Trace Species Detection Using READ and Miniature GC/MS

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JPL

COASTAL SYSTEMS STATION
CSS
DAHLGREN DIVISION
PANAMA CITY, FLORIDA

FAA
Federal Aviation Agency

NASA

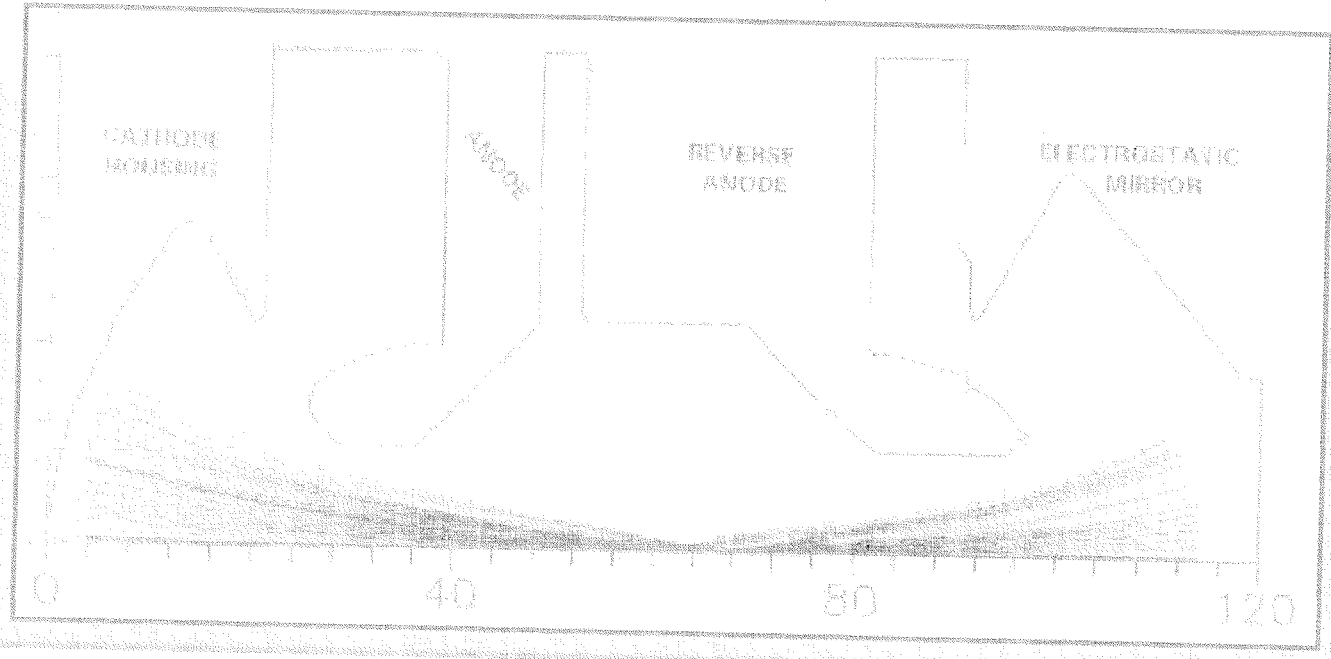
SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

