic missiles (MRBMs) from Central Iraq. Both the TMD and radar WIGs remained on station throughout the three days of conflict.

5. SLCM Application

The SLCM WIG carried a load of 32 Tomahawk land attack missiles (TLAMs), one per cell for its primary mission, and 32 AMRAAMs for self protection (see *Figure 9*). It was deployed to the northern Persian Gulf to react on short warning to detections of launch preparation activities at MRBM sites.



OBJECTIVES

To assess potential advantages gained by using WIGs to launch sea-based cruise missiles.

CONCEPT OF OPERATIONS

- Deploy WIG to northern Persian Gulf.
- Download satellite data on MRBM roll-out/set-up and launch cruise missile strikes.
- Launch Tomahawks against air defense, C3 and other fixed, hardened targets in Baghdad, Baghdad environs, and throughout south/central Iraq.

SYSTEM CHARACTERISTICS

Cruise Missile Wingship:

- 32 missile launch cells loaded with 32 Tomahawk Land-Attack Missiles (TLAM)
- 8 missile launch cells loaded with 32 AMRAAM for self-defense

Figure 9. Sea-Launched Cruise Missile Mission Summary.

The cruise missile technology employed for this mission presupposed future development of capabilities to rapidly reprogram the missile just prior to launch, and/or update missile target data in-flight. A northern Gulf deployment was essential to this mission in order to minimize fly-out time to the target. The modeled MRBM preparation time was approximately 30-45 minutes. The cruise missile fly-out time to targets in southern Iraq would preclude launch from platforms in the southern Gulf given this short targeting window. Only one wingship was employed in this mission.

6. Lift Application

The lift scenarios introduced 3,000 ton GTW WIGs as force generation assets capable of augmenting the base case U.S. early entry force package. Of the three lift variants considered (corps, ACR and small unit), the corps was ruled out because initial analysis indicated the number of WIGs required would be prohibitive. Additionally, time required for assembly of units in CONUS and debarkation to wartime positions in Saudi Arabia would probably exceed the scenario timelines. Examining the other two lift packages, it was decided to start analysis with the tailored, small units designed to fill gaps identified in U.S. combat capabilities in the base case. This analysis indicated requirements to enhance U.S. capabilities in three critical areas: air defense, missile defense, and long-range interdiction of maneuver forces. The small unit force package, therefore, included 8 Patriot launchers, 9 THAAD launchers, 18 MLRS launchers, 24 Marine LAVs specially configured for air defense (25mm guns and Pedestal Mounted Stingers), and all associated munitions reloads, logistics and other support assets. The results of this lift scenario were sufficiently interesting that additional effort was devoted to analysis, while modeling of the ACR was deferred.

E. COMPARISON OF BASE CASE AND WIG EXCURSION RESULTS

This section contains results summaries of the base case scenario and WIG simulation excursions. The first part of the section focuses on a comparison of the base case and combat WIG campaigns, highlighting the collective impact of the WIGs on combat outcomes. Following this scenario overview are brief discussions and statistical summaries of the individual WIG missions. Finally, the two lift excursions are described and compared with the previous cases.

1. Summary of Base Case and Combat WIG Simulations

The threat concept of operations (CONOPS) involved a combined arms corps moving south along two axes to overrun U.S. units and to occupy the staging areas of Al Jubayl and Dhahran. These ground forces were supported by air and missile strikes designed to destroy or disrupt U.S. long-range interdiction capabilities. Threat air and missile attacks therefore focused on U.S. fixed-wing and helicopter bases, and on the nine XVIII Airborne corps MLRS launchers.

The U.S. base case CONOPS centered on exploiting its range and precision targeting advantages to interdict enemy advances and allow time for introducing reinforcements. Initial targeting priorities included suppression of enemy air defenses (SEAD; especially SA-10 radars and launchers) using carrier aviation armed with HARM Block IV. In the first four to twelve hours of the scenario, U.S. targeting was then scheduled to switch to interdict threat maneuver forces. Initial fixed-wing air strikes were to be supplemented by helicopter and MLRS/ATACMS attacks as threat units moved into range.

The maps on the following pages depict relative U.S. and threat unit positions and status at various stages of the base case and combat WIG campaigns. *Figure 10* shows each sides' status sixteen hours after the lead threat elements began to advance at midnight (followed by the main body of ground forces

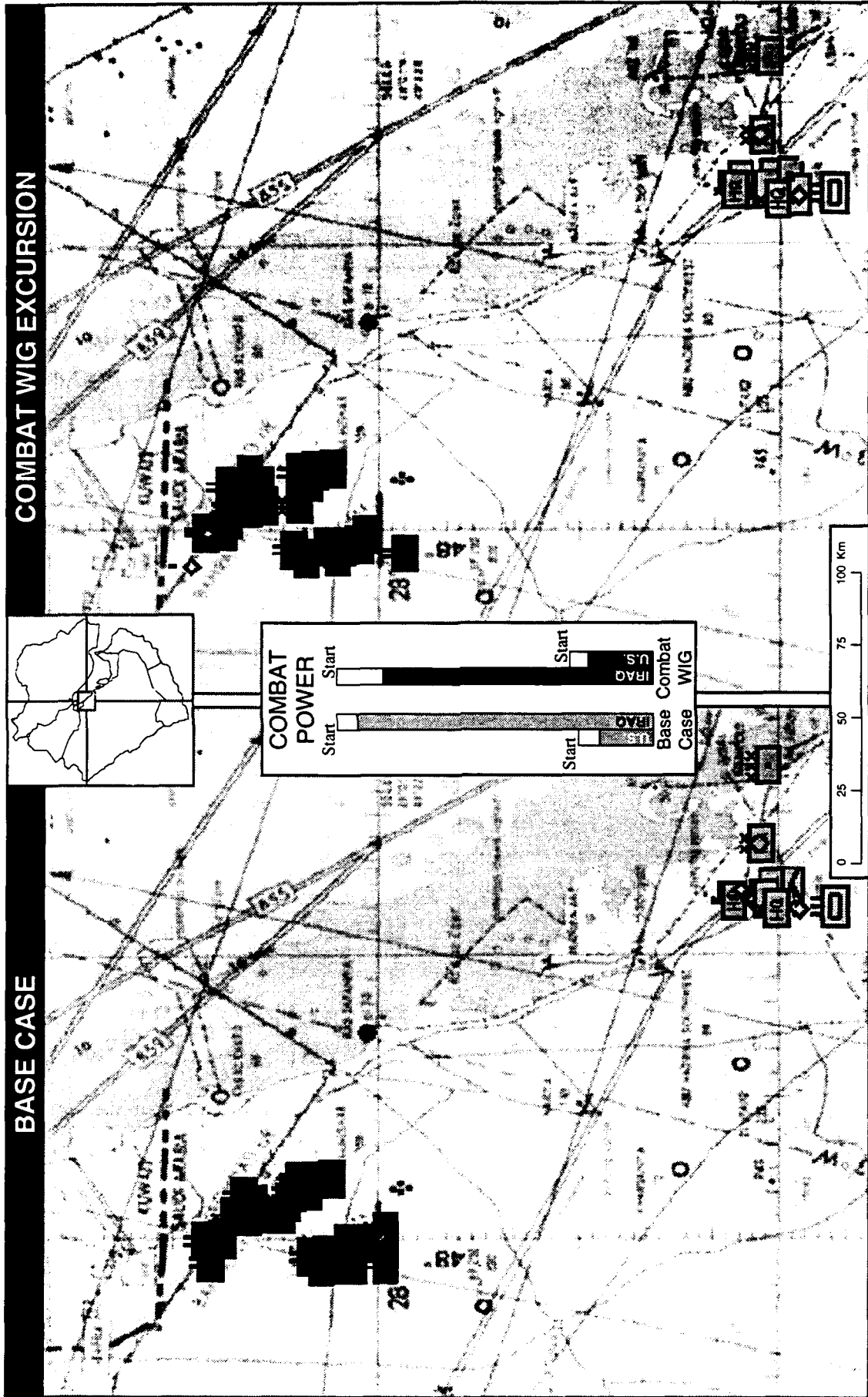


Figure 10. Comparative Combat Results Summary: Day 1, 1600.

beginning at 0400). U.S. unit positions are also shown at the southern part of the map (note: 82d Airborne Battalion positions are indicated by headquarters units to the north and west of U.S. positions, the MEB is in a reserve position in the south).

