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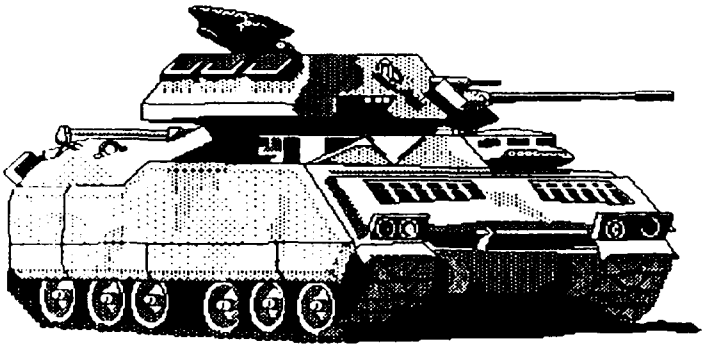
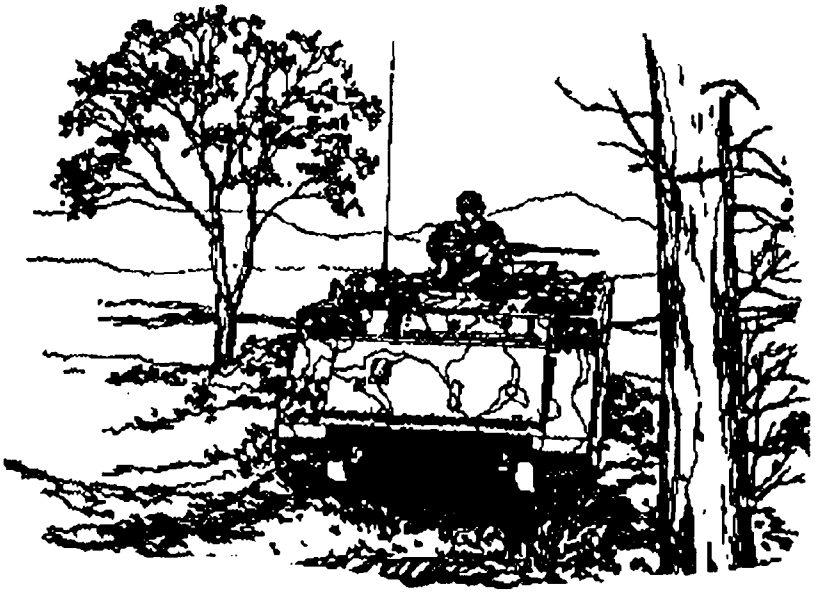


SCOUT SENSOR REQUIREMENTS STUDY



DIRECTORATE OF COMBAT DEVELOPMENTS
UNITED STATES ARMY ARMOR SCHOOL
FORT KNOX, KY 40121
21 JULY 1989

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This study develops a USAARMS position on sensor requirements for light and heavy scouts. Due to ill-defined sensor requirements, the Army has procured sensors for scouts in a piecemeal fashion based on existing technology rather than to meet an identified need. This study examines tactical requirements (required warning times), real world terrain (Europe and Southwest Asia lines of sight), and atmosphere constraints (weather induced visibility levels) to derive sensor requirements for scouts.

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SCOUT SENSOR REQUIREMENTS STUDY

21 July 1989

Directorate of Combat Developments
U.S. Army Armor School
Fort Knox, Kentucky 40121

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Ms. Paula Anthony

SCOUT REQUIREMENTS STUDY

Table of Contents

1. Executive Summary

1-1. A scout on an observation post (OP) can expect to have almost 4000m line-of-sight (LOS) in W. Europe (WEUR) and 5000m in Southwest Asia (SWA). Weather will inhibit his observation significantly (20-30% of the time) in WEUR but not significantly elsewhere.

1-2. Scouts need to recognize turret-sized targets at 2 km and detect them at 5 km to provide the information needed for battalion operations.

1-3. Scouts require a mix of thermal, image intensification (I2), and direct-view optics to have all-weather capability.

1-4. Scouts need to emplace unattended sensors to allow the battalion to monitor follow-on forces after the scouts displace.

1-5. Current sensors fielded in heavy division scout platoons do not meet the scouts' requirements.

2. Introduction.

2-1. Purpose. Develop a USAARMS position on sensor requirements for light and heavy scouts.

2-2. Background. The sensor requirements for scouts are ill-defined. Consequently, the Army has procured sensors for scouts in a piecemeal fashion based on existing technology rather than to meet an identified need. The requirements for light and heavy scouts must be defined in terms of real world terrain and atmospheric constraints and tactical requirements.

2-3. Scope. Current heavy battalion scout platoons are considered the base case. Heavy scouts are limited to man-portable line-of-sight (LOS) or acoustic sensors. Light scouts are limited to lightweight LOS or acoustic sensors. Only sensor performance requirements are identified. Total reorganization of the platoon is outside the scope of this study.

2-4. Assumptions.

2-4-1. The terrain is sufficiently homogeneous to permit generalization of insights gained by looking at individual map sheets.

2-4-2. Weather data collected by multiple observers in widely scattered locations are consistent.

3. Essential Elements of Analysis.

3-1. How far will the terrain allow a scout to see in Southwest Asia (SWA) and Western Europe?

3-2. How often is sight limited by weather?

3-3. To what distance is sight limited by weather?

3-4. How far out must scouts detect, classify, recognize, or identify targets?

3-5. How much warning of an enemy force does a battalion need?

4. Methodology

TERRAIN

4-1. Line-of-sight (LOS) was determined from the Tactical Terrain Intervisibility Classification Study (Oct '86) done by TRADOC Analysis Command, White Sands Missile Range, NM (TRAC-WSMR). This study catalogues the intervisibility ranges in W. Europe (WEUR) and Southwest Asia (SWA). The First Opening Range (FOR) is defined as the first distance at which an observer on military significant terrain has LOS with an attacking force moving on all attack routes on the map sheet. FOR is used as the longest LOS available from an observation post.

4-2. The 84th percentile LOS distance equates to the average FOR plus one standard deviation. This study used the 84th percentile FOR as the distance that the ground will allow a scout to see. By definition, scouts can see farther 16% of the time, but configuring equipment to the last few percent will add disproportionately to their size, weight and complexity. It is our intent to provide the scout platoon adequate capability in the vast majority of instances.

WEATHER

4-3. Atmospheric Sciences Laboratory (ASL) at White Sands Missile Range provided data on the frequency of visual obscuration due to atmospheric conditions in *WEUR, SWA and LATAM.* This study evaluated ASL's data to determine mixes of sensors required to provide adequate capability for scouts. Again the 84th percentile was used. Sensors were recommended to provide adequate capability in 84% of the weather conditions.

4-4. Weather data from Northern Germany, Southern Germany, SWA and Latin America (LATAM) were evaluated. The German areas provided the most challenging weather for scouts, so the sensors were chosen to provide the required capability there.

OPERATIONAL REQUIREMENTS

4-5. How far a battalion needs to see was answered by a literature search and interviews with the Armored Cavalry Tactics, Combined Arms, and Command Tactics Divisions in the Command and Staff Department, USAARMS. Once determined, the distance was reduced by the LOS distance to predict the scouts' general locations. The prediction was checked against scenarios used for the Pre-Command Course and Armored Officer Advanced Course (AOAC) to validate the doctrinal distances that scouts operate from the main body.

