



Army Science Board
and
Naval Research Advisory Committee
Joint
Countermine Technologies Study
(From the Surf-zone Inland)

Final Report
1 May 2001
Mr. Frank Kendall



Outline



- Terms of Reference
- Membership
- Organizations Providing Briefings and Support
- Operational Context and Threats
- Countermine Requirements
- Wide Area Countermine Technologies and Programs
- Ground Vehicle Based Countermine Technologies and Programs
- Man-portable Countermine Technologies and Programs
- Surf-zone Technologies and Programs
- Breaching Technologies and Programs
- Basic Research
- Conclusions and Recommendations



Terms Of Reference (1 of 2)

- Assess Alternative Mine Detection/ Neutralization Technologies
- Consider Physical/Chemical Properties of Mines. Prioritize Investments
- Review Ongoing Programs and Recommend Changes
- Recommend a Technology Roadmap
- Analyze COTS/Other Agency Opportunities for Incorporation into DOD Systems
- Recommend How Most Promising Technologies Can be Utilized in Both Hostile and Administrative Environments



Terms of Reference

(2 of 2)

- Assess Opportunities to Execute Mine Clearing in Marine Corps Operational Concepts and in Army Interim Brigade and Objective Force Contexts.
- Address Both Mounted and Dismounted Operations
- Compare Alternative Detection Technologies on the Basis of PD, PFA, Search Rate, safety and compatibility with Combat and Peacetime Operations
- Compare Mine Neutralization Technologies on the Basis of Prob. Of Neutralization, Rate of Neutralization and in Terms Of Area Cleared and Safety in Military and Peacetime Operations



Membership



- Frank Kendall
- Jim Luyten
- Irene Peden
- Rey Morales
- Dave Martinez
- Keith Smith
- Greg Canavan
- P. Mulgaonkar
- Joanna Lau
- Bob Greenwalt
- Ira Kohlberg
- John Blair
- Buddy Beck
- Jim Sarjeant
- Ray Leadabrand
- Debbie Butler (Ex. Sec.)



Study Sponsors



- Dr. Lee Buchanan ASN(RDA)
- LTG Paul Kern DASA(ALT)
- LTG Rhodes CG MCDC



Overview of Organizations Providing Information and Support



- ASA(ALT)
- TRADOC
- DARPA
- Army NVESD
- ARDEC
- Navy Research Lab
- NGIC
- Ft Leonard Wood
- Ft Belvoir
- SRI
- HQ USMC
- NSB
- MCDC
- DOE Labs
- PM/ MCD
- Navy PEO Mine Warfare
- PM FCS
- LL MIT
- Industry (many)
- Academia (many)



Threats

- Over 2,500 Types of Mines in the World:
 - Simple Pressure
 - Non-Metallic
 - Electronically Fused
 - Blast Hardened
 - Side Attack
 - Wide Area
 - Anti-Helo
- Approximately 127 Million Buried Mines Throughout the World.
- Over 225 Million Manufactured by the Top 10 Suppliers in the World.



Countermine Requirements (Our Best Guess at Priorities)



First Priority: Support Tactical Operations:

1. Wide Area Surveillance to Detect Minefields

- Very High Search Rate
- Moderate to High Probability of Detection (PD)
- Moderate False Alarm Rate (FAR)
- Moderate Location Accuracy

2. Assault Breaching Capability on Land and Through the Surf-zone

3. Route Clearance at Operational Speeds (Cross Country and On-road)

- High Search Rate
- Very High Probability of Detection
- Low False Alarm Rate



Countermine Requirements Cont'd

- Second Priority: Secure Local Area or Support Dismounted Maneuver
 - Moderate Search Rate
 - Very High Probability of Detection
 - Moderate False Alarm Rate
- Third Priority: Administrative Mine Clearing or Humanitarian De-mining
 - Low Search Rate
 - Very High Probability of Detection
 - Moderate False Alarm Rate



Current Major Programs (PDRR or Beyond)