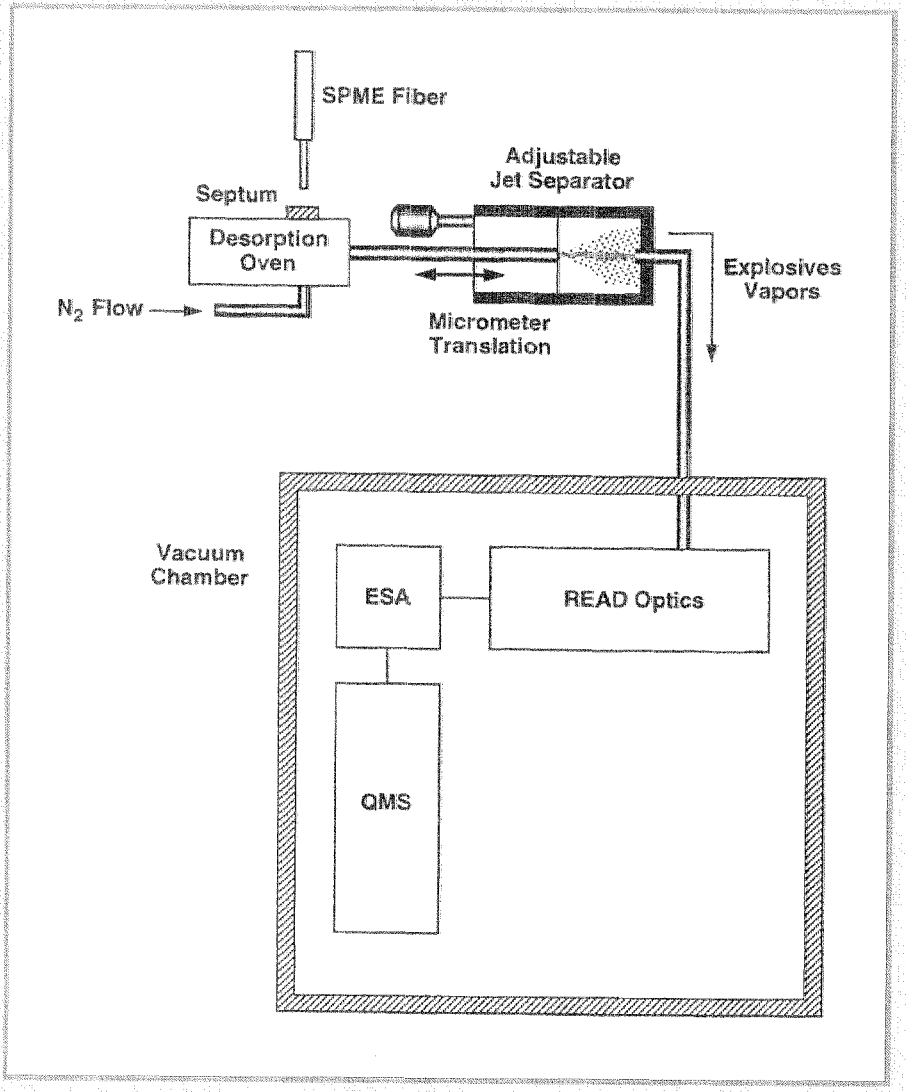
OFFICE OF NAVAL RESEARCH
ONR

DoD
Department of Defense

READ : Reversal Electron Attachment Detector

- Developed through FAA, DOD, and DOE funding (9 years)
- Real-time pptr sensitivities to explosives, contraband and nerve and blister agents
- Interfaces for vapor, liquid, and solid sample interrogation
- Sensitive to unconventional non-nitrated explosives
- Currently testing new READ - real-time ppqd sensitivities