4-6. For AirLand Battle Future (ALBF) the distance was given by the U.S. Army Operational Concept, AirLand Battle-Future (Heavy) 2004 Revised Final Draft, 3 Mar 89.

4-7. A threat analysis identified what scouts can expect to encounter while conducting reconnaissance and security missions. The level of acquisition required was determined by interviews with the Command and Staff Department and the Cavalry Systems Team, Materiel and Logistics Division (MLD), Directorate of Combat Developments (DCD), USAARMS.

4-8. The identified requirements for reconnaissance and security missions were evaluated using the C2NVEO Sensor Performance Model to determine which were stricter. The tougher requirements were chosen for the final recommendation.

TECHNOLOGY REVIEW

4-9. Current systems were evaluated against the requirements for sufficiency. Sensor types were recommended in areas that deficiencies exist.

5. Terrain

5-1. The first step in this investigation is assessing the physical extent of typical line-of-sight ranges allowed by terrain. In October 1986, TRAC-WSMR published the Tactical Terrain Intervisibility Classification Study. The study develops intervisibility information for use in characterizing the ability of ground forces to see and detect targets in a military environment. The methodology classifies terrain with regard to landform, surface clutter, and tactical deployment. The study predicts ground-to-ground intervisibility ranges for likely battlefield attack paths and defensive positions for several geographic regions. Line-of-sight is corrected for earth curvature, but not for refraction. The resolution of the digital terrain database was 50 meters horizontal and 1.0 meters vertical.

5-2. The geographic regions selected for examination in this scout study are Central Europe and the Middle East. Due to the abscence of digitized terrain data, no intervisibility predictions are available for tropical/jungle regions. Intervisibility predictions were made for fourteen locations in the northern (lowlands) and southern (highlands) regions of the Federal Republic of Germany (FRG) and for four locations in the deserts of the Middle East.

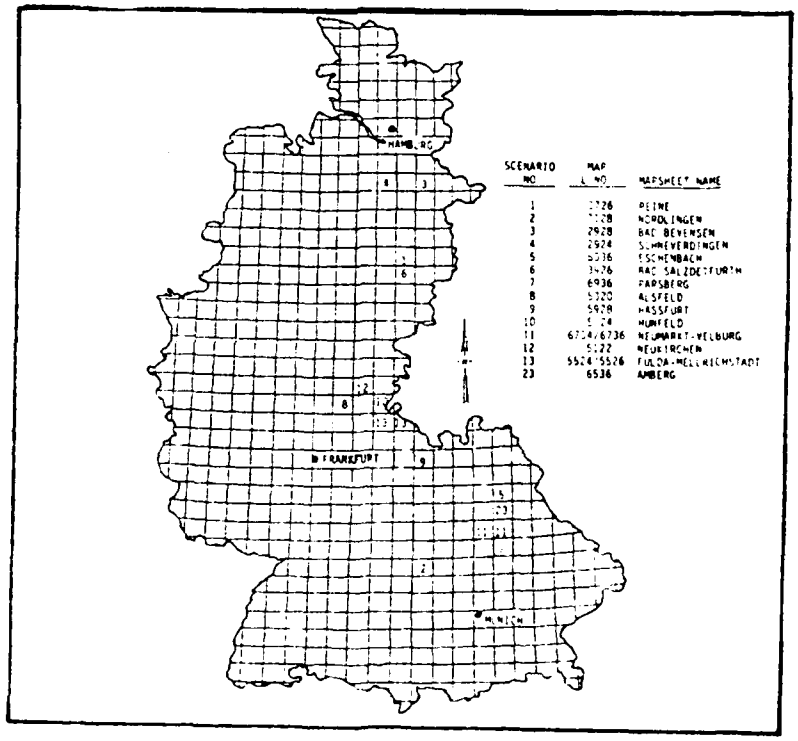

Figure 1. Federal Republic of Germany

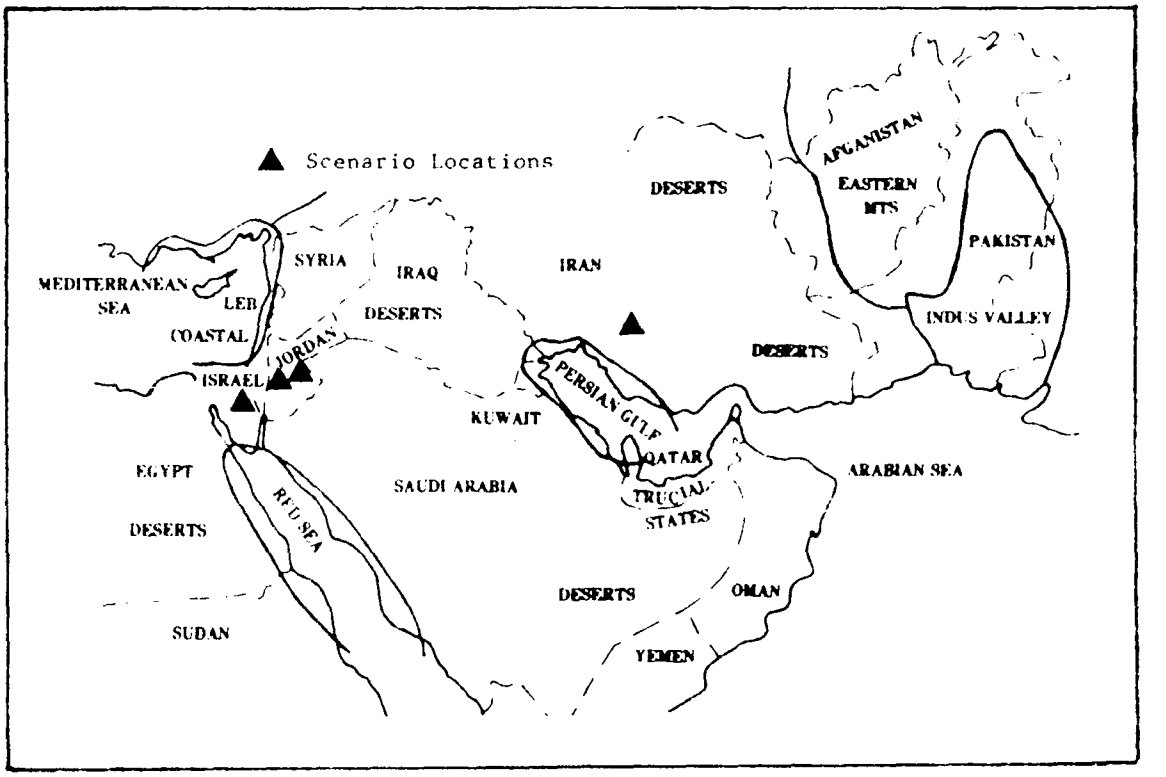

Figure 2. Middle East

5-3. The TRAC-WSMR study uses several measures of effectiveness to describe the intervisibility features of these regions. The First Opening Range is a measure of the greatest range at which a line-of-sight is achievable between a ground system on militarily significant terrain and a ground target on an attack path towards the observer (the maximum range considered was 5000 meters). Other measures consider the length of visibility of a target relative to the time required to engage. Since the scouts' first priorities are to observe and report and not to engage, the First Opening Range was chosen as the most appropriate measure for the scout study. This is the range at which the scouts have their first opportunity for enemy detection. Figures 3 through 5 present the mean first opening ranges and the standard deviations for the Central European and Middle Eastern locations. By considering one standard deviation greater than the mean values, 84 percent of all first opening ranges for a particular location are included. In defining requirements for the scouts' needs, it would not be prudent to plan for 100 percent of possible sightings. For all of the opening range predictions in this report, the 84th percentile value is used.