Each sides losses are depicted in two ways. Units that have suffered concentrated losses sufficient to render them combat ineffective are shown as small diamonds. The level of attrition necessary to cause a loss of unit integrity varies depending primarily on unit type, size and operation, as well as casualty rate (a unit can sustain greater losses without becoming ineffective if the losses occur over a longer time period). Other unit losses (insufficient to cause "unit death") cannot be distinguished from the symbols on the maps, but the combat power bars provide an approximation of each sides' relative strength. These bars were derived by a METRIC post-processing routine that tabulates each sides' starting and current equipment, applies a weighted score to each system, and then displays a cumulative "snapshot" of each sides' combat potential (these post-processed scores are derived from U.S. Army and OSD qualitative measures of effectiveness and are not used in METRIC combat calculations).

According to *Figure 10*, therefore, the U.S. has lost three units (two are colocated) by Day 1, 1600, in the base case (two MLRS batteries, and an artillery battalion). The third MLRS battery has also been reduced to one effective launcher at this point, meaning that eight of the nine original MLRS have been eliminated. U.S. long-range firepower has thus been drastically reduced. In total, the U.S. has lost 37 percent of its theoretical combat power (or 63 percent remaining) by this point in the scenario.

On the threat side, the U.S. SEAD campaign has been marginally effective, with several SAM radars and launchers destroyed. However, only one of the three high priority SA-10 units has been reduced in capability. This is in part due to U.S. data latency and unit misidentification, but is more a result of the MiG-29s performing combat air patrol (CAP) over threat forces. While U.S. air superiority aircraft are able to defeat opposing aircraft on a one-to-one basis, carrier-launched strike aviation are still deterred in some cases from reaching their primary targets. A combination of U.S. aircraft non-availability and continued strong threat air defenses has limited the effectiveness of U.S. interdiction attacks, initiated in the two hours preceding the map depiction. Threat strength is thus at 92 percent of the starting total.

In the combat WIG excursion on Day 1, 1600, the relative positions are improved for the U.S. The air defense, and to a lesser degree TMD, WIGs have helped both U.S. defensive and offensive capabilities. Defensively, higher threat aircraft losses have reduced the number of successful attacks on U.S. ground forces. Offensively, the degraded enemy CAP has relieved some of the pressure on U.S. air forces and allowed more successful strikes—particularly of the critical SEAD missions. As a result, the U.S. has doubled the number of effective kills of threat air defense units (from five in the base case to ten) by destroying missile radars. The Flaplid radar site in one SA-10 battery has been destroyed (although the other two SA-10 units were still missed) and two other air defense units were entirely destroyed. The reduced air defense environment has allowed more successful air interdiction of threat maneuver units, and these attacks have been augmented by the first attacks from each of the NTACMs WIGs.

The greater success of the U.S. air defense campaign has also helped preserve more of its ground forces, including all three MLRS units (although reduced to one effective launcher each). U.S. combat power has thus been attrited but not as significantly as in the base case. Threat losses have doubled over the base case. Relative standings have the U.S. at 73 percent of starting effectiveness versus 85 percent for the threat force.

Figure 11 shows relative unit positions and conditions on the second day of the engagement. In the base case, the U.S. interdiction has been generally unsuccessful and the threat ground forces have advanced

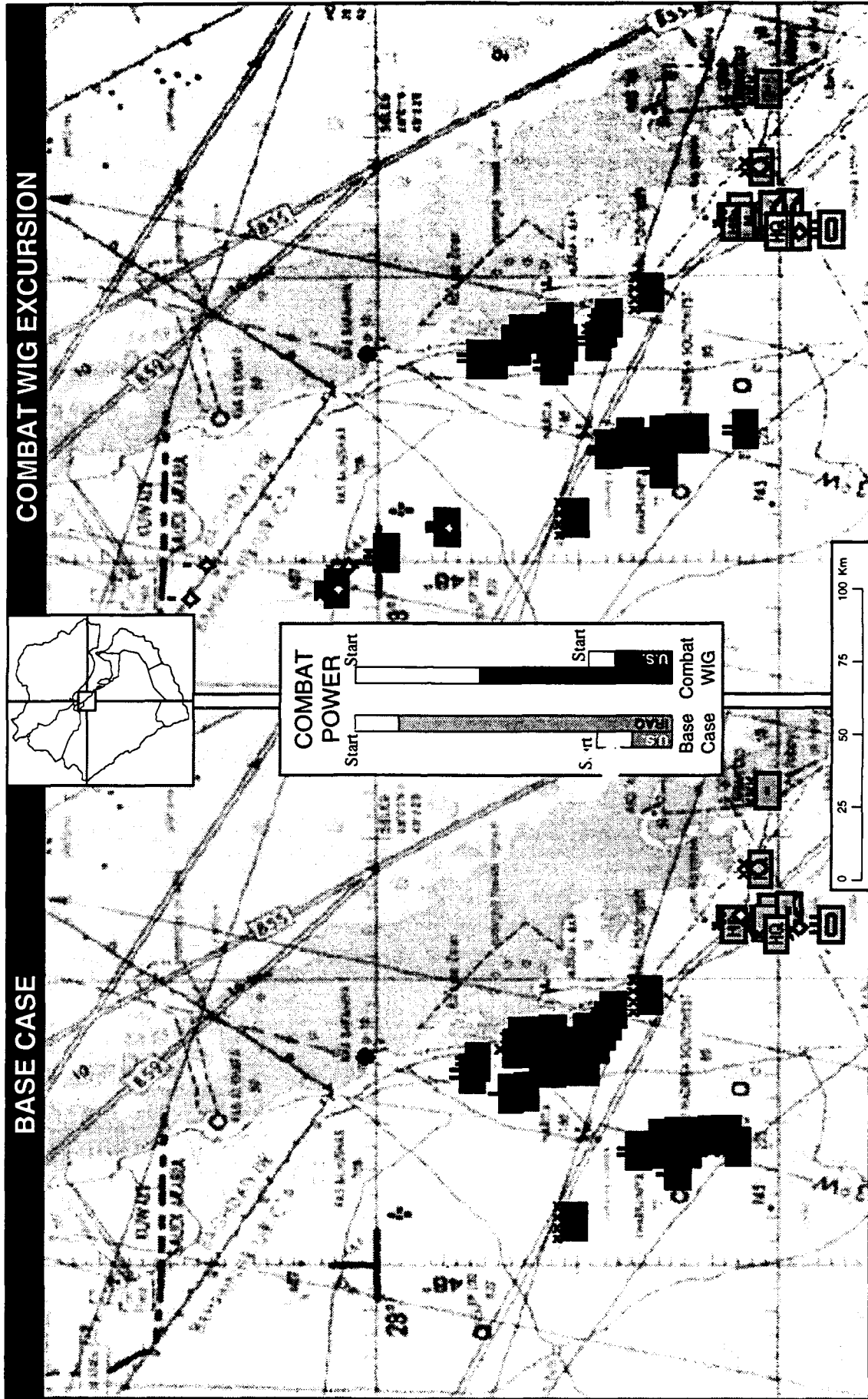


Figure 11. Comparative Combat Results Summary: Day 2, 1600.

in good order along both axes. Both sides have continued to exchange air attacks, but not at the high tempo of the first day. As a result, no additional units have been lost by either side. Equipment losses from the air and missile attacks have continued, however, with the U.S. reduced to 47 percent effectiveness and the threat to 85 percent.

The *Figure 11* maps and bars show a much more significant threat attrition in the combat WIG excursion. The most apparent change is along the inland advance axis where units have been strung out over 200 kilometers due to a combination of attrition, suppression, and loss of higher-level command and control. Less obvious at this level of resolution, the main bodies of troops in both axes have also been disrupted and lost inter-unit cohesion at regimental, brigade, and division levels. Most of the OPFOR maneuver units and many support elements have suffered some attrition and four brigades are less than 50 percent combat effective. The greater success of U.S. interdiction can be attributed mostly to the two NTACMs WIGs, operating off-shore contiguous to the area of OPFOR movement. However, the increased survivability of U.S. ground and air forces due to the air defense WIG interdiction of threat aircraft also contributes significantly to preserving U.S. long-range interdiction capabilities. At this point, most losses on the U.S. side have been sustained by the northern 82nd Airborne element and the Marine reserve. Overall, the U.S. forces are at 47 percent strength while the threat has been reduced to 59 percent.

Figure 12 shows relative unit positions at a higher map resolution on the morning of the third day of combat. In both the base case and excursion, artillery and direct fire contact has been initiated in the north. In the base case, the threat has overrun the U.S. forward positions, although sustaining heavy losses in the process. Lead elements of two tank brigades have bypassed remaining U.S. forward positions and are advancing on the rear area (including the helicopter base and XVIII Airborne Corps headquarters). Of the defending U.S. forces, only the western 82nd elements are still viable, with little artillery or air support. The Marine reserve, which moved north to defend against the first threat attacks, has also been overrun. Meanwhile, the flanking threat force is in good order and has taken relatively light losses due to the concentration of U.S. fire to the north. Total U.S. strength is down to 34 percent, while the threat is at 72 percent, concentrated mostly in the flanking force.