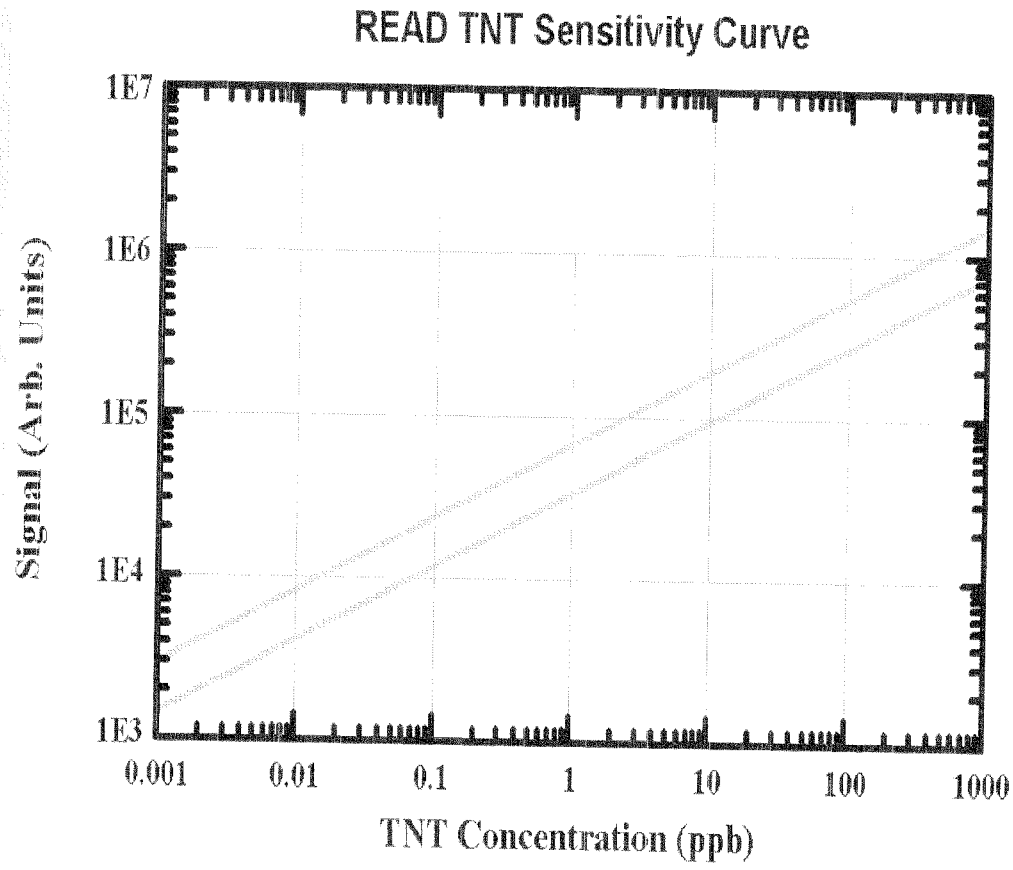
SPME / READ analysis for explosives

- ~100g of sediment collected within 1 foot of 12 UXOs.
- Add MeOH, pipette liquid, dry, add H_2O, then microextract (SPME)
- inject SPME fiber into READ explosives detector
- time/sample ~ 2 hrs