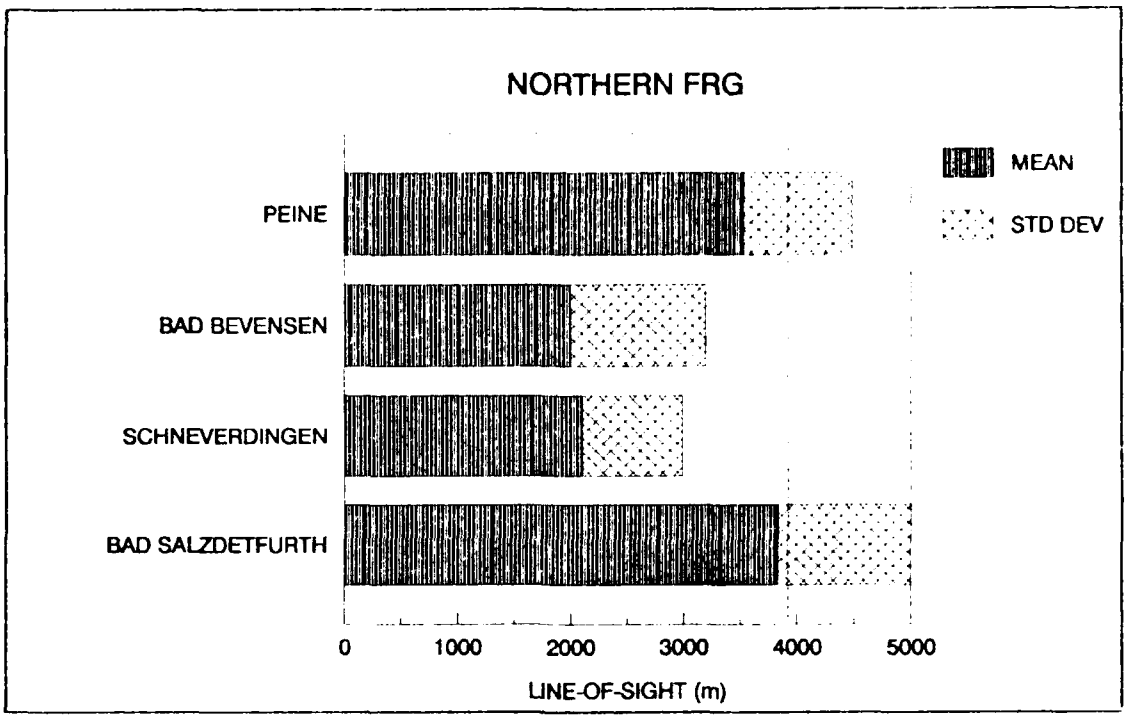

Figure 3. First Opening Ranges - Northern FRG

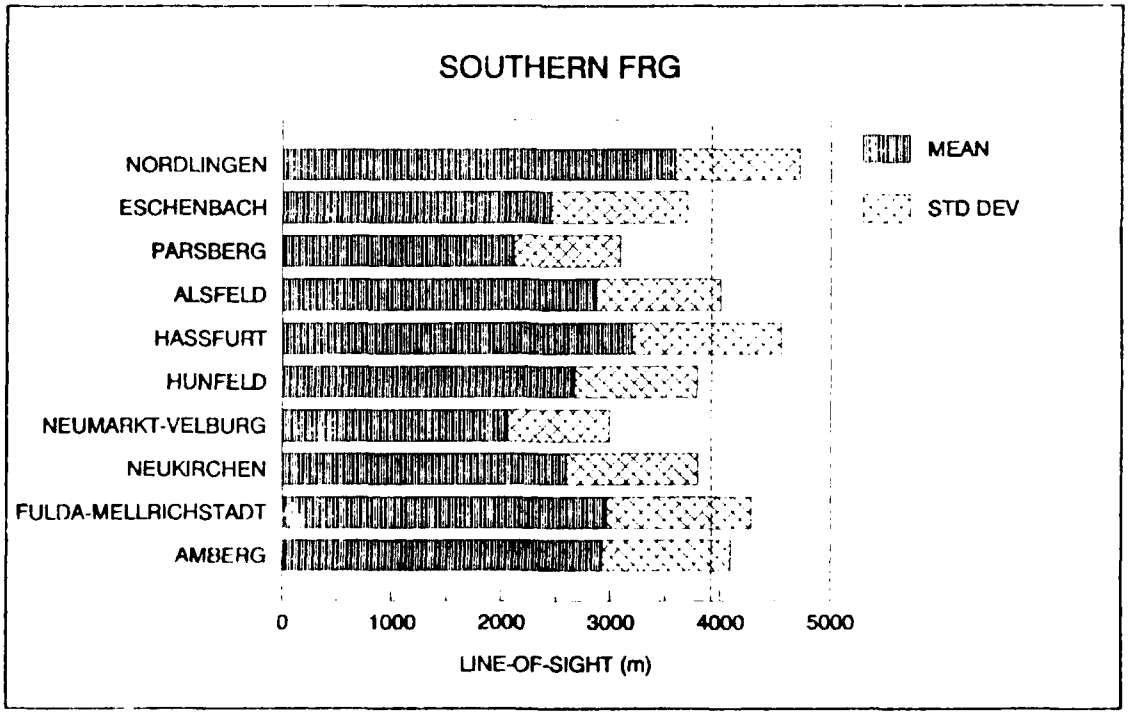

Figure 4. First Opening Ranges - Southern FRG

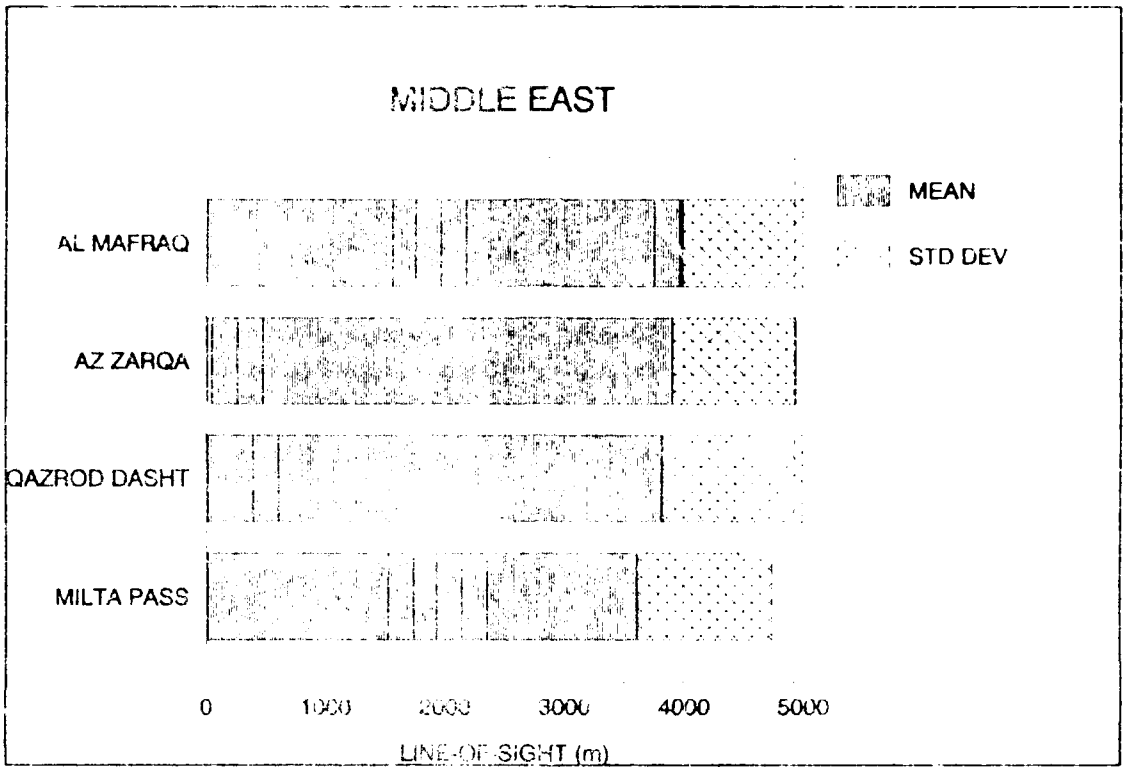

Figure 5. First Opening Ranges - Middle East Desert

5-4. The 84th percentile for the ten locations in Southern FRG is approximately 3900 meters. Similarly, the average intervisibility range for the four locations in Northern FRG is just greater than 3900 meters. Individual locations in FRG allow longer individual intervisibility distances ranging from 4500 to 5000 meters (Nordlingen, Hassfurt, Heide, Bad Salzdetfurth). In the Middle East deserts, where the land is more consistently open, the average intervisibility range is about 4900 meters. The desert regions of the Middle East have more open terrain and less ground clutter (vegetation and construction) than Central Europe.

5-5. A later study of line of sight visibility at two locations in FRG was conducted by the BDM Corporation (Extended Battlespace Study, February 1989). This study examined long range anti-tank guided missile (ATGM) positions in Fulda and Bad Salzdetfurth. This study used the same terrain data as the TRAC-WSMR study, but with advances in computer modeling, BDM was able to obtain 12.5 meter resolution (compared to 100 meter resolution by TRAC-WSMR). This study considered ranges out to 9000 meters.