The combat WIG excursion follows a similar sequence of events, although in this case the threat force has been delayed by the U.S. attacks and has only just began its northern assault. Although badly attrited, the U.S. MEB has moved to a blocking position in the north, while the second battalion of the 82nd Airborne is holding its defensive position in the west. The threat has been reduced to 41 percent effectiveness versus 47 percent for the U.S., but it still has a greater than 3:1 direct firepower advantage. Without additional air and artillery support the U.S. forces are still in a precarious position.

Figure 13 shows unit positions near the end of the engagement. In the base case, U.S. ground force resistance has effectively stopped and several threat units have bypassed to the south and east of the U.S. positions. The situation is much the same in the combat WIG excursion, despite the greater success of earlier U.S. attacks. Even in the excursion, the preponderance of threat ground forces negates the offensive and defensive advantages gained from the WIGs (primarily the NTACMs and air defense variants), and U.S. positions are overwhelmed. Although the U.S. holds out longer in the excursion, the introduction of limited numbers of combat WIGs was insufficient to stop the threat advance. Numerous threat units were destroyed, but the remaining forces (38 percent of original combat power versus 71 percent in the base case) are still sufficient to overpower the lightly armed U.S. forces. U.S. strength is 39 percent in the combat WIG excursion versus 30 percent in the base case at the time of the figure.

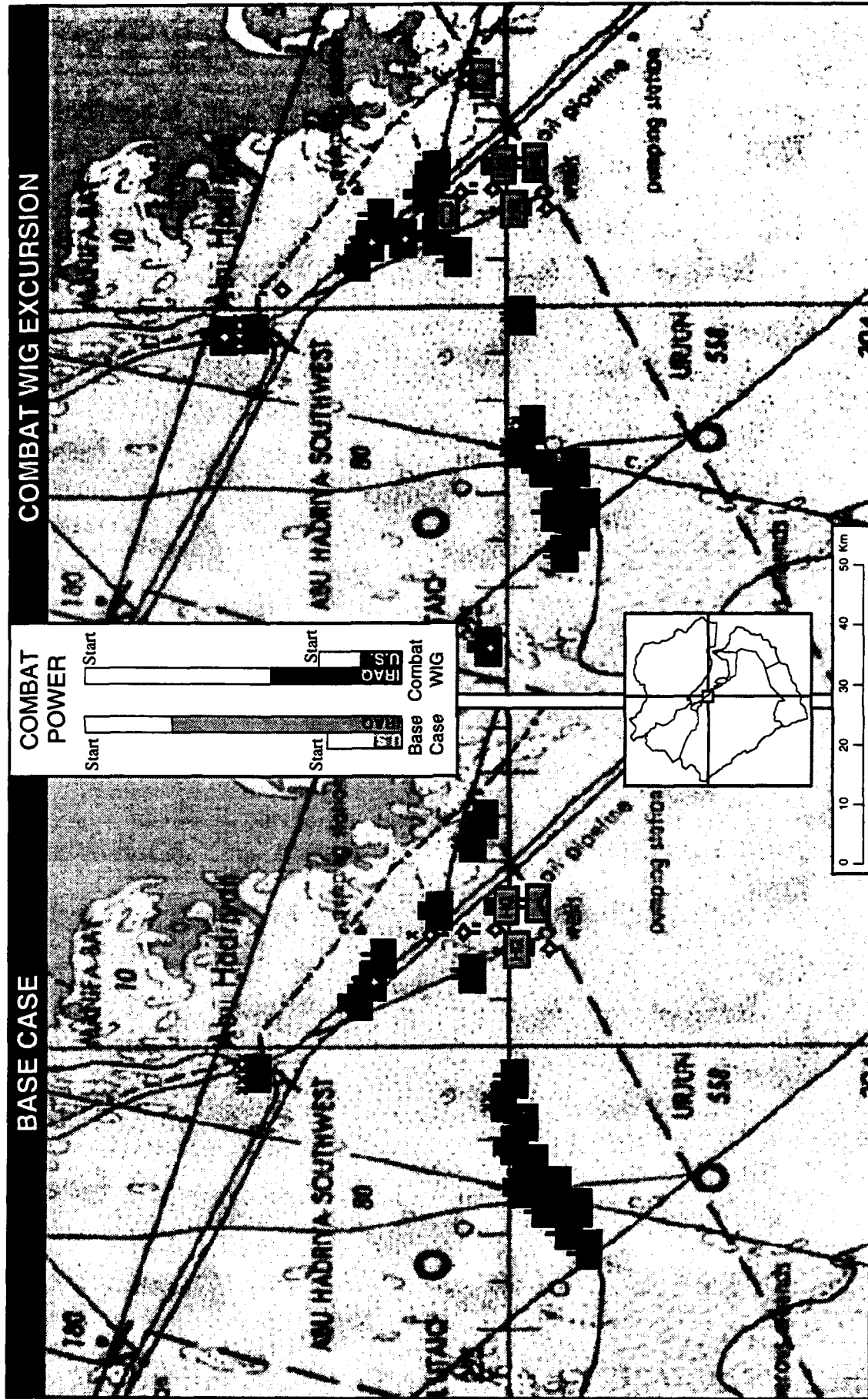


Figure 12. Comparative Combat Results Summary: Day 3, 0600.

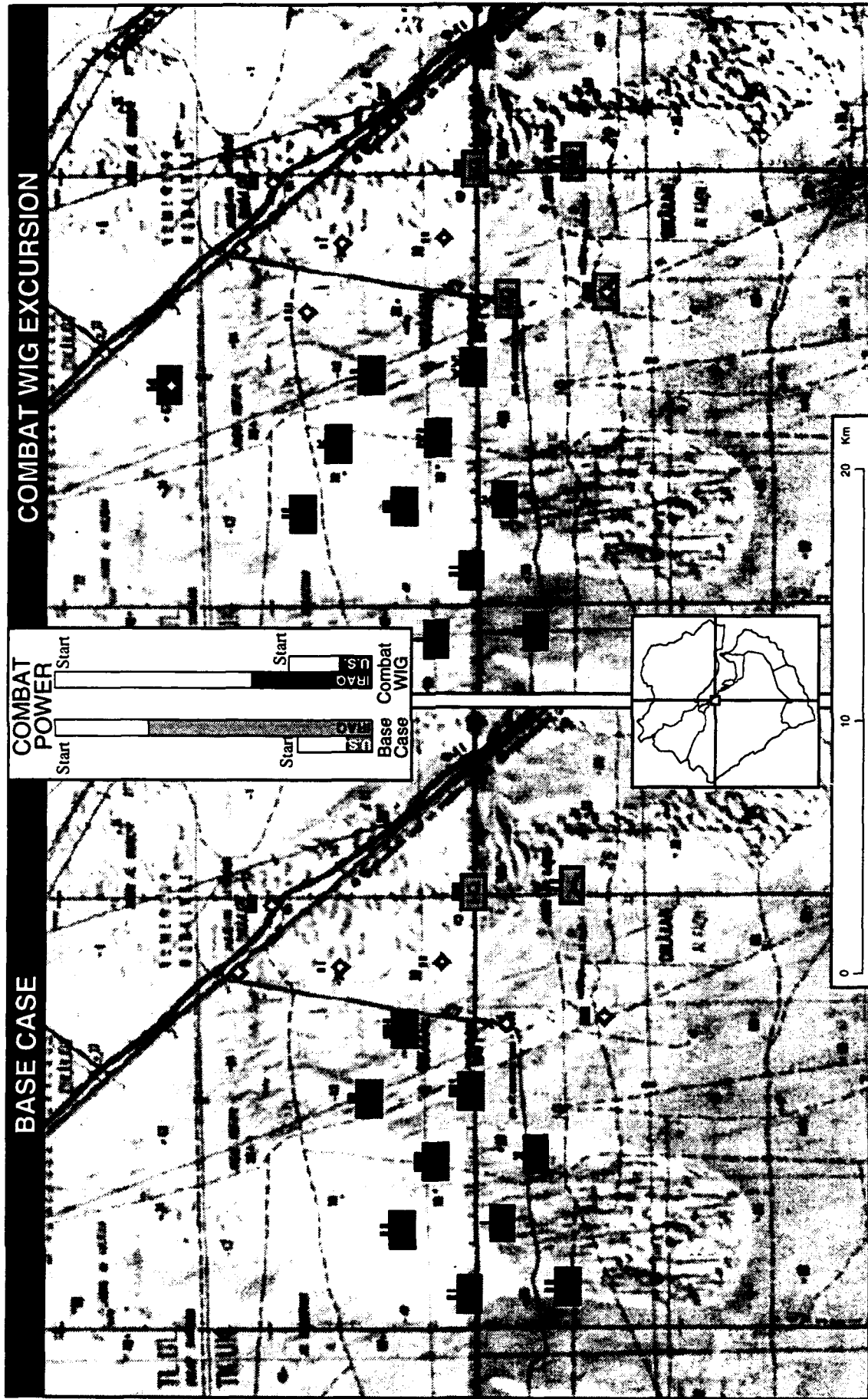


Figure 13. Comparative Combat Results Summary: Day 3, 1400.