SPME / READ Sensitivity

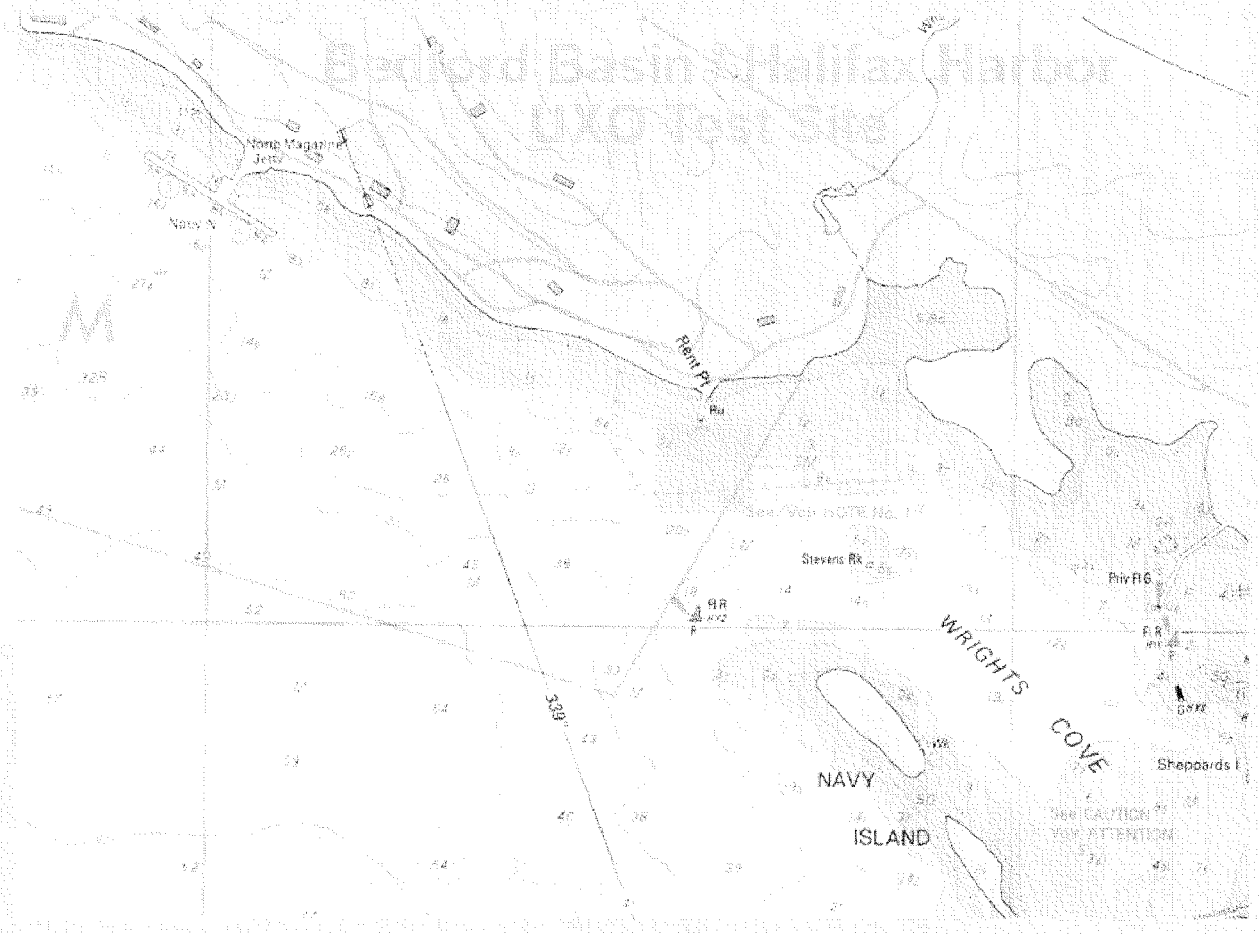
1 pptr QUANTITATIVE

50 ppqd QUALITATIVE

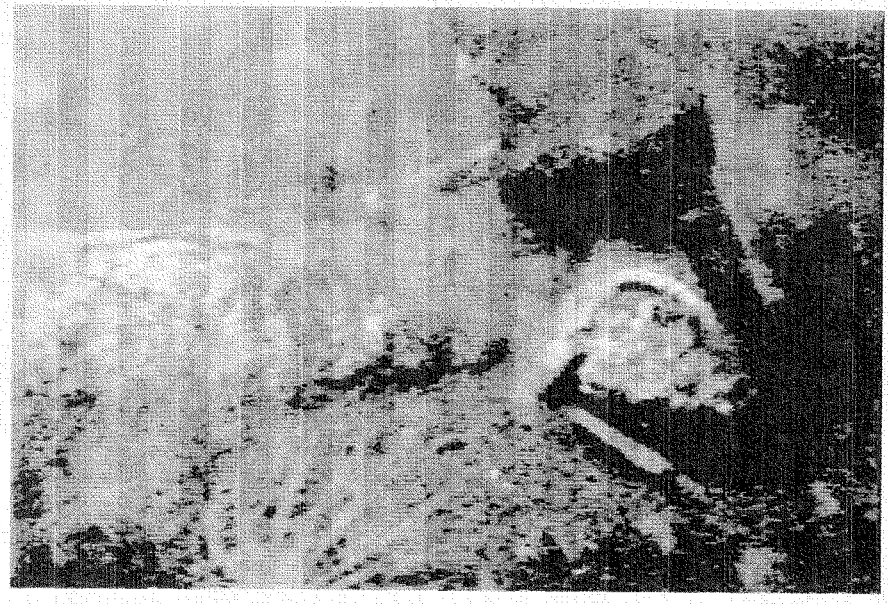


Halifax harbor site

- all "live" ordnance
- undisturbed since 1945
- shallow water
- silt/sand bottom