5-6. The intervisibility ranges predicted in the BDM study are longer than the TRAC-WSMR study predictions. In the cumulative intervisibility chart below, the 84th percentile value in the Fulda region is approximately 4700 meters compared to approximately 4300 meters in the TRAC-WSMR study. These two predictions are within 10 percent of each other. In the more open area of Bad Salzdetfurth, the 84th percentile value is approximately 6500 meters compared to the 5000 meter prediction by the TRAC-WSMR study.

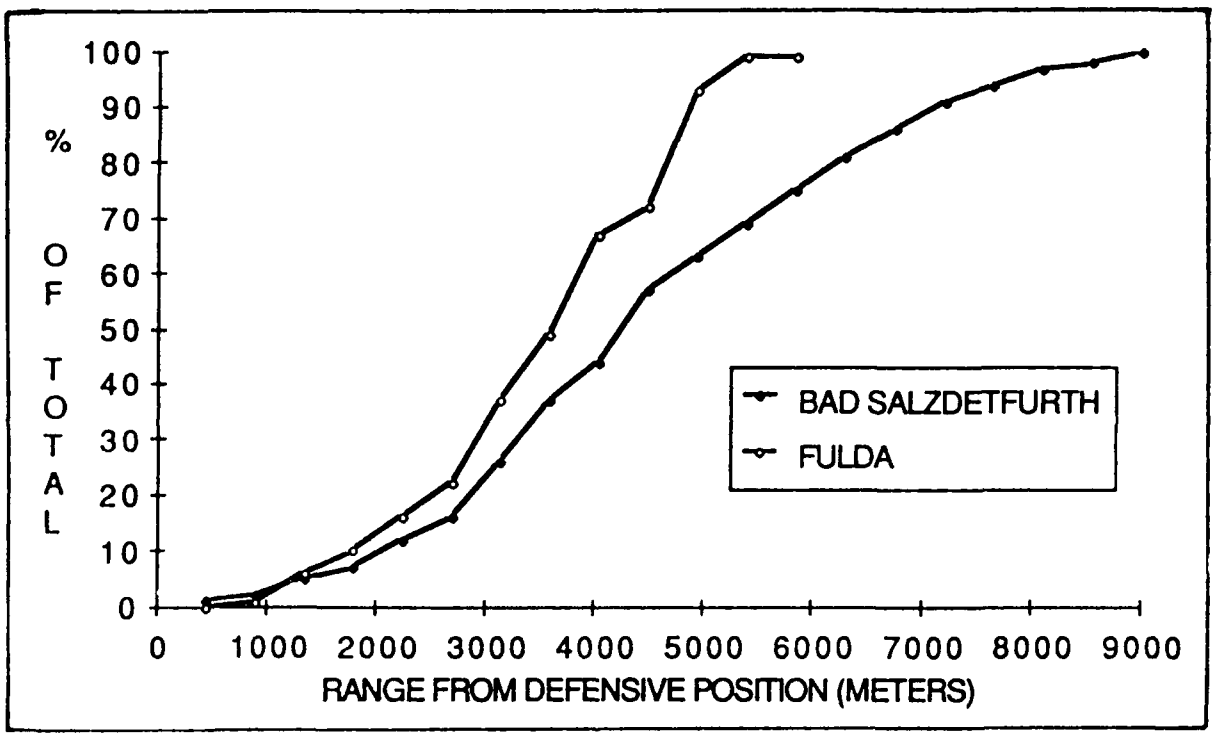

Figure 6. Cumulative Intervisibility Ranges (BDM Study)

5-7. From this comparison of predictions for just two locations, it appears that higher resolution data, a less restrictive upper range limitation and focusing on long-range anti-tank positions will yield slightly longer intervisibility predictions. Therefore, the average TRAC-WSMR predictions of 3900 meters in FRG and 4900 meters in the Middle East desert may be slightly conservative.

6. Weather

6-1. The terrain data presented in the TRAC-WSMR and BDM studies give no consideration to intervisibility degradation due to atmospheric effects. The predictions of intervisibility made by those two studies assume a perfectly clear day with unlimited visibility.

6-2. The Atmospheric Sciences Labortory (ASL) at White Sands Missile Range has collected weather data at various sites of military significance around the world. Much of ASL's research has focused on Central Europe and the Middle East. The portion of ASL's research most significant to the scout mission is the frequency of occurence of various levels of visibility. These data are categorized by range of visibiliity (1 km, 3 km, 7 km), season of the year, and time of day.

