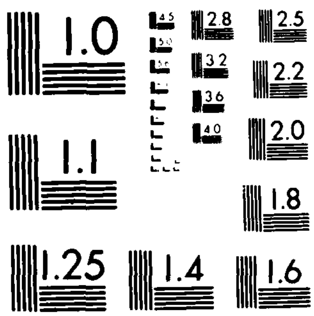
AD-A136 254 ROBOTIC RECONNAISSANCE VEHICLE WITH TERRAIN ANALYSIS 1/1
(U) ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA
B B ZIMMERMAN 28 JUN 83

UNCLASSIFIED F/G 15/7 NL

END
DATE
FILMED
84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Robotic Reconnaissance Vehicle with Terrain Analysis		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Bruce B. Zimmerman		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Engineer Topographic Laboratories Fort Belvoir, VA 22060		12. REPORT DATE 28 June 83
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

A136254

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release
Distribution unlimited

DTIC ELECTE DEC 23 1983 A

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

presented at AUVS 83, Unmanned Systems: Confidence for the 80's, Salt Lake City, Utah, 28-30 Jun 83

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

terrain navigation
autonomous operation
AI/Robotics
Terrain Analysis
unmanned vehicle

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U.S. Army Engineer Topographic Laboratories (ETL) is participating in the development of a battlefield robotic platform, with a recon sensor suite payload, that will be teleoperated from a remotely located control van via RF communication links(s). A major component of the system is a sophisticated terrain navigation subsystem, to be later evolved from a teleoperation to an autonomous operation capability. The system will demonstrate an application of AI/Robotics for meeting future Army needs.

DTIC

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

83

ROBOTIC RECONNAISSANCE VEHICLE WITH TERRAIN ANALYSIS

Bruce B. Zimmerman

U.S. Army Engineer Topographic Laboratories
Ft. Belvoir, VA 22060

Abstract

The U.S. Army Engineer Topographic Laboratories (ETL) is participating in the development of a battlefield robotic platform, with a recon sensor suite payload, that will be teleoperated from a remotely located control van via RF communication link(s). A major component of the system is a sophisticated terrain navigation subsystem, to be later evolved from a teleoperation to an autonomous operation capability. The system will demonstrate an application of AI/Robotics for meeting future Army needs.

Introduction

ETL, responding to a Department of the Army AI/Robotics Steering Committee request, prepared a plan for the demonstration of a Robotic Reconnaissance Vehicle with Terrain Analysis in conjunction with the Human Engineering Laboratory (HEL), Aberdeen Proving Grounds, MD. A key component of the demonstration system is a terrain navigation subsystem, which is the generic capability to traverse terrain with an unmanned vehicle platform. A suite of reconnaissance sensors will constitute a modular payload, independent of the vehicle platform, and will be the basis for a demonstration mission scenario. Other payloads could be substituted in the future to provide other mission capabilities for this system. The demonstration is a joint effort with HEL, and it is anticipated that overall responsibility will be assumed by the Tank and Automotive Command (TACOM), with ETL maintaining responsibility for the terrain navigation subsystem.

Background

An Army Steering Committee for AI/Robotics was established in 1981, chaired by the Assistant Director for Army Research Programs in the office of the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA), HQDA. Just prior to this, DCSRDA tasked ETL to prepare a baseline R&D plan for AI/Robotics, which was submitted in 1982. As a part of this effort, ETL awarded a competitive contract to SRI International to define the R&D efforts leading to systems that could assist combat and combat support personnel in the field.

In June, 1982, responding to a Steering Committee request in the form of a tasking letter from DCSRDA, ETL prepared a plan for a Terrain Analysis Demonstrator and HEL prepared a plan for a Reconnaissance Vehicle Demonstrator. These plans were combined into the Robotic Reconnaissance Vehicle with Terrain Analysis, with ETL responsible for the hardware, software, and system integration, and HEL responsible for the demonstration scenario, soldier-machine interface, and actually conducting the demonstration.

Four other plans were submitted to the Steering Committee and all five were reviewed by the Army Science Board ad-hoc subgroup on AI/Robotics. The ETL/HEL plan was awarded the highest priority, and subsequently all five Army AI/Robotics demonstrators have been funded for FY84 and 85. And TACOM, which is the Army's vehicle developer, has been requested to assume overall responsibility for the demonstration.