The overall campaign impact of the WIG combat missions is depicted in *Figure 14*. As the chart shows, threat losses more than double in the WIG excursion. Despite these losses, however, the threat force retains an overwhelming force advantage as direct fire exchanges commenced on Day 3. This advantage was achieved by threat abilities to neutralize key U.S. assets (primarily MLRS and aircraft) early in each scenario. Consequently, it appears that a potential key to increasing U.S. survivability, and consequently lethality, is to augment the U.S. ground force ability to defeat enemy air attacks. Detailed analysis of base case and excursion results supported development of the lift excursion (described in paragraph 6), in which relatively small numbers of highly lethal advanced systems were added to the U.S. ground forces. Statistics associated with specific combat WIG missions are included in the paragraphs below.

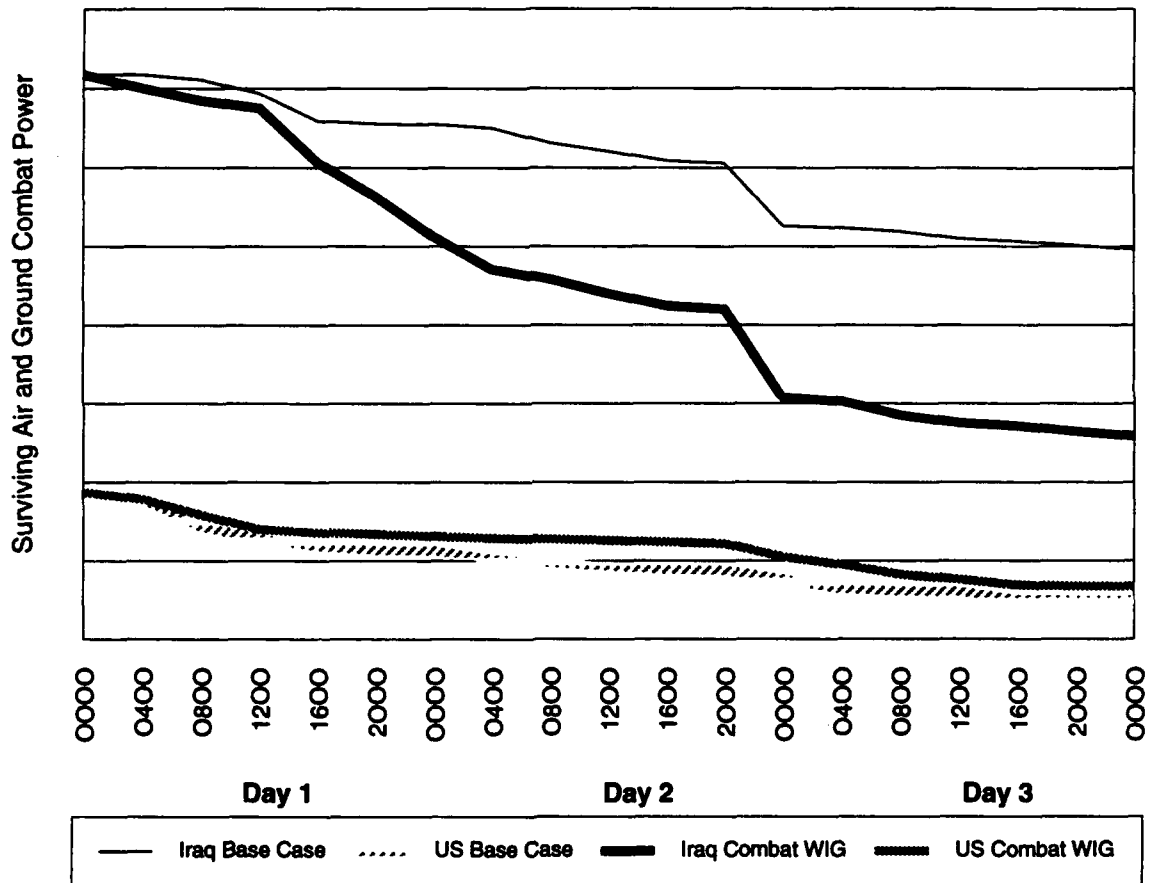


Figure 14. Combat WIG Campaign Impact.

2. Air Defense Mission Results

The air defense WIG deployed to the northern Persian Gulf early on Day 1. In the high-intensity early hours of the conflict, this WIG craft was successful in engaging a large number of Fulcrums attempting to push the threat air defense zone out into the Gulf against U.S. ground attack sorties. As shown in *Figure 15*, the air defense WIG was the largest contributor to Blue air defense during the early stages of the battle. By the end of Day 1, this combat WIG killed 32 Fulcrums, and damaged several other aircraft. After Day 1, the air defense WIG was not further resupplied.

Figure 16 shows relative U.S. and Iraqi aircraft losses over time in the base case and combat WIG excursion scenarios. The impact of the WIGs can be seen in the numbers of aircraft losses sustained by both sides through 1600 Day 1. Threat losses are almost double in the combat WIG excursion over the base case (108 versus 58). About 60 percent of these losses are directly attributable to the air defense WIG, while the rest are a combination of improved U.S. aircraft effectiveness (due to the reduced air threat) and NTACMs strikes against the enemy FARP.

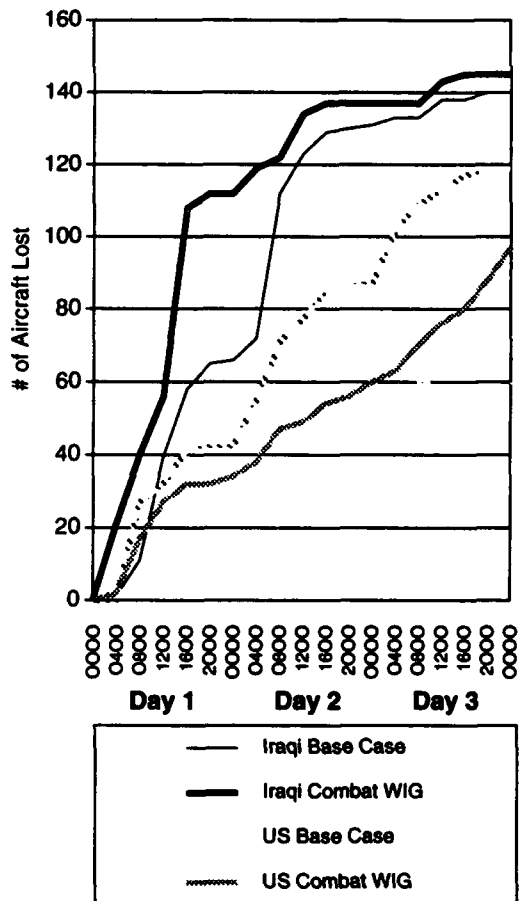


Figure 16. U.S. and Iraqi Aircraft Losses Over Time.

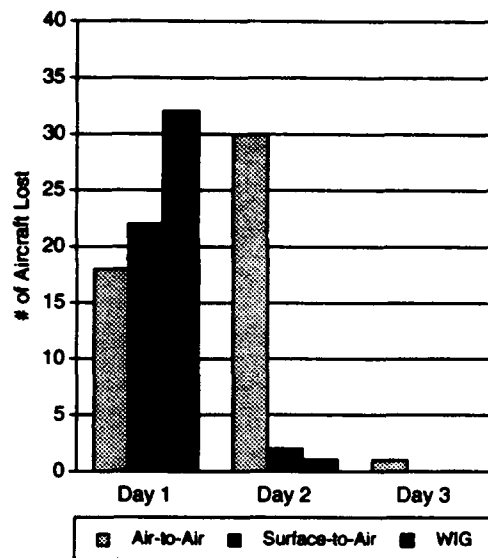


Figure 15. Iraqi Aircraft Losses in Combat WIG Excursion.