• Wide Area	None
• Cross Country Mobility	None
• Route Clearance	GPR/QR
• Handheld Detection	HSTAMIDS
• Breaching	APOBS
• Surfzone Breaching	None
• S&T	Multiple Programs
• Basic Research	Multiple Programs



Current and Programmed CM Capabilities Our Assessment



• Status	Current	Programmed
– Wide Area Surveillance	R	R+
– Combat Breaching		
• In-land	Y	Y
• Surf-zone	R	Y?
– Route Clearance		
• Road	R	Y+
• Cross Country	R	R
– Security/Dismounted Man.	R	Y
– Demining	Y	Y+



Wide Area Countermine Technologies Observations

- This Is the Highest CM Priority for Maneuver Unit Commanders
- It Is an Enabling Capability for Operational Maneuver From the Sea
- In Ongoing Wide Area RSTA Systems Emphasis Is Not on Countermine Mission (CM Payload Priority for Army TUAV Appears to Be Low)
- Unlike Other Areas, Wide Area Detection Can Accept Less Than Perfect Performance and Be Very Useful Operationally
- Technologies to Support Minefield Detection With Useful Levels of Capability Exist
- An IR Based System Should Be Effective Against Recently Emplaced Minefields
- Other Technologies, Including RF Based Systems Should Also Be Considered. Significant Advances Have Been Made in Airborne RF
- The Army and USMC Should Explore Common Platforms and Sensors (TUAV, VTUAV, Other)



LAMD

Army ATD Approach



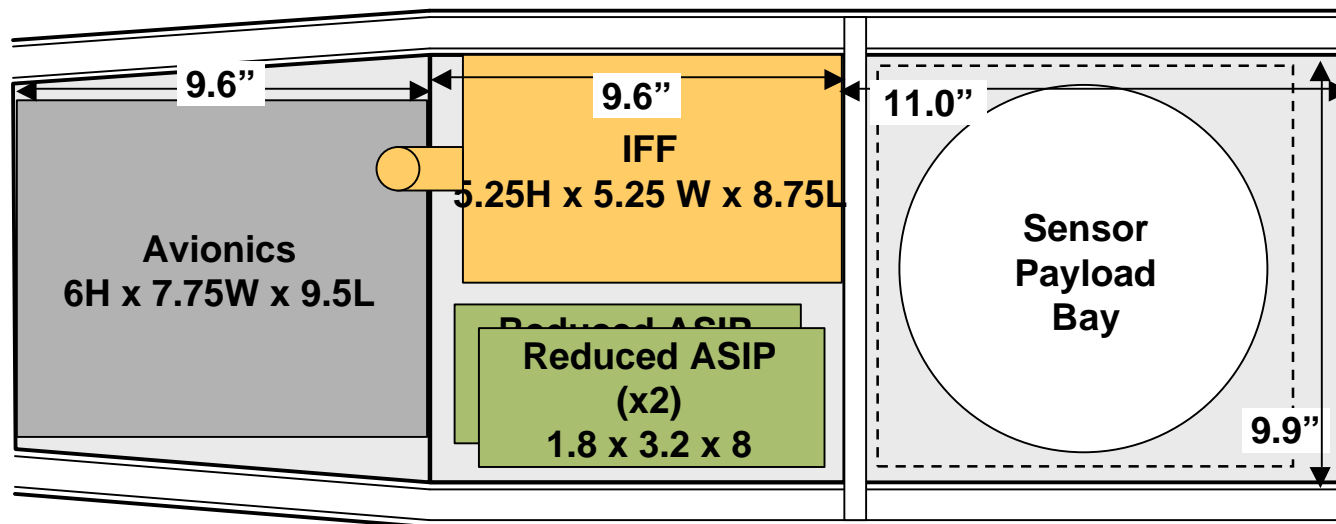
Technical Assessment and Strategy:

- Broadband IR Has Some Potential for Detection of Surface Laid and Recently Buried Minefields
 - Modify TUAV ATD IR Sensor w/o Compromising RSTA
- Polarized Laser Offers Highest Potential for Detection of Surface Laid Minefields
 - Develop LADAR for TUAV Integration
- Multi-spectral LWIR Offers Good Potential for Detection of Recently Buried Mines, Especially on Roads
 - Preserve Growth Option for Multi-spectral IR on TUAV



Shadow 200

Tactical Unmanned Aerial Vehicle (TUAV)



Usable depth = 6.5"

US Army selected the Shadow 200 as its TUAV with contract award on 27 Dec 1999 - Sensor payload < 65lb, Volume <2800 cu in.