The mission of ETL, a Corps of Engineers R&D laboratory, includes mapping and terrain analysis research and development for both the Field Army and the Defense Mapping Agency (DMA). The basic source of this information is the aerial photograph, and ETL has considerable experience in image processing, pattern recognition, and image understanding in attempting to automate the feature extraction process from monoscopic and stereoscopic imagery. In addition ETL has a strong background in data base design and application products derived from terrain/topographic data bases, and the development of weapon systems survey/fire control support systems (inertial platforms).

One purpose of the original ETL plan, the Terrain Analysis Demonstrator, was to demonstrate a generic unmanned platform with the ability to traverse battlefield terrain. Certainly a vision/sensor system is required to sense the actual environment as a vehicle is travelling, and the ETL expertise in image processing/pattern recognition would provide the ability to "understand" the vision sensor signals. A priori knowledge of the terrain, in the form of a terrain analysis data base, would provide the ability to plan a mission (a route planner), determine critical points (a bridge to be crossed), preview a critical point on the route (perspective view), and perhaps even preview portions of the route that will be traversed (surrogate travel). And a means of always knowing the vehicle position, azimuth, and perhaps attitude relative to a fixed frame of reference (geographic coordinates) could be provided by an inertial platform.

The present plan simply adds a modular payload in the form of a suite of reconnaissance sensors, and provides a focus for demonstration scenarios. The recon sensor efforts will be coordinated with other Army labs with expertise in this area, such as the Night Vision and Electro-Optical Lab (NV&EOL) or the Combat Surveillance and Target Acquisition Lab (CSTAL). The demonstration, slated to be held two years after start of funding, is scheduled for late FY85 at the Wilcox Range, Ft. Knox, KY, with the support of the U.S. Army Armor and Engineer Board.

System Design Considerations

The long range interest of ETL in terrain navigation is a capability for autonomous operation. A more accurate term is supervised autonomous operation as there will always be some level of supervision, eventually at a very high level such as a command to travel to a specified destination. Unfortunately the current state-of-the-art, particularly in computer vision, does not allow for any meaningful demonstration of autonomy in the two year time frame of the demonstration plan. Point-to-point or drive-by-map vehicle operation are not useful examples of autonomous operation, and autonomously avoiding pylons in a parking lot is not considered a meaningful demonstration for Army applications.

Because of the time limitation for the demonstration, and the lack of developed, or nearly developed technologies in autonomy, it was decided to use teleoperation for control of the unmanned vehicle. Teleoperation is a proven technology, the system as designed could be ruggedized and fielded for use in any terrain if desired, and the system will be capable of demonstrating the value of terrain navigation. It should also be pointed out that ETL is maintaining its long term interest in autonomous vehicle operation in parallel with the development of the demonstration system. Currently a long term research plan, that will detail how the technologies of the demonstration system can be evolved thru a semi-autonomous and into a supervised autonomous operational capability, is being developed. And if development of a fieldable teleoperated system is initiated as a demonstration follow-on, the results of developments of our research in autonomous operation can be phased in or PIPed as they become available.

The two year Army funding for the AI/Robotics demonstrators is not scheduled to start until FY84. However, ETL feels strongly that the technologies described here are a necessary component of terrain navigation, and therefore work was started in FY83 with in-house funding. And in support of this work ETL has two current contracts with the Jet Propulsion Laboratory (JPL). The first is to work on the conceptual design of the demonstration system, concentrating on the terrain navigation subsystem, and the second is to work on the long range research plan for an autonomous operation capability.

System Description

Figure 1 depicts the three major components of the demonstration system: in the distance is the unmanned vehicle (approaching an area of hostile activity), the use of RF communication link(s) is depicted by the antennas, and in the foreground is the command and control station which needs to maintain only RF, not visual, contact with the vehicle.

Since this is strictly a capability demonstrator and not a prototype, and one of the goals is to develop a generic terrain navigation capability, the choice of a vehicle is not critical. However, in anticipation of future payloads and applications, a tracked vehicle will be used, such as the M113. It will be equipped with remote control actuators, an inertial platform, and stereo TV navigation sensors. Other sensors, such as engine RPM for monitoring the vehicle, and audio to provide feedback for telepresence, will also be included.