While the total number of threat aircraft losses was virtually identical by the conclusion of the base case and combat WIG scenarios, those losses thus occurred much earlier in the excursion. As a result, U.S. air and ground forces survived longer—particularly strike aviation and MLRS—enabling them to inflict more attrition on threat maneuver forces (see *Figure 17*).

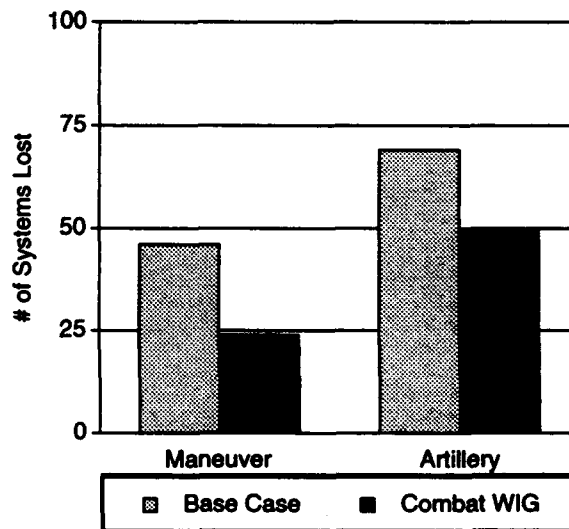


Figure 17. Representative U.S. Air-to-Ground Losses.

3. NTACM Mission Results

The two WIGs fitted out with NTACMs each performed two sorties, with standard loads of 32 missiles. Three of these sorties targeted threat maneuver units, primarily armor, with NTACMs Block II; the other sortie targeted the Iraqi FARP and a SCUD battery with NTACMs Block I submunition warheads. All four sorties were completed between mid-morning and mid-afternoon on Day 1.

As shown in *Figure 18*, Iraqi tank losses increased more than three-fold in the combat WIG excursion as compared with the base case (from 227 to 743). Only 185 of the additional threat tank losses were directly from NTACMs fires. The higher U.S. lethality with the combat WIGs, however, acted as a force multiplier for other systems. The NTACMs mission against the threat FARP, for instance, significantly improved U.S. abilities to interdict threat armor throughout Day 2 and Day 3 because it preempted a second wave of Hind ground attack sorties against U.S. MLRS and artillery that occurred in the base case. The NTACMs strike against the FARP and SCUD battery also enhanced the survivability of U.S. helicopters and freed them up to attack other targets (in the base case, the FARP was interdicted by Apaches during the night of Day 1/Day 2).

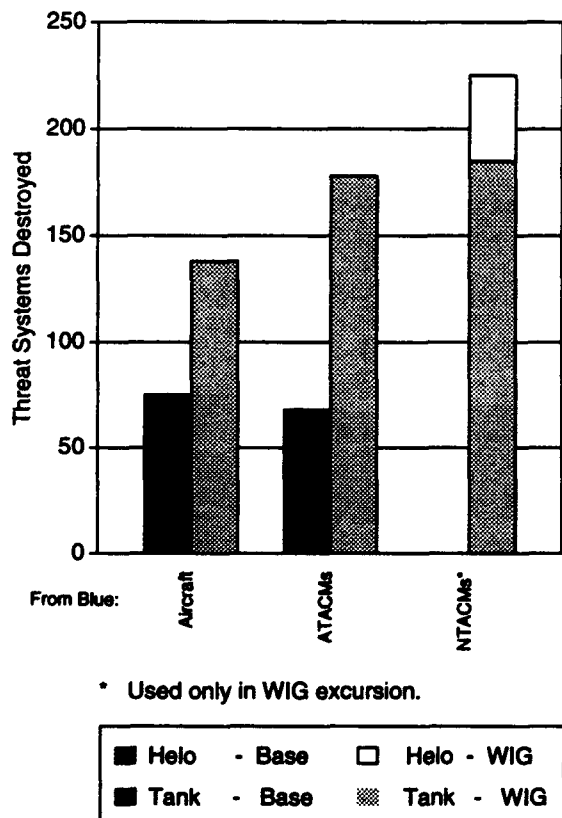


Figure 19. Threat Tank and Helo Losses.

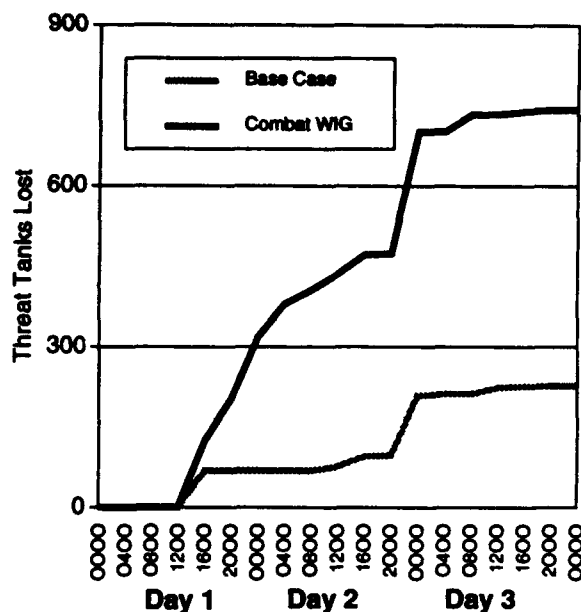


Figure 18. NTACMS Impact on Threat Tank Losses

Figure 19 shows how the NTACMs missions were indirectly responsible for increased tank kills by AH-64s, ATACMs and artillery/direct fire by limiting the damage caused by threat ground and air systems early in the combat WIG scenario. By the end of Day 3, however, the overall survival of U.S. forces remained very similar to the base case. As discussed earlier, at the time the forces approach direct contact late on Day 2, the excursion case threat force still retains an overwhelming advantage in combat power even though it is substantially weakened in comparison with the base case. For instance, the threat still retains 324 tanks in the end of the combat WIG excursion (roughly equal to the number of tanks in a U.S. armored division). This force, including other unit equipment, was still far too strong for the lightly armed U.S. units to stand against in a direct fire engagement. *Figure 20* shows how total U.S. losses were virtually identical by the end of each scenario.

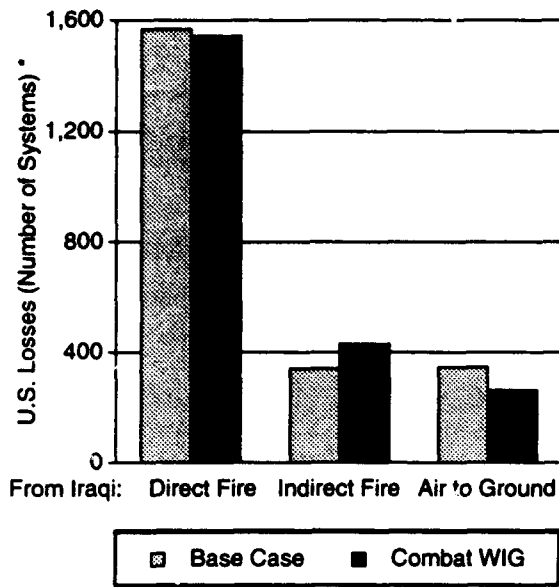


Figure 20. NTACMS Impact on Final U.S. Losses.

were intercepted over Riyadh and Dhahran, requiring a total of fourteen THAAD missiles. In the excursion, only one MRBM struck a target—versus five base case MRBM strikes—because of the successful intercept of three missiles by the TMD WIG, and interdiction of a fourth on the ground by the SLCM WIG (see Figure 22). The lack of improved terminal intercepts was probably a function of how the hand-off of forward radar data was handled in the model; although saturation of the single THAAD launchers at Riyadh and Dhahran may have also affected the outcome. Additional analysis may be appropriate to investigate both