LAMD Sensor Development Strategy Study Concerns



- Will Army Permit TUAV to Fly at 1000 Feet?
- Will Army Buy the ATD TUAV EO/IR Payload?
- Should Options Be Limited to TUAV Payload?
- Strategy Is Understandable, But:
 - It Defers Exploration of the Most Promising Technology: Hyper-spectral IR/ LWIR
 - It Does Not Include Other Promising Technologies Such As Various RF Approaches
 - It Is Highly Constrained by TUAV Payload Limitations and Priorities

Recommend Vigorous Joint 6.2 Program to Explore Alternative Technologies Without the Constraints of the LAMD Program



Wide Area Surveillance Conclusions

- A Strong System Engineering Approach Is Needed to Guide Ongoing Work (A 1997ASB Recommendation)
- Long-term Monitoring of Known Threat Areas for Change Detection Should Be Explored
- Multi-sensor/ Phenomenology Approaches Should Be Investigated in a Strong 6.2 Program
- Signal Processing and Clutter Rejection Remain Serious Issues and Should Be Priorities for Research
- Investment in Wide Area Surveillance Is Urgently Needed to Support IBCT, the Objective Force and Operational Maneuver From the Sea
- An ASTAMIDS Like System Should Be Reconsidered
- An Airborne Testbed for Multiple Sensor Types Is Needed

The Priority of Wide Area CM Surveillance Should Be Increased



Ground Vehicle Based Systems

- Current Focus Is on Route Clearance for Roads
 - Interim Capability Being Fielded in Small Numbers
 - Major Program (GSTAMIDS) Is Robotic Vehicle With GPR and Induction Sensor
 - Quadrapole Resonance Being Pursued As Confirmation Sensor
 - Neutralization by Robotically Emplaced Focused Explosive Device
- Future Goals Are Forward Looking GPR and Off-road Detection
- WAM Type Mines Are Not Being Addressed

Evolution of Capabilities

GSTAMIDS Block 1



Provides Improvements over Interim System:

- Integrates Vehicle Tele-Operations Capability
- Integrates Emerging Mine Confirmation Technology
- Integrates Improved Multi-Sensor Array
- Probability of Detection Exceeds 95%
- Clears 40 kilometers of Road in 6 Hours
- Enhanced Operator Protection from Small Arms and Mine Blast Effects
- Neutralizes Mines Through Deflagration
- Distributes Minefield Information Reports Across all Echelons Through compatible C4I Systems



GSTAMIDS Present Limitations and Study Concerns



- Speed Goal Is 40 Km in 6 Hours for GSTAMIDS Block I ~ FY04
 - Is This Acceptable for FCS If It Could Be Achieved?
- Clearance Time Is the Limiting Factor: 15 Min./Spot
- With the Present FAR/m² of 0.042, the OPTEMPO Is Too Slow!
- Need to Reduce FAR by Two Orders of Magnitude (~100x Less)
- Lower FAR Will Permit Route Clearance at ~ 5 KPH
- FCS Would Desire a Faster Route Clearance Than 5 KPH OPTEMPO
 - GSTAMIDS Is Far From Meeting Even 5 KPH Goal

Recommend Army Review GSTAMIDS Blk 1 Cost-Effectiveness



Chemical Detection System

- Quadrupole Resonance (QR)
 - Transmit RF Energy to Disturb the Nuclei in Explosives
 - 800 Khz for TNT and 3.4 Mhz for RDX
 - Very Low FAR
 - Challenges:
 - Signal Recovery Time on TNT Is 1 to 30 Seconds, Have to Wait This Time to Scan Again
 - Recovery Problem Is A Fundamental Limitation
 - Loss of Signal With Temperature
 - TNT Signal Lies on the AM Radio Band