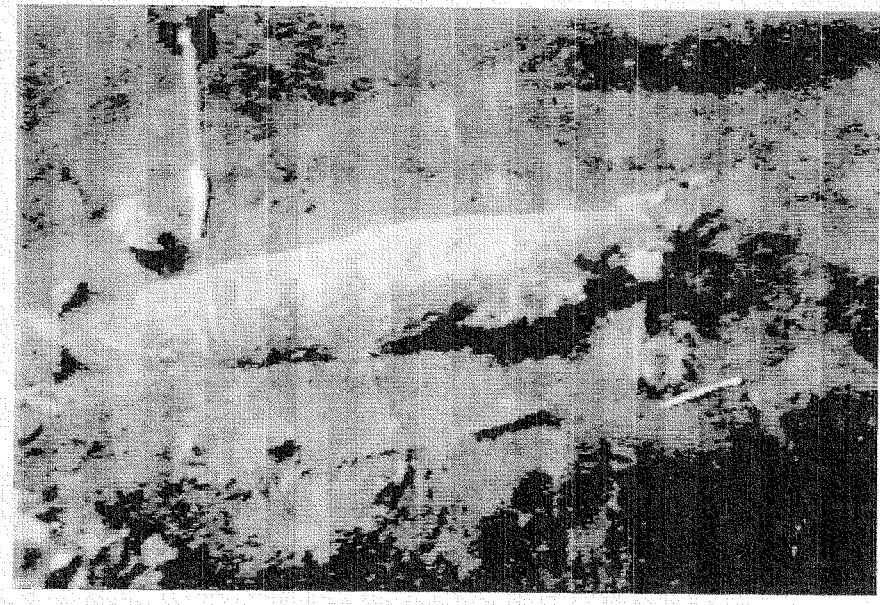


Two 5" Artillery Shells Broken Open



No Explosive Traces Detected

5" Artillery Shell Intact

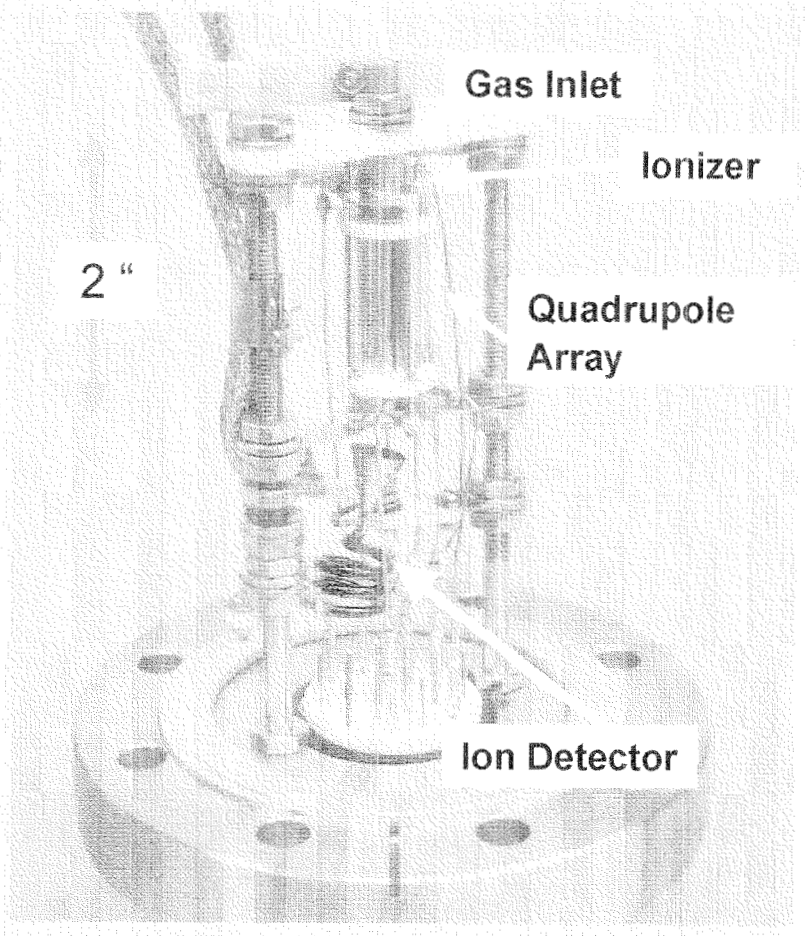


Trace TNT Detected at pptr levels

Target	Target Type	Samples	Results
1	5" Shell Poor Condition Broken Open	A,B,C,D	No Explosives Detected
2	5" Shell Very Poor Condition Broken Open	E,F,G,H	No Explosives Detected
3	5" Shell Very Good Condition Intact	I,J,W,X	TNT Detected at low ppb concentrations
4	9" Shell Semi-Buried Appeared Intact	K,L,M,N	DNT Detected at high pptr concentrations
5	2 x 5" Shells Very Poor Condition Broken Open	O,P,Q,R	No Explosives Detected (Confirmed by Independent Lab)
6	5" Shell Semi-Buried Intact with Fuse	S,T,U,V	DNT Detected at low ppb concentrations (Confirmed by Independent Lab)
7	Background	17,20	No Explosives Detected