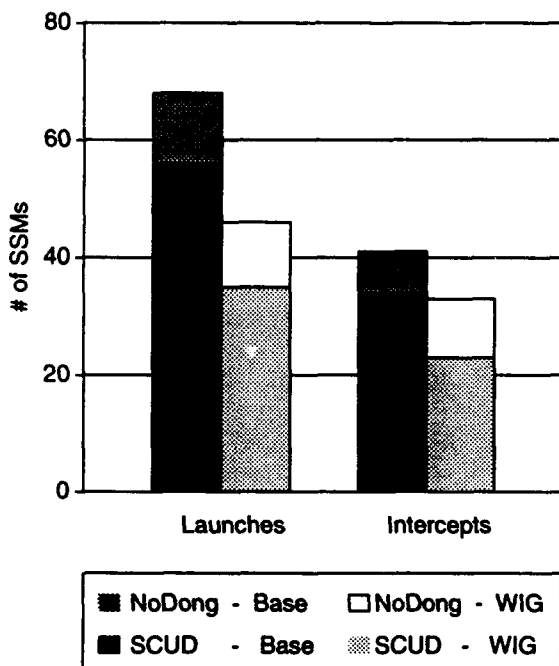
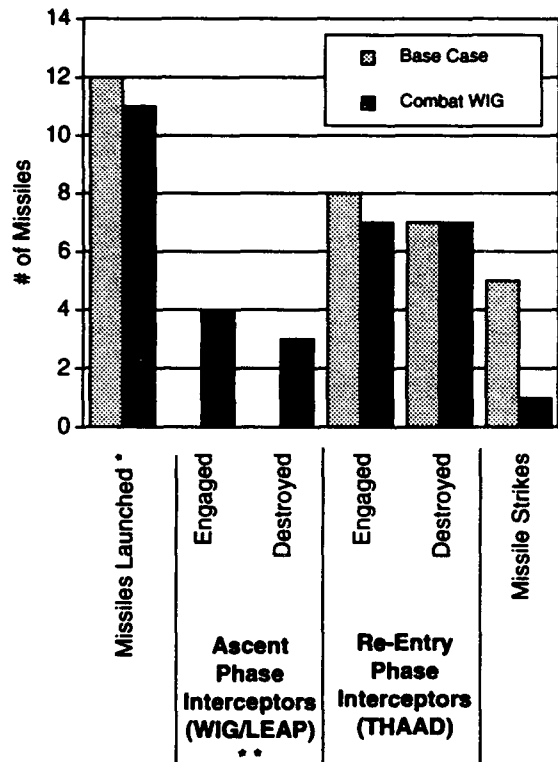


Figure 21. Summary of Threat SSMS

4. TMD Mission Results

The WIG TMD mission involved one WIG armed with 40 SM-2/LEAP missiles on station to intercept MRBMs throughout the engagement. As Figure 21 illustrates, threat MRBMs and SCUDs were able to saturate the 2 THAAD launchers comprising U.S. base case TMD, with 26 threat SSMS penetrating missile defenses. In the WIG excursion, the total number of successful threat missile strikes decreased to 8.

The LEAP WIG succeeded in destroying three MRBMs during their ascent phase, and the radar WIG provided tracking data beyond the range of the THAAD radars. Despite the improved acquisition and tracking data provided to the terminal defenses, no improvement in MRBM intercepts was seen. In both the base and excursion cases, seven MRBMs



* One MRBM destroyed on pad by cruise missile in combat WIG excursion
 ** Not used in Base Case

Figure 22. TMD Results Against MRBMs.

these possibilities. Some saturation problems persisted in the excursion case, indicating a need for increased numbers of TMD launchers.

5. SLCM Mission Results

One combat WIG was deployed to the northern Persian Gulf late on Day 2 to attempt preemptive strikes against MRBM launch areas in southern Iraq. This WIG was equipped with Tomahawk cruise missiles. Once on station, the SLCM WIG waited for detections of launch preparation from overhead sensors watching the target area. The WIG's northern deployment was intended to shorten missile fly-out time to target because the anticipated reaction window, from detection to MRBM launch, was approximately 30-45 minutes.

Preparation activities at the MRBM site were detected at midnight on Day 2, and the SLCM launch occurred 25 minutes into Day 3. This rapid launch sequence on the WIG would require an ability to quickly reprogram the Tomahawk just prior to launch or in flight. Fly-out time to the target was 17 minutes and one launcher was destroyed several minutes before a MRBM would have been fired. The effect of this mission was to reduce the total MRBM firings by just one, but the mission did demonstrate the potential value of a shortened fly-out time that can result from the ability to rapidly move a SLCM platform into an extreme forward deployment.

6. Lift WIG Excursions

The purpose of the lift WIG excursions was to test the impact of introducing additional U.S. force increments into the base case scenario (i.e., without the combat WIGs). It was assumed for this initial analysis that large WIGs (3,000 ton GTW) would serve as the lift platforms. Analysis of other potential lift platforms was not conducted (in keeping with the initial task to assess potential WIG military missions, with trade-offs analysis of competing systems to follow).

Threat objectives and CONOPS were not changed from the base case to the lift WIG excursions. The only new elements were the improved U.S. offensive and defensive capabilities represented by the additional MLRS, THAAD, and Patriot launchers, and USMC LAV-AD vehicles. The early stage of the lift WIG excursion, therefore, closely parallels the base case results. By 1600 on Day 1 (corresponding to the base case unit position and status displayed on *Figure 10*), threat forces were reduced to 90 percent effectiveness. The slightly higher threat casualties relative to the base case scenario (2% additional losses) reflect the loss of some additional aircraft to the improved U.S. air defenses. However, the overall difference is slight because the threat forces have not yet moved within range of the U.S. MLRS/ATACMS batteries.

The impact of the additional force increment on U.S. survivability to this point is more dramatic. Although the U.S. is still taking heavy losses from threat air attacks (especially helicopters), total combat strength remains at 75 percent of the starting total, versus 63 percent in the base case (note: the additional force increment also raised the U.S. combat power calculus by about 10 percent according to the methodology used so actual U.S. strength at the time is equivalent to 83 percent of the base case starting total). Most importantly, significantly greater numbers of U.S. MLRS assets are surviving as compared with the base case. In the lift WIG excursion at the time, 21 of 27 MLRS, divided into nine batteries, are still active (although three additional MLRS are killed within two hours and well before the mass of threat ground forces moves within range). In the base case at this time, eight of nine starting MLRS had already been lost. U.S. capabilities to interdict threat ground forces are thus significantly higher than in either the base case or combat WIG excursion (no MLRS survived to fire ATACMs in the base case; two NTACMs

WIGs, each with roughly an MLRS battery of firepower, and three MLRS—totaling the equivalent of nine MLRS—were used in the combat WIG excursion).

The effects of these additional U.S. interdiction resources are seen as threat losses increase substantially starting in the morning of Day 2. The biggest impact comes between midnight and 0400, when threat advances first bring them within ATACMs range. Almost 20 percent of all threat losses throughout the lift WIG excursion are sustained in this four-hour period. By 1600 on Day 2, effective threat combat power is down to 52 percent, which compares favorably with the base case at 85 percent, and the combat WIG excursion at 59 percent. U.S. survivability continues to improve relative to the base case (62 percent versus 47 percent; a 15 percent relative improvement in survivability).

As the threat forces continue their advance into Day 3, the cumulative impact of attrition becomes more apparent. In addition to the losses causing substantial reductions in unit effectiveness, significant threat forces have stalled in their advance south (see *Figure 23*). The latter result is primarily caused by a combination of unit suppression from incoming fire, and losses of coordination with higher command and control echelons. The breakdown of C3 functions substantially undermines threat unit coordination, and in some cases, follow-on advance orders are delayed or never received. By Day 3, 0600, the remnants of the threat force reach contact with U.S. positions. By this time, the only effective threat units are elements of one armored brigade, a reconnaissance battalion, and supporting artillery and air defense. At 17 percent of starting combat strength, however, the threat force is still larger than the remaining 47 percent of U.S. forces (for instance, threat tanks number 113, as compared to 30 for the U.S.).

The map on *Figure 23* shows the furthest reaches of the threat advance. The map inset gives a clearer picture of the actual forces in contact as described above. Due to suppression effects, the timing of the two flanking maneuvers has been disrupted. As the map inset shows, the U.S. is able to deploy the Marine reserve in a blocking position against both attacks, rather than being overrun (as in the base case), or drawn significantly out of position (as in the combat WIG excursion). The *Figure 23* graph shows the difference between the relative combat strengths of both sides in the base case and lift WIG excursion. As is apparent from the chart, threat strength in the excursion is about one-fifth the base case level, while the U.S. is doing much better than in the base case. The main driver of the difference in threat combat power is represented by the steep decline in the lift WIG excursion curve on Day 2 representing the impact of the ATACMs. This sharp decline is absent in the base case due to successful threat interdiction of U.S. MLRS units. The second major decline in threat excursion strength between Days 2 and 3 is caused by the greater survivability of U.S. artillery and direct fire assets as compared with the base case.

With some of the threat combat power tied up in units farther north, and superior U.S. tactical C2, threat forces in contact actually end up facing localized inferiorities. In the hours following the *Figure 23* map, therefore, the U.S. is able to force the surviving threat units to retreat with substantial losses. At the end of the scenario, the last threat units to reach the U.S. positions have taken up a defensive position in favorable terrain (southwest of the inset map). At 200 miles from main supply bases and within easy reach of U.S. artillery and aircraft, however, the threat position is untenable. The scenario was therefore terminated at the end of Day 3.