QR Is a Major Breakthrough in Detection Technology, but Best Application May Be As a Confirmation Sensor



Ground Vehicle Based System Recommendations



- Continue Investment for GSTAMIDS System to Improve Its Desired Capability to Permit:
 - Clearance Speed of at Least 5 KPH
 - PD % = 0.95
 - FAR/m² = 0.0003
 - Reduce Logistics Burden by Employing Automated Vehicles (Robotics)

- **Examine Cost-effectiveness of Block 1 GSTAMIDS Before Proceeding to EMD With Current Performance Levels**
- **Consider a Combination of Expendable Teleoperated Proofing Vehicles Followed by GSTAMIDS/ NQR**



Manportable Detection Systems



- Supports Dismounted Maneuver and Local Security Needs
- Current System
 - US Army AN/PSS-12. NDI
 - Uses Pulse Induction Technology at 65 Hz
 - Over 16,000 Procured and Deployed in All Army Units
 - Performance Is Unacceptably Low
- Concerns with Current System
 - Detects Presence of Metal Only
 - No ATR Algorithms to Enhance Performance
 - Audio Tone at 3600 Hz, Common Area for Hearing Loss
 - Only 4 Hours of Training Conducted at USAEC



Army/USMC Requirements and Study Group Conclusion



<u>Requirements</u>	Goal	Actual
•Buried, off road (AT - 6", AP - 3")	90%	95.2
•Surface Mines	90%	N/A
•Buried, nuisance mines on unpaved road	90%	98.7
•False Alarm Rate - 0.6 per square meter		.254
•Single soldier operable ≤ 35 lbs (w/o carry case)		Too Heavy
•Rate of Advance: Operators can sweep approximately 10 meters per minute (based on the current AN/PSS-12) in a 20-meter path		Too slow
•PM Office understands limitations and is addressing them in EMD		

**HSTAMIDS is a Major Improvement Over Current
Systems and Should be Fielded**



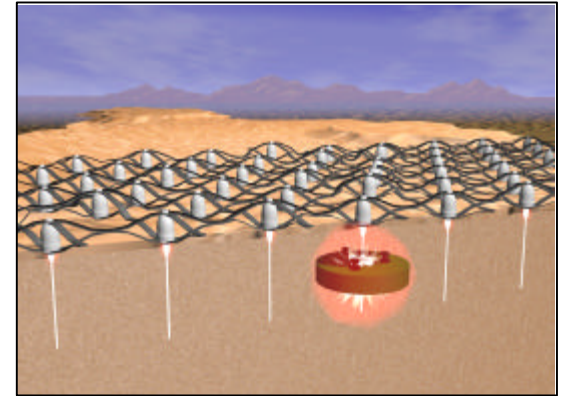
Breaching Technologies Observations



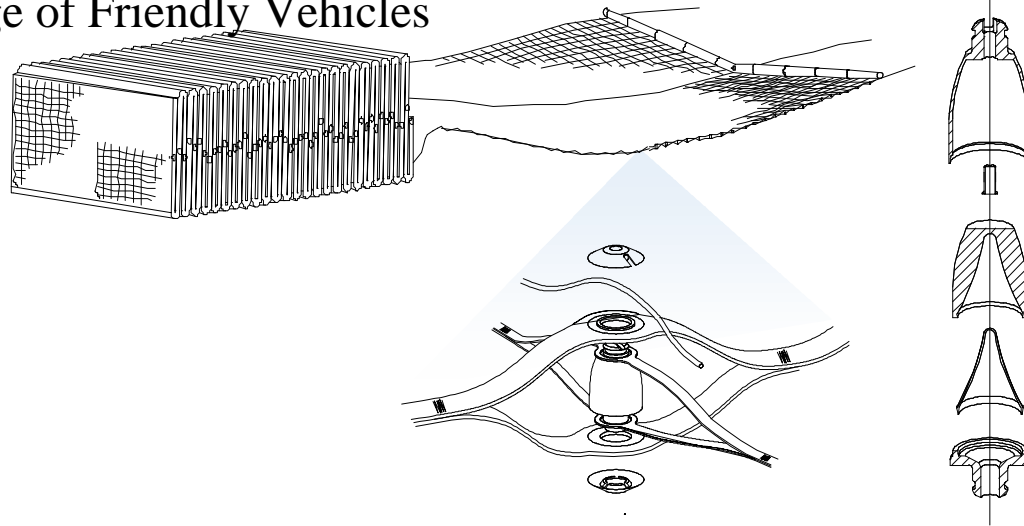
- An Area Where Its Hard to Keep a Program Alive (or at Least Healthy):
 SABRE
 Grizzly
 Mongoose
- Best Approach to Craft Landing Zone and Surf-zone Appears to Be Brute Force Breaching Devices
- New Requirements and Approaches Under Consideration by Navy and Army