6-3. Figures 7 and 8 present the frequency of occurence for visibility conditions of three kilometers or less in Northern and Southern FRG. The previous discussion of terrain intervisibility revealed that many locations in FRG provide line-of-sight capability to about 4000 meters. However, figures 7 and 8 suggest that the German climate limits visibility to less than three kilometers a significant portion of the time. The winter and autumn seasons may limit the visibility 20 to 30 percent of the time. Even in the less cloudy spring and summer seasons, weather may limit the visibility 10 to 15 percent of the time. The early morning hours (0300 - 0900) are the most likely to limit visibility.

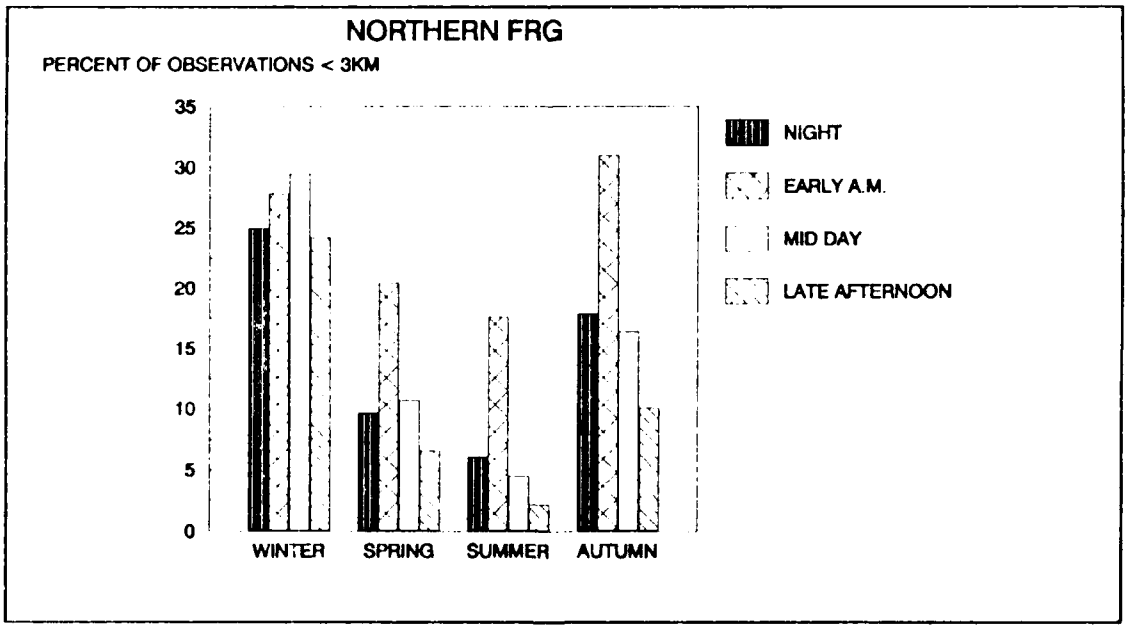

Figure 7. Visibility Less Than 3 Kilometers - Northern FRG

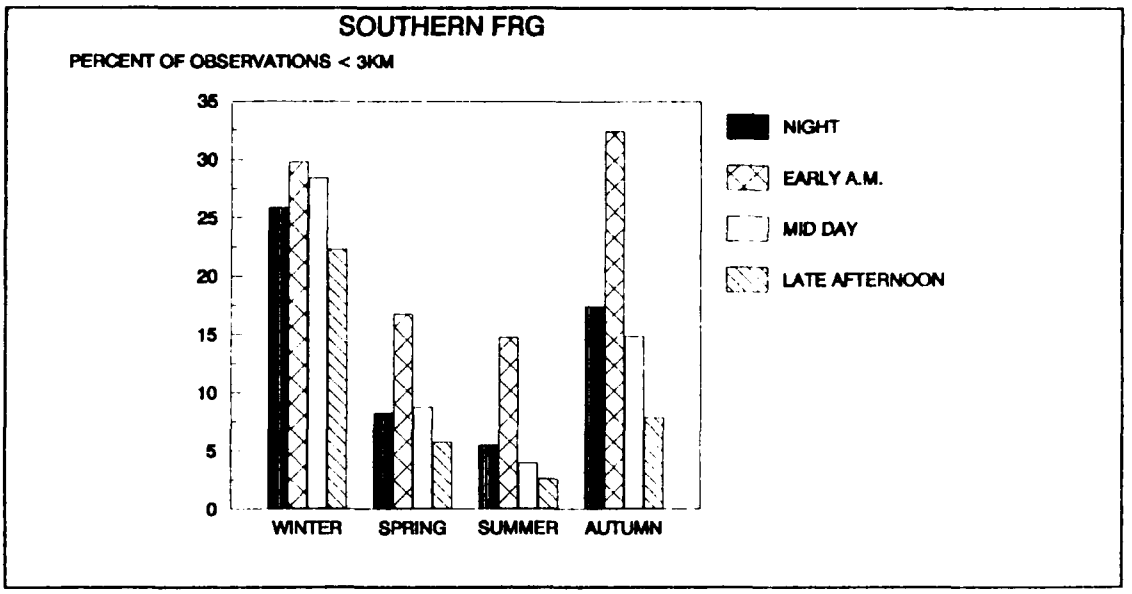

Figure 8. Visibility Less Than 3 Kilometers - Southern FRG

6-4. Figures 9 and 10 show the frequency that German weather restricts visibility to one kilometer or less. This heavy visibility restriction may occur 10 to 15 percent of the time in the winter and autumn and 2 to 6 percent of the time in the spring and summer.

