



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
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- 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**



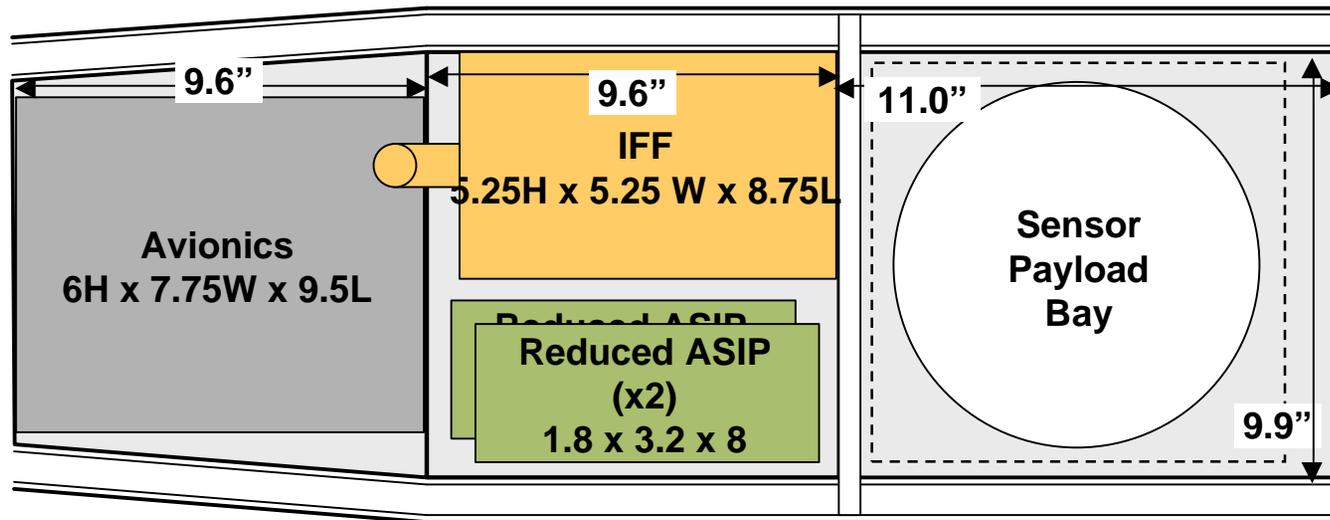
### Technical Assessment and Strategy:

- 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**

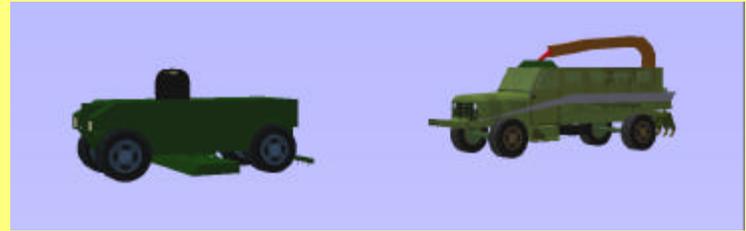


# Ground Vehicle Based Systems

- 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/m<sup>2</sup> 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/m<sup>2</sup> = 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



<b><u>Requirements</u></b>	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 $\leq$ 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**



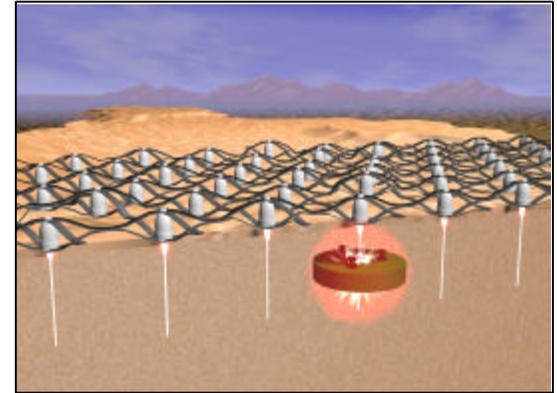
# Breaching Technologies Observations



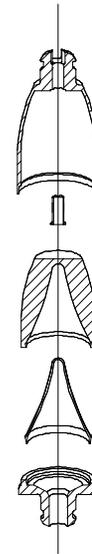
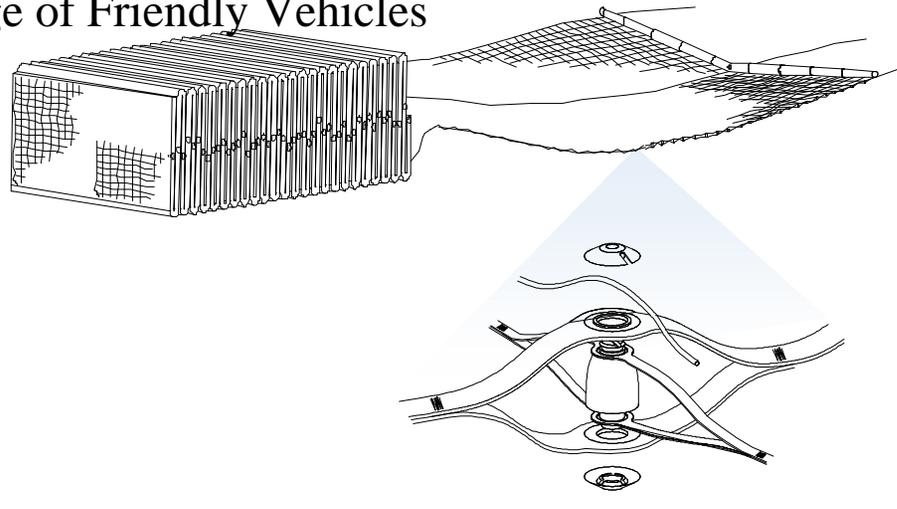
- An Area Where Its Hard to Keep a Program Alive (or at Least Healthy):
  - SABRE
  - Grizzly
  - Mongoose
- Best Approach to Craft Landing Zone and Surf-zone Appears to Be Brute Force Breaching Devices
- New Requirements and Approaches Under Consideration by Navy and Army

**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 Countermines 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 Countermining 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 Countermining 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