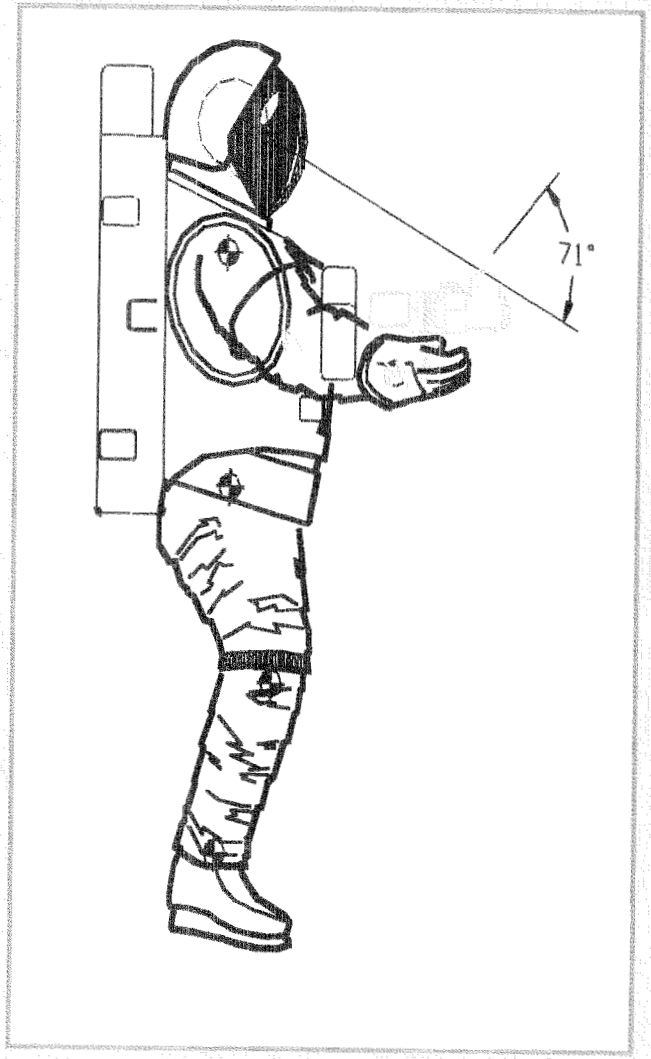
- Conclusion: Chemical traces of explosives (or related chemicals) have been detected from sampling the sediment near intact, unexploded ordnance (UXOs).

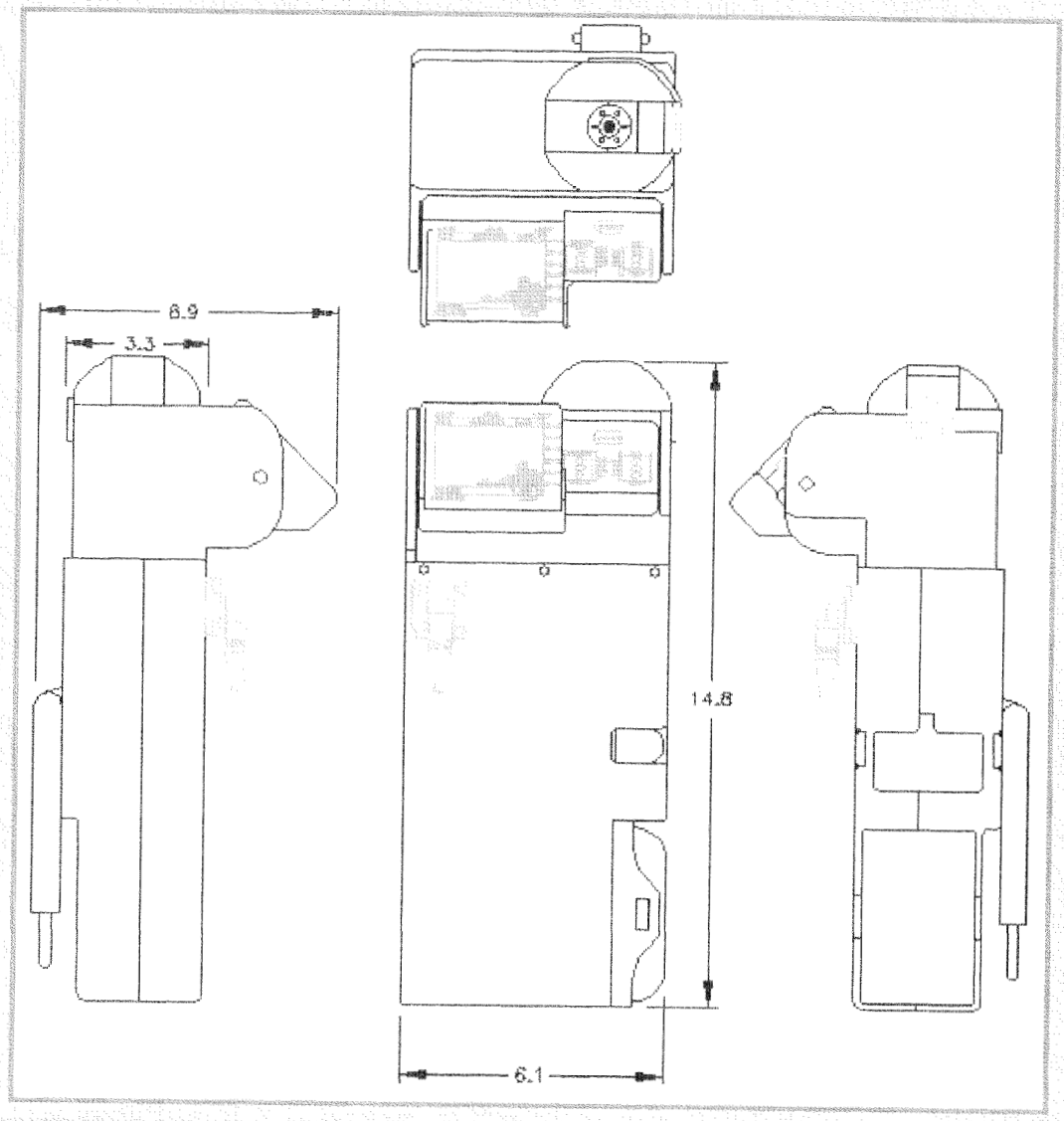
- Conclusion: UXOs that are not intact have yielded no detectable explosives traces at the parts-per-trillion level.