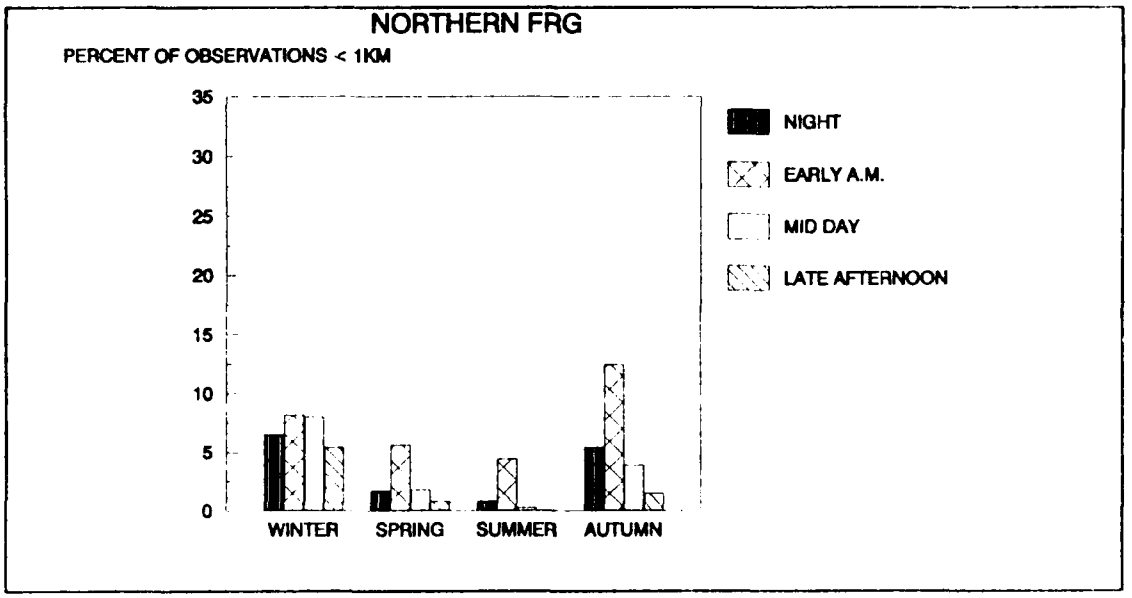

Figure 9. Visibility Less Than 1 Kilometer - Northern FRG

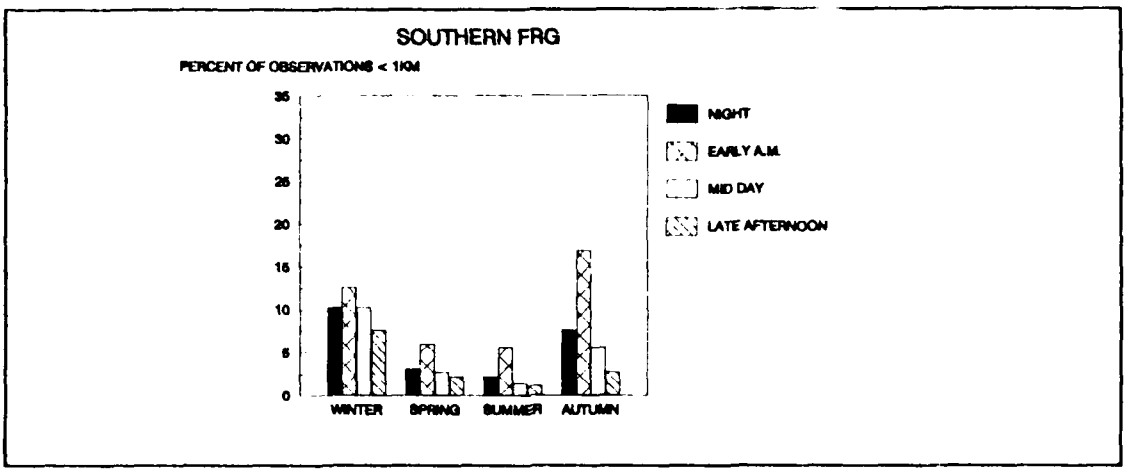

Figure 10. Visibility Less Than 1 Kilometer - Southern FRG

6-5. Cloud cover and precipitation occur frequently in Central Europe. ASL's data for the early morning hours (0300-0900) reflect a fog, haze, or mist 40-50 percent of the time. Again, the fall and winter seasons have the most frequent occurences. Conditions described as rain, drizzle, or thunderstorms occur 15-20 percent of the time. On winter mornings, snow is falling 5-10 percent of the time, and even in the spring, snow falls 3-6 percent of the time.

6-6. Weather is much less a factor on visibility in the Middle East. Figures 11 and 12 show the frequency of visibility of three kilometers or less. The year round frequency is between 2 and 6 percent with no distinguishable seasonal differences.

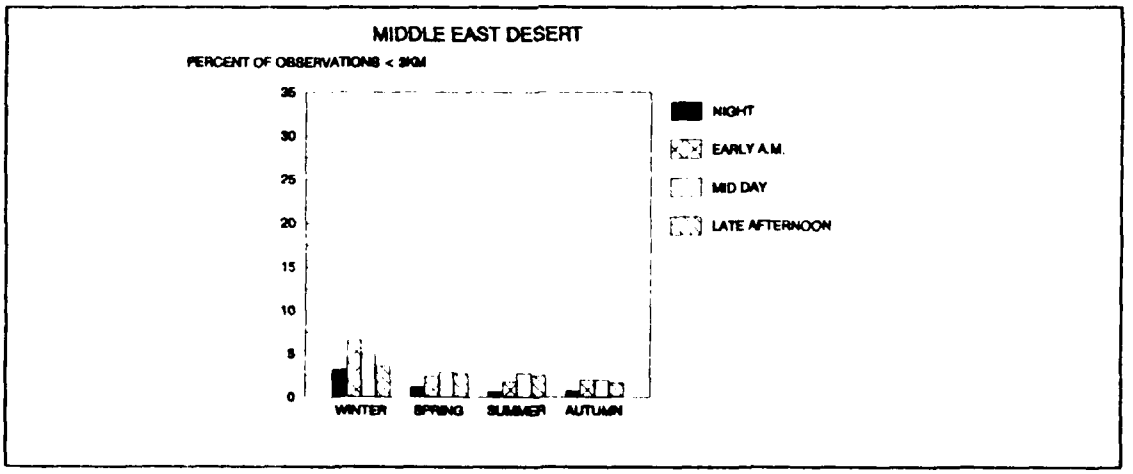

Figure 11. Visibility Less Than 3 Kilometers - Mid East Desert

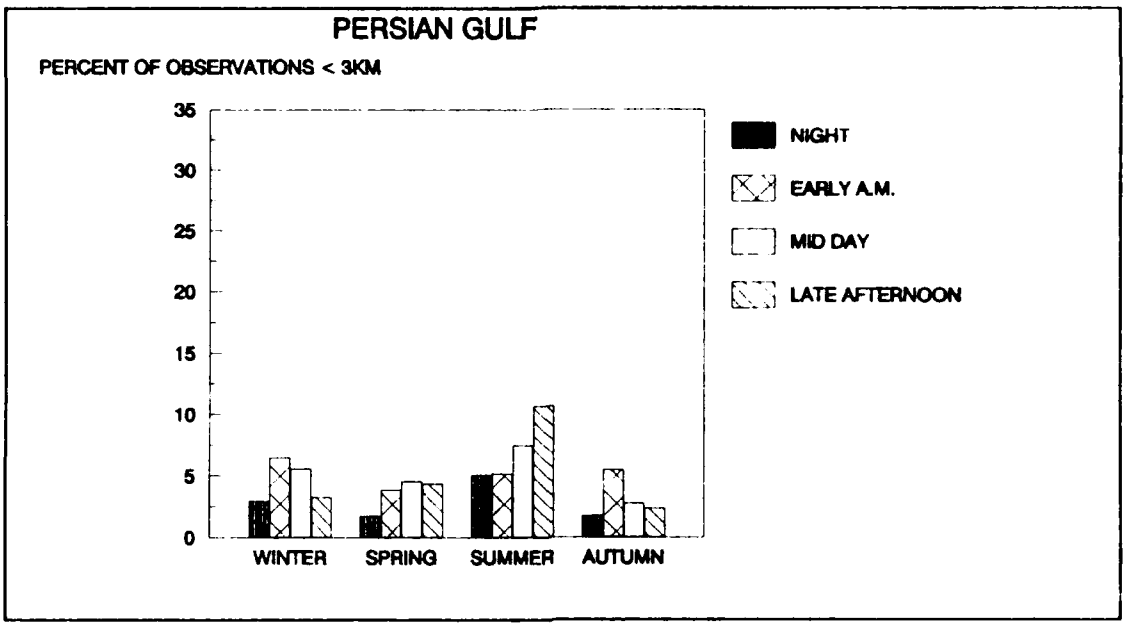

Figure 12. Visibility Less Than 3 Kilometers - Persian Gulf

6-7. Figures 13 and 14 present visibility frequencies of 7 kilometers or less. The desert regions are only limited to this range 6 to 12 percent of the time. The Persian Gulf area is more restrictive with 15 to 25 percent of the time with visibility limited to 7 kilometers or less.