The demonstration system will not attempt to develop a sophisticated communications system (multiplexed, unjammable, secure, etc.), again because this is a capability demo rather than prototype. The important point is to show that non line-of-sight communications between the vehicle and command and control station can be used.

The command and control station will contain both a vehicle control station and a recon sensor control station, each with its own operator. The recon control station will contain dual microprocessor based display systems. One display will be a composite of all the recon signals/images, while the other will allow for operator selectable single sensor display.

Figure 2 depicts the main information displays at the vehicle control station as seen by the operator. The two upper displays (which are red and blue in the color version of the figure) depict an anaglyphic stereo display of the vehicle mounted TV navigation sensors. It is felt that monoscopic vision will not suffice, especially for close quarters maneuvering, because of the lack of depth information.

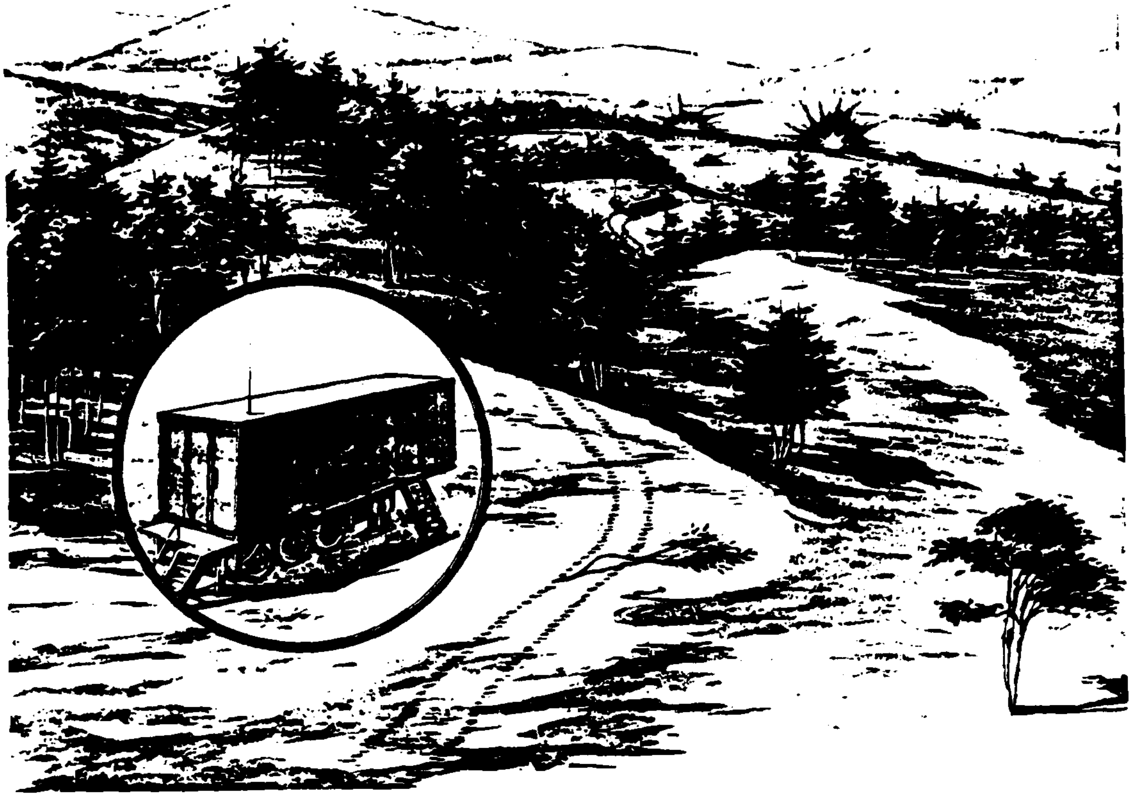


Figure 1 Robotic Reconnaissance Vehicle with Terrain Analysis

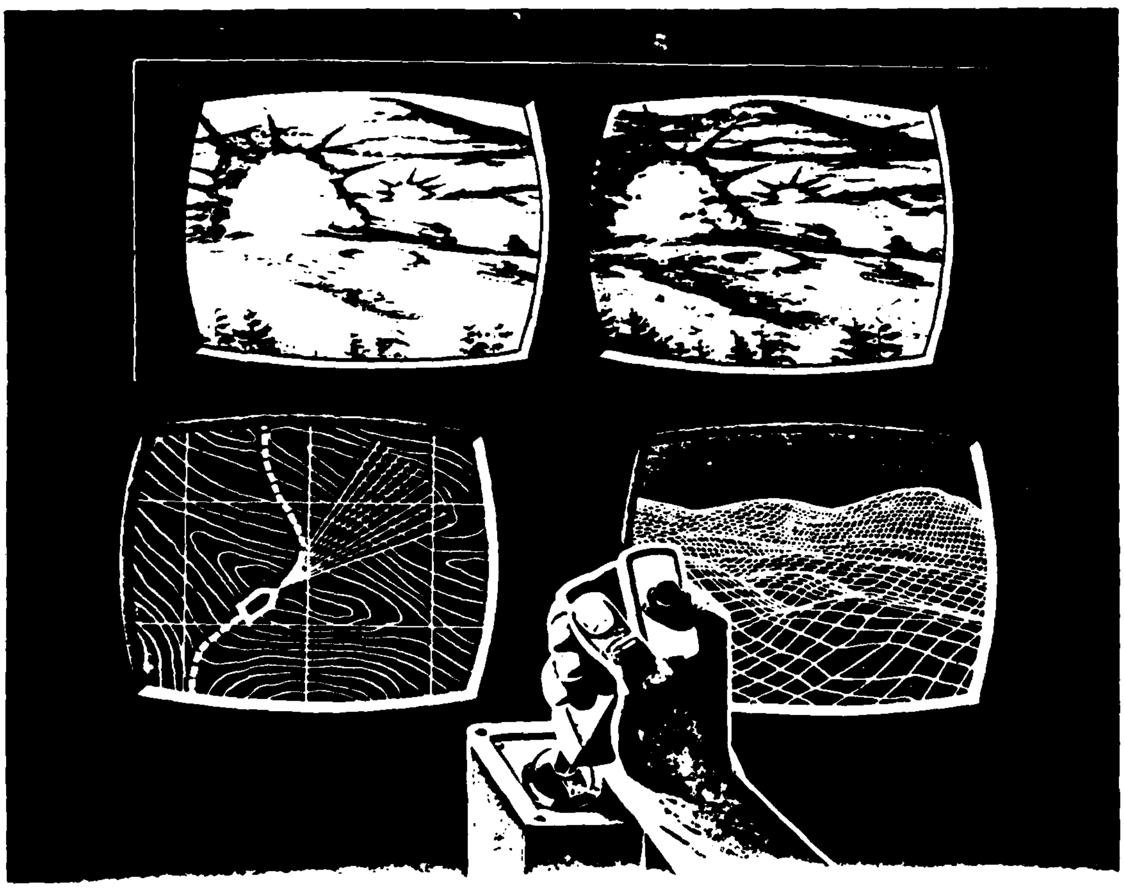


Figure 2 Vehicle Operators Control Station

The actual display method used in the system will not be anaglyphic, but something that is easier for the operator to use, such as the extended area exit pupil. ETL has conducted research in the use of this stereo display technique where the viewer does not need auxiliary devices, such as polarized or colored glasses, to see stereo. The navigation (vision) sensors will provide a realtime update to the data base information (is a bridge still standing) and the higher resolution required for local rather than global navigation (recognition of individual trees, boulders, ditches, etc.).

The lower right display in figure 2 is the auxiliary graphics display. Using the terrain analysis data base, critical points can be determined and views of these can be precomputed before the start of a mission. The operator can then call for display of these views as a critical point is approached, and use them as decision aids in determining when the vehicle is actually at the critical point. An excellent example of a critical point is a bridge at a river crossing (the criticality is whether the bridge is still usable or whether it has been knocked out). These graphic products can be perspective views using elevations only, elevations with shaded relief, or elevations with both the shaded relief and the planimetry correctly "draped" over the terrain, an example of which is shown in figure 3. Another useful product is a synthetic stereo view, derived from elevation data, using either digitized features or actual imagery, and which would be displayed on the stereo viewing displays. Table 1 lists a rich set of terrain/topographic data base derived products that can be shown on the auxiliary graphics display and called on either while the vehicle is traversing the terrain, or during the route planning operation discussed below.