Based on the success of a relatively modest introduction of force in the lift WIG excursion, the ACR scenario was temporarily suspended. Instead, additional analysis was devoted to an excursion that combined the elements of the combat and lift WIG scenarios. This scenario (henceforth referred to as the combat WIG lift excursion) added the six combat WIGs, with the same configurations and operational concepts as previously employed, to the initial lift excursion scenario. *Figure 24* shows the results of this final excursion.

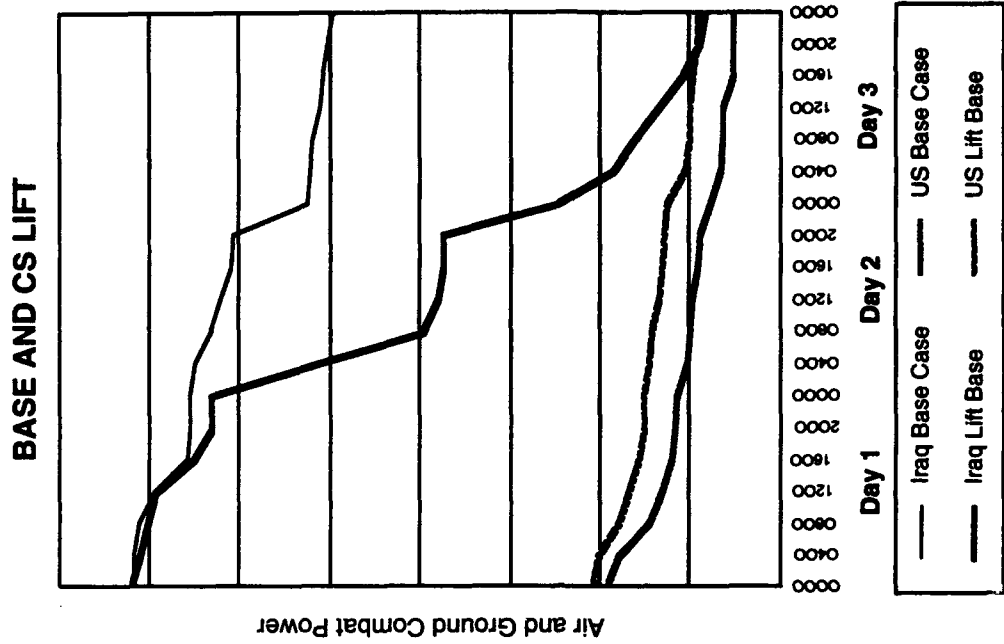
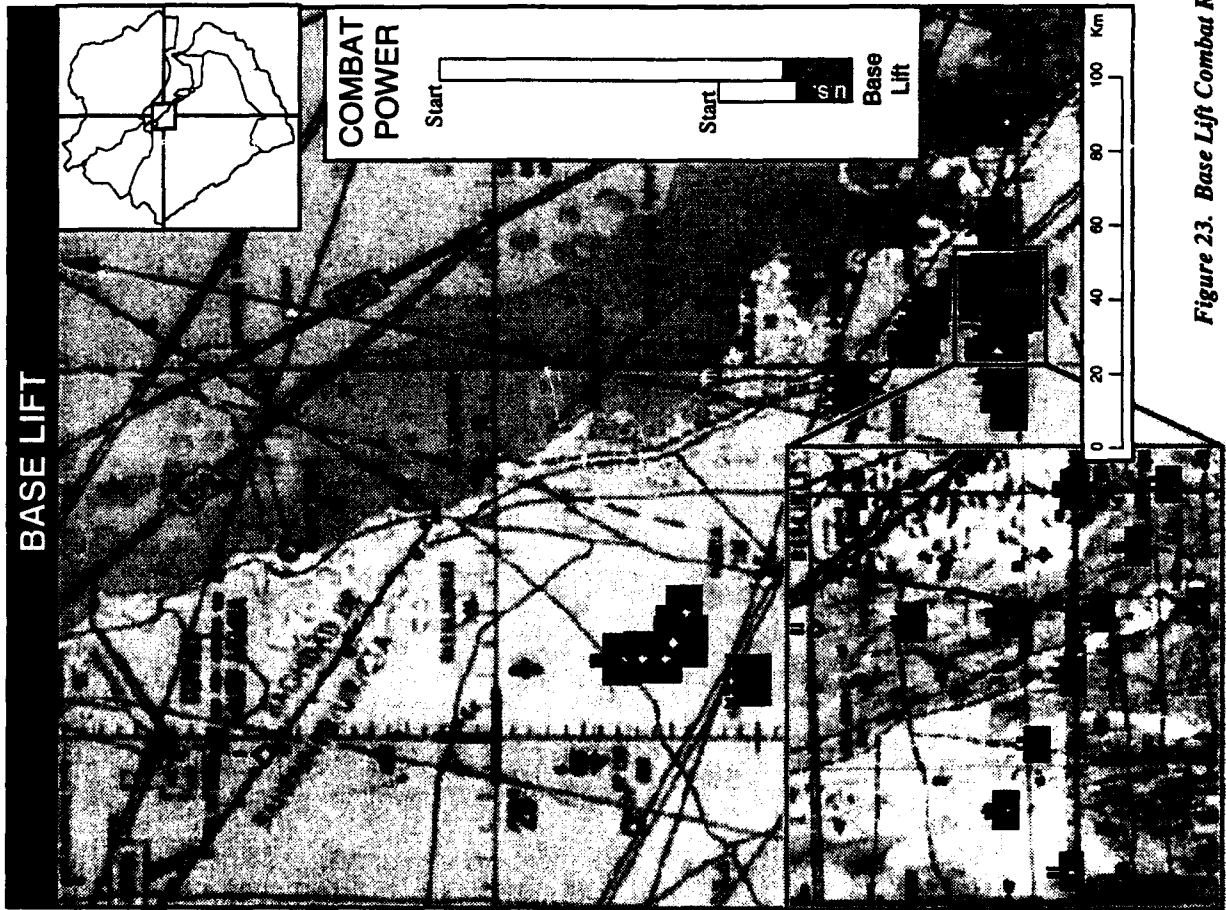


Figure 23. Base Lift Combat Results Summary: Day 3, 1400.