Biggest Problem Seems to Be Institutional Commitment

What is Mongoose?



- Containerized, Command-Detonated, Rocket-Deployed Array of Shaped Charges Launched onto Mines/Minefields to Provide a High Confidence Cleared Lane Against All Known Mine and Fuze/Sensor Types for the Passage of Friendly Vehicles



- Integrated System Delivers Ground Penetrating Countermine Shaped Charges to Directly Attack the Mines and Provide Greater Than 95% Probability of Cleared Lane



Breaching Conclusions and Recommendations

- Insufficient Exploration of and Commitment to Brute Force Approaches
- Beach Exit Zone Responsibilities Are Not Clear - a Joint Problem
- Army Initiative to Resurrect Mongoose Should Receive Serious Consideration, Independent of Conclusion Regarding Grizzly
- Low Tech Surf-zone Breaching Options Such As Precision Bombing Should Be Reconsidered (Specialized Munitions May Be Required)



Basic Research Observations



- Basic Research Issue in Countermine Is Not Shortage of Ideas or Approaches
- Issue Is Sorting Out Best Approaches, Investing, and Cutting Losses When Promises Are Not Fulfilled
- MURI (Multi-university Research Initiative) Program Has Been Reasonably Successful, but Is Not Budgeted to Continue in This Area
- Multiple Phenomenologies Including RF, IR and Chemical Detection Merit Additional Effort
- A Disciplined Test Program, With a Statistically Meaningful Data Base of Results Is a Necessary Element of Basic Research
- There Should Be More Collaboration With the International Community in This Area (A Great Deal of Applicable Research Is Being Conducted)

Study Group Strongly Recommends Continuing an Independent Basic Research Program, on the MURI Program Model, With a Highly Qualified External Annual Peer Review



Closing Observations



- A Lot of Commendable Work Has Been Going On
 - HSTAMIDS Development
 - Maturation of QR and Its Integration Into the Army Program
 - Integration of Robotics Into Countermine Systems
 - Broadly Based Basic Research
 - Initiation of a Blind Test Facility Supporting Statistical Results
 - Progress Toward GPR Goals
 - And More
- But We Are a Long Way From a Robust Countermine Capability



Top Level Recommendations



- Operational Needs and Priorities Need to Be Clearly Thought Through and Quantified
- Focus Needs to Shift From Route Clearance to Meeting Maneuver Unit Commanders Operational Needs, Particularly Wide Area Surveillance
- Implications of APLM Ban by Treaty Need to Be Considered
- Army Proponency Needs to Extend Beyond Corps of Engineers and Intelligence Branches
- Wide Area Surveillance Mine Detection Should Be Pursued As a High Priority.
 - There Are Cooperative Opportunities Between the Army and Navy and Internationally



Top Level Recommendations Cont'd



- HSTAMIDS Should Be Fielded As Planned, but Upgrades Should Be Pursued
- GSTAMIDS Cost-effectiveness Should Be Assessed Prior to Any Further Commitment to Block I
- QR Development Should Continue
- A Strong Basic Research Program Like the MURI Program Should Be Continued and Strengthened
- S&T Efforts in the 6.2 Area Should Increase 2 to 3x and Be Focused on High Priority Problems, Particularly Wide Area Surveillance