Table 1. Terrain Data Base Products

- Perspective View
- Perspective View with Shaded Relief
- Oblique View
- Cross Country Mobility model
- Slope model
- Local Relief model
- Terrain Profile model
- Cover model
- Concealment model
- Key Terrain model
- River Crossing model
- Path Loss/Line of Sight model
- Masked Area model
- Target Acquisition model
- Composite Target Acquisition model
- Multiple Site Acquisition model

The lower left display of figure 2 is part of the vehicle control station but will be configured for shared viewing with the recon sensor operator. The purpose is to provide either operator with a sense of where the vehicle is located,

Figure 3 Perspective Shaded Relief

where it is heading, and where it is intended to go. The background is a digital topographic map representation of the area of operation and the dashed line overlay is a preplanned route. The interactive route planner, which uses the a priori information in the data base and a Cross Country Mobility (CCM) model, figure 4, offers a powerful capability for global mission planning. Routes can be selected for different criteria such as minimum distance, maximum speed (not necessarily the same route), maximum concealment (using the type of information shown in figure 5), etc. The route can be planned to minimize open area exposure time by "running" from one patch of vegetation to another, for example, or to provide a sort of continuous defilade operation by moving parallel to a ridge line. And the route planner can be reentered and dynamically modified at any time during operation which would allow, for example, selecting an alternate river crossing when the bridge at a critical point was found to be unusable or destroyed.

Additionally there will be a blinking cursor displayed on the screen to show both x,y location and vehicle heading based on the inertial platform information. The fan lines emanating from the front of the vehicle (faintly visible in figure 2), show the coverage of the recon sensors, which can be scanned at least in azimuth independent of the vehicle. These fan lines will aid the recon sensor operator in interpreting the information on his displays through correlation with the actual terrain being scanned.

Present and Future Operation

Operation of the system is a two step process- first to plan a mission, and then to conduct the mission. The planning includes establishing the global level route by inputting a start point, end point, and, optionally, intermediate points to the interactive route planner. The point selection is made in conjunction with the areas where it is desired to perform reconnaissance.

Conducting the mission will be accomplished by a combination of both local and global operations. In the global sense the vehicle operator is following the preplanned route, and in the local sense that operator is performing obstacle detection and avoidance as the vehicle is maneuvered around trees, boulders, ditches, etc.

The vehicle operator is continually making decisions while operating the vehicle based on human interpretation of the information presented at the control station. These decision making processes will subsequently be automated to provide a supervised autonomous operation capability. This will be done using an AI approach, it will be a long term process, and the results of the research will be obtained incrementally. But the research results can be incorporated incrementally, such as with a PIP program, in any development system based on this demonstrator. In this manner, a teleoperated system fielded in the near term can evolve into a fielded system with a supervised autonomous capability in the long term, rather than become technologically obsolete.

Summary

The Department of the Army has recognized the potential payoff of AI/Robotics for meeting present and future Army needs, and has embarked on a development