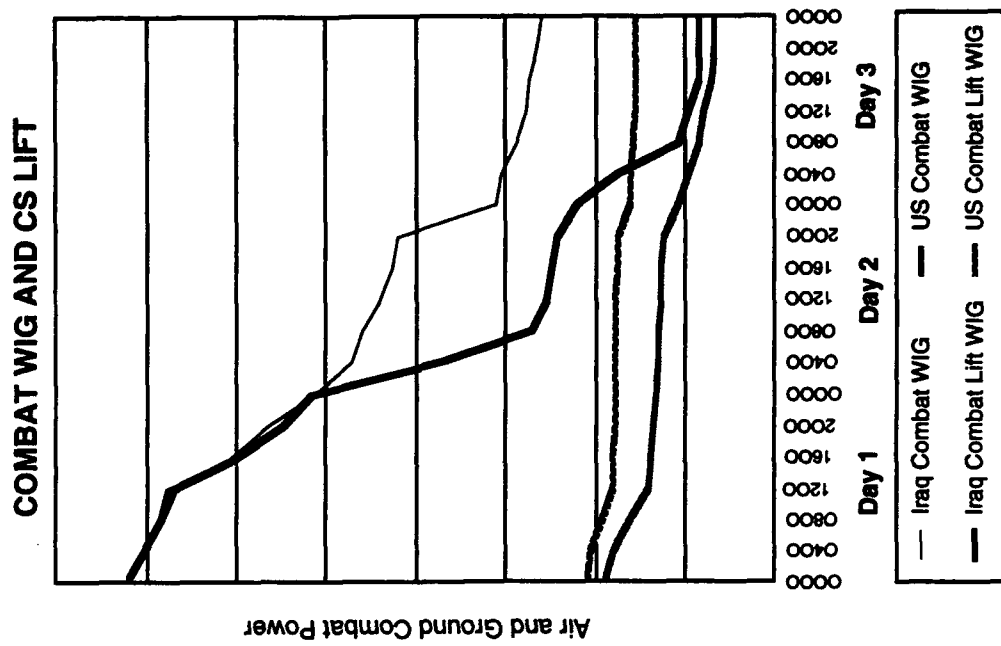
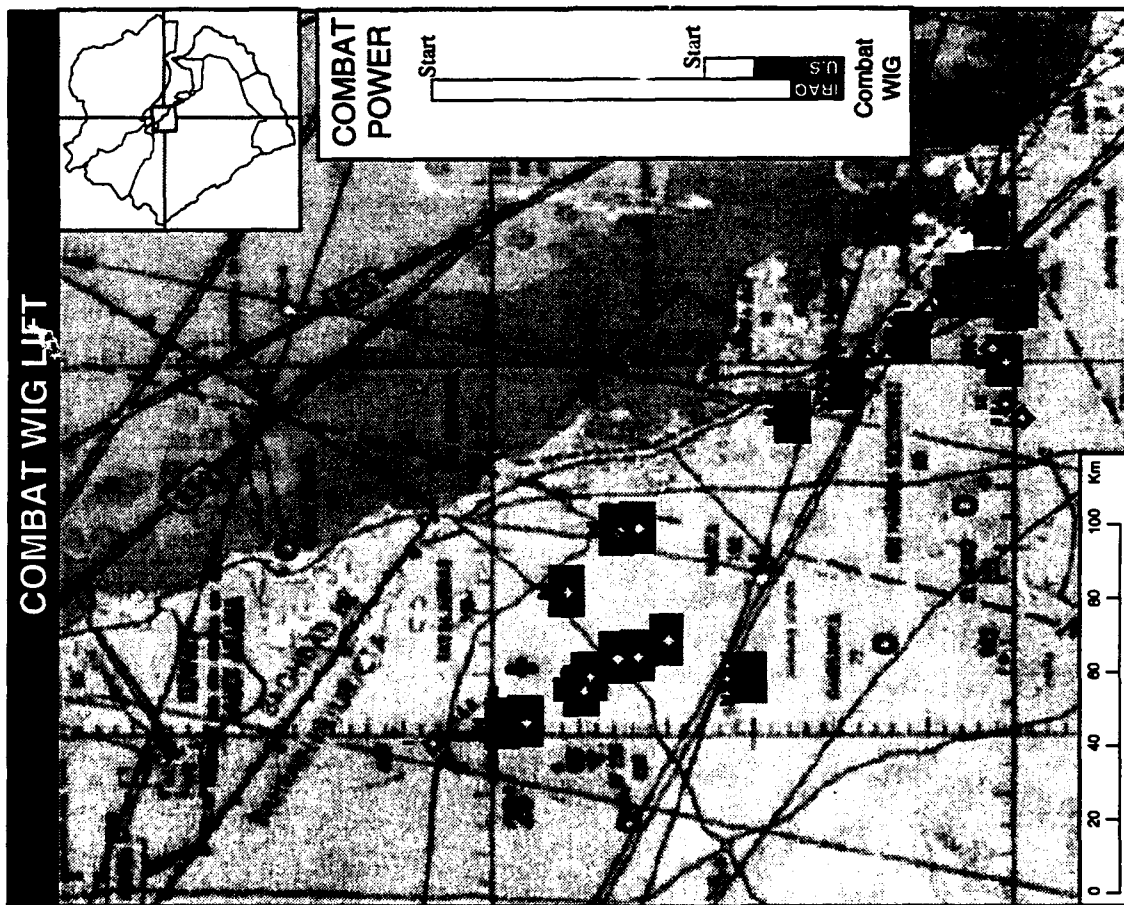


Figure 24. Combat WIG Lift Combat Results Summary: Day 3,1400.

The combination of small numbers of seaborne combat WIGs with the additional ground force increment was dramatic. In the previous model runs, the U.S. had only been able to substantially disrupt the threat advance at most once outside of the final close combat phase of the engagement: (late in Day 1 with the NTACMs combat WIGs; early Day 2 with the additional lift MLRS and not at all in the base case). With the combat WIGs (especially NTACMs) and high numbers of surviving MLRS (23 in the combat lift WIG versus 18 in the lift WIG), the U.S. is able to continuously interdict the threat forces. The results of these attacks can be seen on both the map and chart on *Figure 24*. With constant bombardment of N/ATACMs, numerous threat units are stalled or eliminated. The accompanying chart shows the steep decline in threat combat power. *Figure 25* shows the relative standings of both sides at the four checkpoints used earlier in this analysis.

	Starting	Day 1, 1800	Day 2, 1800	Day 3, 0600	Day 3, 1400
Base Case					
U.S.		63%	47%	34%	30%
Threat		92%	85%	72%	71%
Force Ratio (Threat: U.S.)	3.8:1	5.5:1	6.9:1	8.3:1	9.1:1
Combat WIG					
U.S.		73%	66%	47%	39%
Threat		85%	59%	41%	38%
Force Ratio (Threat: U.S.)	3.8:1	4.5:1	3.4:1	3.3:1	3.8:1
Lift WIG					
U.S.		75%	62%	49%	47%
Threat		90%	52%	24%	17%
Force Ratio (Threat: U.S.)	3.5:1	4.2:1	2.9:1	1.7:1	1.2:1
Combat Lift WIG					
U.S.		86%	84%	76%	74%
Threat		84%	34%	19%	12%
Force Ratio (Threat: U.S.)	3.5:1	3.4:1	1.4:1	0.9:1	0.6:1

Figure 25. Relative Combat Standings at Key Engagement Times

F. CONCLUSIONS

Based on the analysis conducted, WIGs appear to have a high potential to perform militarily useful missions. The addition of a relatively modest force of six combat WIGs and critical ground combat assets reversed the base case outcome in the final excursion as the Figure 25 table shows. The improvements to U.S. force lethality and survivability in the successive cases are significant and traceable to the new elements represented by the WIGs. The firepower of the NTACMs and MLRS/ATACMs units play the most prominent roles in defeating the threat forces. The importance of the additional WIG- and ground-based air defenses in protecting the U.S. forces, however, should also be emphasized.

Having stated that a high potential for militarily useful WIG missions exists, it is important to note several caveats. Most significantly, the chosen scenario represents an almost ideal proving ground for the selected WIG applications. The presence of a heavily mechanized force, moving a long distance in open terrain adjacent to coastal areas, presents an optimal interdiction target set. This does

not mean the scenario is unrealistic for planning purposes, but the WIG roles must be evaluated against the range of potential conflict environments involving U.S. forces. Similarly, alternative operational concepts for WIG employment could significantly change their relative combat contributions.

Related to the previous caveat is the need to assess other potential WIG applications. Several possibilities such as mine warfare, special operations and amphibious assault seem appropriate to the existing scenario. Other scenarios involving different conflict environments and intensities would probably suggest additional applications for consideration. Assuming that only small numbers of WIGs would ever be available for deployment—consistent with current capital ship numbers—it will be important to demonstrate multi-mission flexibility. The viability of WIG concepts would be further enhanced if commercial or dual-use applications could be developed. The ability to operate in a wide variety of roles will therefore be key to proving WIG concept utility.

Another scenario consideration that should receive special attention is the ability of WIGs to operate in nuclear, biological and chemical (NBC) environments. Given continued proliferation trends, all major U.S. force structure planning should include the possibility of threat employment of NBC weapons. If WIGs can operate in such environments, other mitigating technical and operational factors may be offset. The speed and mobility of combat WIGs may make them more difficult targets for NBC weapons than stationed ground forces. If lift WIGs can operate at low/no infrastructure locations, U.S. power projection capabilities would also be significantly enhanced, especially if traditional air and sea ports have been shut down due to NBC use. The integration of conventional and NBC operations, therefore, appears to be an important area for future WIG assessments.

Several caveats emerging from the current analysis concern the technical viability of WIG concepts. Detailed engineering studies obviously must be conducted, although such are outside the purview of this analysis. Some basic technical factors (e.g., weight and volume limitations, fuel fractions, etc.) were considered and additional model-assisted analysis could be conducted. A principal focus for this analysis should be to conduct vulnerability assessments of WIG concepts under different operational conditions. These assessments could be done based on one-on-one or few-on-few engagements, as well as in broader scenario contexts. The results of this analysis will not provide definitive WIG vulnerabilities (impossible without tests against a real system), but will provide important benchmarks for WIG designs. If WIG designs cannot meet vulnerability/survivability criteria, then overall military utility must be questioned.

Possibly the most significant obstacle to WIG development is the projected cost of the technical solution. Cost effectiveness will be key in determining if WIGs can perform missions better than competing platforms. Detailed cost estimates should be conducted and factored into existing and future operational assessments. The operational integration is important because economic trade-offs between systems should be balanced with potential military consequences. For instance, the deterrent value of being able to deploy and loiter significant WIG combat power around the world in very short time periods should be factored into the research, development and acquisition planning process. If future WIG utility assessments indicate an opportunity for filling a crucial U.S. military requirement, then the cost of not building and deploying such a system or force, both in economic terms and in human lives, may be high if the required mission cannot be adequately fulfilled by other means. Future assessments should include emphasis on identifying such opportunities for unique WIG contributions to U.S. military capabilities.