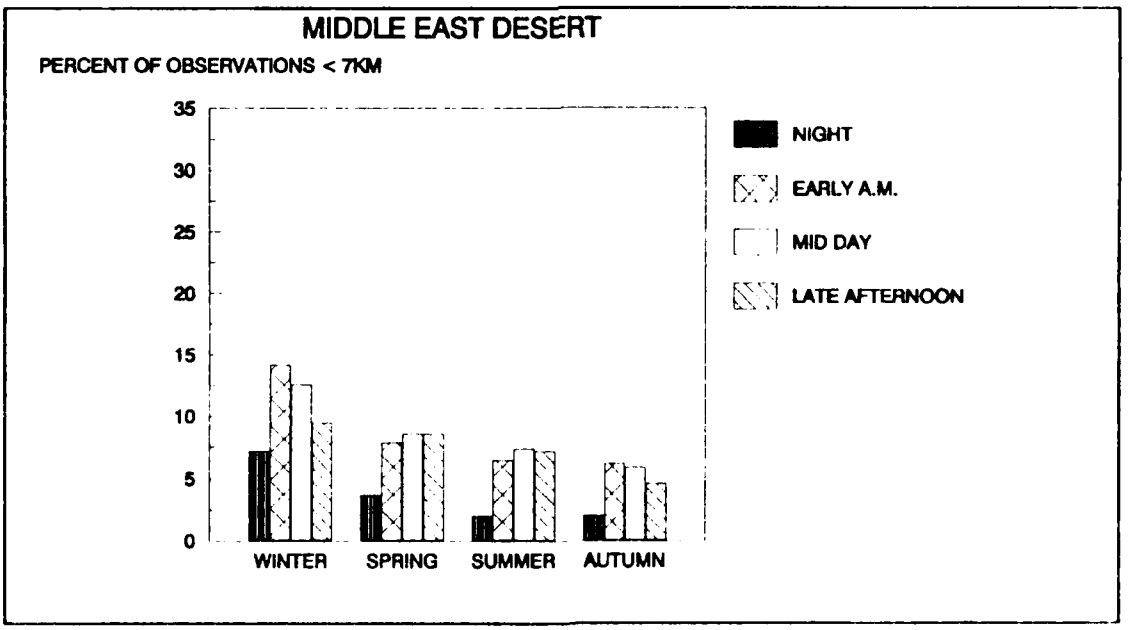

Figure 13. Visibility Less Than 7 Kilometers - Mid East Desert

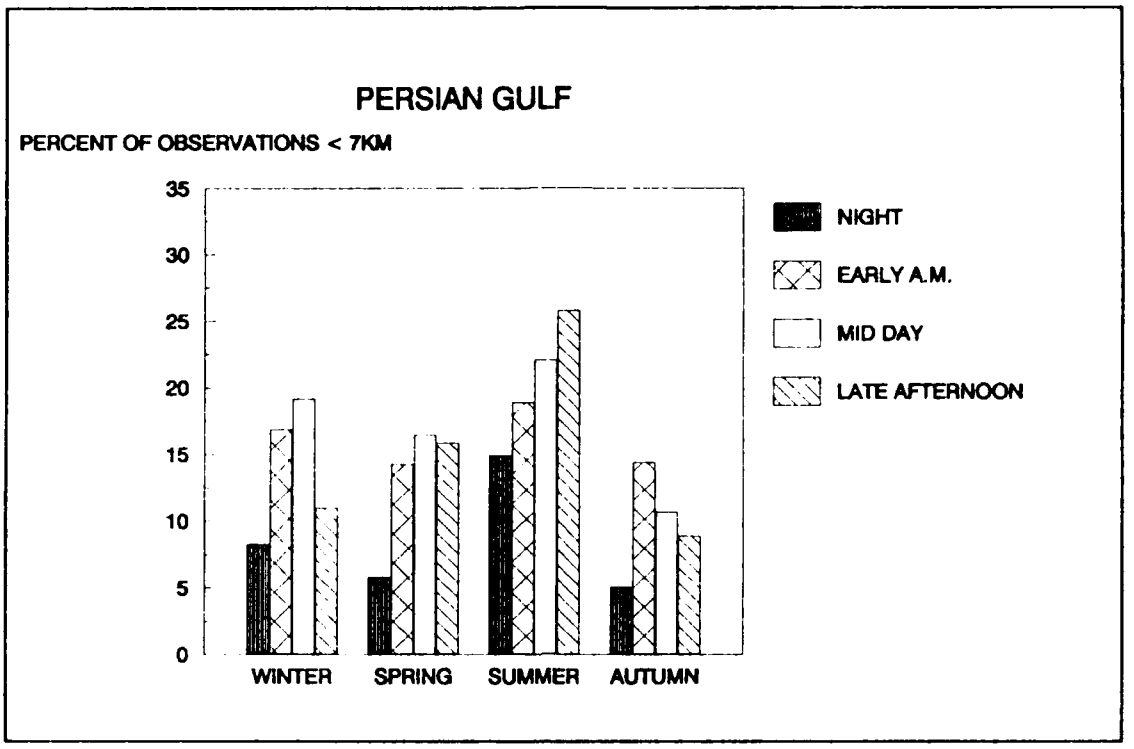

Figure 14. Visibility Less Than 7 Kilometers - Persian Gulf

6-8. The terrain data published by TRAC-WSMR predicted lines-of-sight of nearly 5000 meters for the Middle East locations on a clear day. The weather data presented here indicates that, in the majority of cases, enemy detection will not be limited by weather in this region.

7. Operational Requirements

7-1. How far a scout needs to see is bounded by the line-of-sight (LOS) distance afforded by terrain. The battalion's information requirements drive how far out the scout must be from the main body and how well the scouts need to see the target. The requirements are different for reconnaissance and security missions. The requirements are identified and compared by mission.

7-2. Acquisition can be divided into four degrees of clarity. From lowest definition to highest they are: detection, classification, recognition, and identification. All of these are common terms except classification. It is not used in JCS PUB 1 but is used extensively by Center for Night Vision and Electrol-Optics (CNVEO). It is a distinct level of acquisition so its inclusion makes sense for our purposes.

7-3. Detection is acquisition of a target with no definition apparent. Classification is the ability to determine if the target is heavy or light, tracked or wheeled. Recognition is determination of class of vehicle (which should allow determination of friend or foe). Identification is typing vehicles as M-1, T-72, etc.

7-4. The battalion's and brigade's intelligence needs drive how fine the acquisition needs to be. It is an advantage to the scouts to give them the lowest level of acquisition required. Lower requirements equate to a larger field of view, faster scan rate, and a smaller, simpler, cheaper sensor.