Miniature Quadrupole Mass Spectrometer Array (QMSA)

- world's smallest quadrupole mass spectrometer
- Sensor 1" long x 0.5" Diam and 50 grams
- 9 parallel quadrupole mass analyzers
- mass range 1-600u Δm=0.5u (FWHM)
- sensitivity 10^{12} counts/torr/sec
- operating pressure ~ 1 mTorr
- power consumption = 15W at 150u
- Currently commercially produced by InSitu (Laramie, WY)


71°


6.9
3.3
14.8
6.1

Spacecraft Air Monitoring - Spacecraft Maximum Allowable Concentration (SMAC)

Partial SMAC List

Acetaldehyde	0.10 ppm
Formaldehyde	0.01 ppm
Methanol	0.20 ppm
Dichloromethane	0.03 ppm
Acrolein	0.01 ppm
Ethylene	0.05 ppm
Furan	0.01 ppm

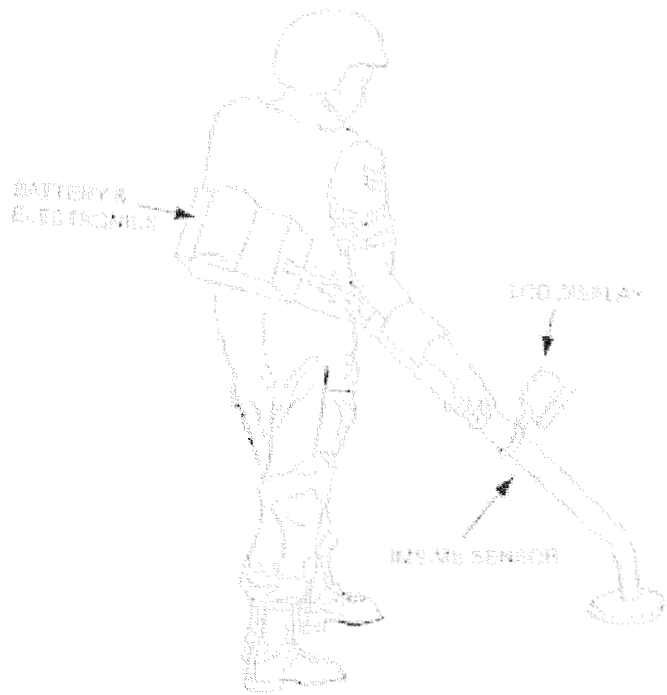
μGC and QMSA

- μGC (1 W, 100 grams)
- small Pfeiffer Turbo Pump (10 l/s) (10 W, 1.5 kg)
- KNF rough pump (4 W, 1.0 kg)

Target Sensitivity > 0.01 ppm

1 hour operation time per battery

Field Detection of Explosives, Contraband, Nerve and Blister Agents

- low mass, power, volume
- sub-pptr sensitivities
- low false alarm rate in dynamic "vapor" environment

Solution: IMS / Mini-READ and µGC/QMSA sensor