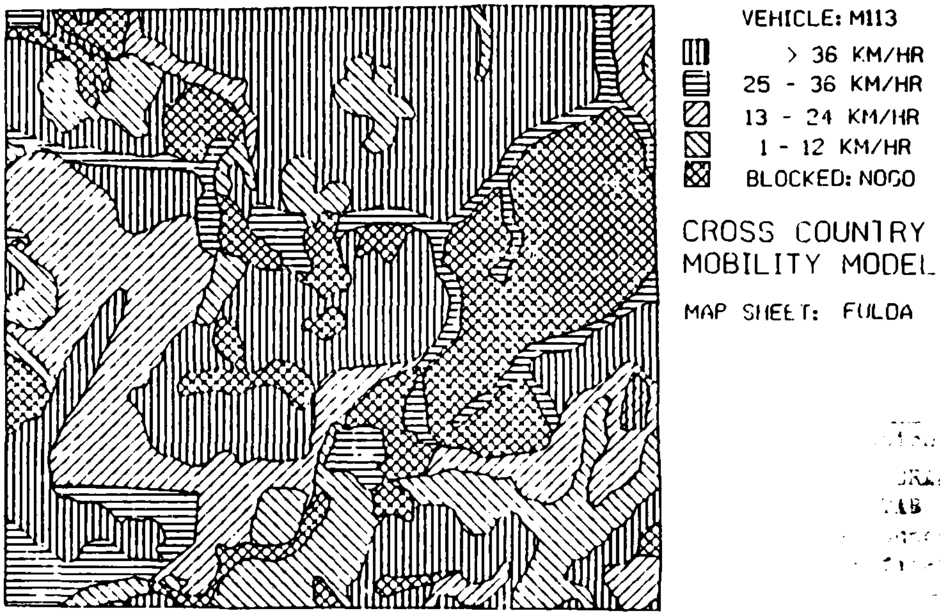


Figure 4 Cross Country Mobility Plot

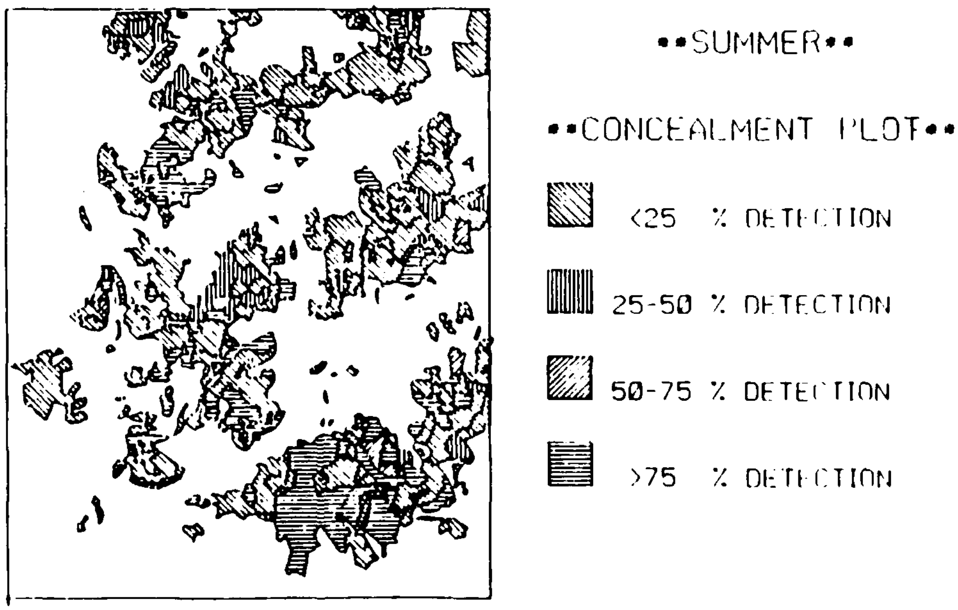


Figure 5 Concealment Plot

program to implement these new technologies. One of these new developments is the Robotic Reconnaissance Vehicle with Terrain Analysis, which will demonstrate the ability to plan and conduct unmanned battlefield reconnaissance operations. But more importantly, the ability to navigate battlefield terrain with an unmanned platform will be developed. Other payloads may be placed on the platform, such as NBC equipment, weapons, laser designators, etc., to provide a variety of unmanned battlefield systems.

References

1. Brown, D.R., et al at SRI International, R&D Plan for Army Applications of AI/Robotics, report #ETL-0296, Aug, 1982, NTIS #AD-A118297.

2. Leighty, R.D., The Army's Activities in Artificial Intelligence/Robotics, SPIE, vol 360-10, Aug, 1982.

3. Robotic Reconnaissance Vehicle with Terrain Analysis, internal plan prepared by the U.S. Army Engineer Topographic Laboratories and the U.S. Army Human Engineering Laboratory, Sep, 1982.

4. Terrain Analysis Demonstrator, internal U.S. Army Engineer Topographic Laboratories plan, Jun, 1982.

5. Zimmerman, B.B., Autonomous Vehicle Navigation, Army Environmental Sciences, Jun, 1983.

6. Zimmerman, B.B., Robotic Vehicle Terrain Navigation, Army Environmental Sciences, Mar, 1983.