SECURITY

7-5. In AirLand Battle, task forces (TF) need about 30 minutes warning of an approaching enemy. Generally more is needed in the offense, less in the defense. Scenarios produced at the Armor School for use in the Pre-Command Course and AOAC support 30 minutes as a general guide. Assuming a Soviet rate of advance of 20 kmph, 30 minutes equates to about 10 km. Since scouts can see (LOS) 4-5 km (Western Europe and SWA) they will position themselves 5-6 km from the main body; well within artillery range. The current scout doctrine provides the battalion adequate warning until the scouts pull back to avoid engagement. The battalion commander then relies on intelligence from higher to tell him the location of the 2d echelon MRB/TB's.

7-6. AirLand Battle-Future extends the range requirement to 15 km to encompass the entire attacking regiment. Current and projected scout platoon organizations lack the robustness to operate 10 km from the TF. This shortfall must be addressed with unmanned sensor systems dedicated to or organic to the battalion.

7-7. To a battalion commander, knowing what type of formation is 10 kms away is not essential. The battalion will take action immediately upon the scout's initial detection. The essential information is direction and number of targets. His scouts need to detect at the earliest time possible. SWA puts that distance at almost 5 km.

7-8. The brigade commander increases the scout's requirements, however. The brigade has no organic scouts and relies on the subordinate battalions for visual confirmation of intelligence reports from higher. He fights the Soviet division and needs to know the division's intentions. Most of the indicators occur across the FLOT, but a battalion scout can see when the ITB is used as a forward detachment. A forward detachment will often precede the main attack against the brigade sector. The scouts' requirement is then raised from detection to classification at 5 km. Classification by the scout will tell the brigade that the force is an MRB/TB or an ITB.

7-9. Scouts must recognize enemy vehicles prior to displacement. To remain outside Soviet acquisition range the scouts must displace when the enemy is no less than 2000m away. To give the scouts an additional 5 minutes to recognize the enemy vehicles, report them, and receive displacement permission, the scouts must recognize at 3000m.

7-10. Scouts will also be presented with aerial targets. Soviet doctrine (like our own) dictates that helicopters will fly low-level contour until 5 km from the FEBA then Nap-Of-the-Earth (NOE) to their firing positions. A scout, then, can expect to be presented with aerial targets flying NOE at ground LOS distances. The battalion will not gain beneficial information by a higher level of acquisition than detect. The closure rate alone eliminates the value of a long-range identification. The requirement for aerial targets is detection at 5 km.

7-11. Light force requirements are the same as for heavy force. The LOS will often be shorter as light forces prefer to fight in close-in terrain. However, they require an all-weather capability to acquire heavy forces out to the LOS limit.

RECONNAISSANCE

7-12. A scout conducting reconnaissance can expect to find different targets depending on how long the enemy has been in position. If the Soviets have been in position less than one hour, scouts will find vehicles in hasty, hull-down positions primarily. Tanks and infantry will be digging themselves in. From one to three hours the tanks will be dug hull-down and infantry will be in individual fighting positions. The spoil from this digging should be apparent. Beyond three hours most tanks and BMPs will be in hide positions and the infantry dug in. The vehicles in hull-down positions scanning the area will be camoflaged. Near and far minefields may be surface laid at this point.

7-13. To identify Soviet positions scouts need to be able to detect turrets at the LOS limit (5 km). The scouts can then report the location and attempt to find out the type and quantity of equipment and limits of the position. To allow them to do that outside of Soviet acquisition and direct-fire range and beyond the far minefield, if any, the scouts must be able to recognize turrets at 2 km.

REQUIREMENT COMPARISON

7-14. The requirements for reconnaissance and security were evaluated using the Night Vision Laboratory Sensor Performance Model to determine which is most restrictive. Classifying full-sized targets at 5 km and detecting turrets at 5 km are roughly equivalent. Recognizing turrets at 2 km is more difficult than recognizing full-sized targets at 3 km. The final requirement for scouts to perform all assigned missions is to detect tank or BMP turrets at 5 km and recognize them at 2 km.

SENSOR TYPES

7-15. A requirement for a mix of acquisition devices is dictated by weather conditions. Thermal devices are superior to image intensification (I2) in most conditions because it is difficult to camouflage a heat signature. Thermal sights lose effectiveness in cold rain when the targets and their surroundings become isothermal. Conversely, I2 devices are not significantly degraded by rain. A mix will provide continuous capability in Western Europe. SWA and LATAM weather conditions favor thermal and direct view optics with no requirement for I2 devices.

8. Technology Review

8-1. Off the shelf fixes for scouts appear first. Projected fixes are addressed after the nondevelopmental item (NDI) recommendations.

NDI SOLUTIONS

8-2. The close-in systems in the field (AN/PVS-7B Night Vision Goggles, AN/PVS-4 Individual Served Weapon Sight) work very well. They assist the scout in night navigation and self defense roles. They do not, however, have the range to assist finding long-range targets. For long-range targets the scout relies on the M3 BFV's on-board thermal, the AN/PAS-7 Hand-Held Thermal Viewer (HHTV), M-19 binoculars, and the AN/UAS-11 with AN/GVS-5 Laser Rangefinder. None of these have the range the scout needs.

8-3. Current forward looking infrared (FLIR) technology exists to put adequate systems in the field in packages applicable for scouts. I2 technology has not kept pace and will not support fielding a complementary system. The scouts cannot have an all-weather capability with current or projected technology.

8-4. As a low-cost interim solution, a directional microphone can be fielded to provide long-range detection in most weather conditions. It will compensate for the thermal sights' ineffectiveness in cold rain unless the rain becomes a downpour. The noise from large moving armored formations, although subject to background noise and attenuation, should alert the scouts that a force is approaching.

8-5. Raising binocular magnification to 10 or 14 power requires stabilization. Candidate systems are on the market but lack reliability. The 7 x 50 binoculars do not meet the requirement but they are rugged. If higher-power binoculars meet the field test requirement they should be fielded. If not, 7 x 50 binoculars are better than broken 10-power.

8-6. Unmanned sensors are in the Army and Marine Corps inventory. The information level required for a heavy battalion is considerably less than for a military intelligence (MI) battalion. The sensor should be tailored to that level. The battalion needs only to detect moving vehicles and troops. Speed and direction of the enemy can easily be estimated by location of the sensors on an avenue of approach and when the sensors activate. A mix of sensors (seismic, magnetic, and infrared) arrayed in belts will confirm initial activations and indicate type target. The sensors must be cheap. They must be truly throw-away. They must provide adequate range for the battalion tactical operations center (TOC) to monitor them. Candidates are in the Department of Defense (DOD) system and on the open market.

FUTURE DEVELOPMENTS

8-8. In 2d Qtr FY91 a prototype millimeter wave (MMW) device is due for testing. It is projected to be a vehicular-mounted, all-weather, high-resolution target acquisition device. Its size prohibits its use for dismounted scouts, pending a major breakthrough reducing the power requirements. It is not a passive sensor so the risk of intercept must be weighed against its advantages when the prototype is delivered.

9. Conclusions

9-1. The scout needs to recognize turrets at 2 km and detect them at 5 km. To give him an all-weather capability the following technologies are recommended. Thermal, direct view and image intensification are required. In the short-term, an acoustic sensor is required to fill the void left by lack of an I2 device.

9-2. Unmanned sensors that are small, cheap and effective are available. They should provide the battalion the capability to monitor from behind the FLOT.

9-3. In the mid-term (3-5 yrs) MMW should be tested for its risks and benefits to scout organizations.

APPENDIX

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