Block II Chemical Biological Mass Spectrometer (CBMS)

Winner

R&D 100

Year 2000
Research and Development 100 Award

ornl UT-BATTELLE Orbital MSP School of Mines 1874 Colorado

Block II Chemical Biological Mass Spectrometer (CBMS)

- The first ***integrated*** system capable of detecting and identifying ***both*** chemical and biological warfare agents
- Reconnaissance, point detection and stand-alone deployment
- Applications to counter-terrorism, civil defense, health care
- Winner of the 2000 R&D 100 Award
- Sponsor: U. S. Army Soldier and Biological Chemical Command
- 1997—2002, Ca. $45M
- Team: ORNL (Lead); Industrial Partner: Hamilton Sundstrand Sensor Systems; Bio Sampler: MSP Corporation; Bacterial Identification by Pyrolysis MS: Colorado School of Mines. Also AFIP, DPG, WSMR.

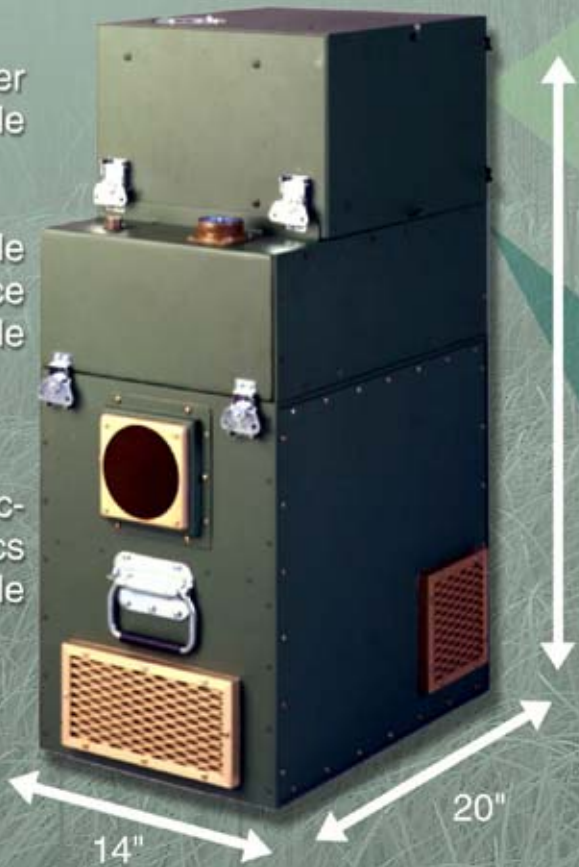
Block II CBMS Specifications

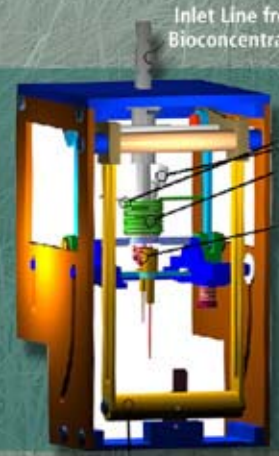
- Physical:
  - Mass - 175 lb
  - Volume - 5.7 ft^3
  - Peak Power - 1,200 W
- Sensitivity:
  - Bio - < 25 Agent-Containing Particles/L of air (ACPLA)
  - Chem - < 0.4 mg/m^2
- "Better than current systems"

Block II CBMS Specifications (cont.)

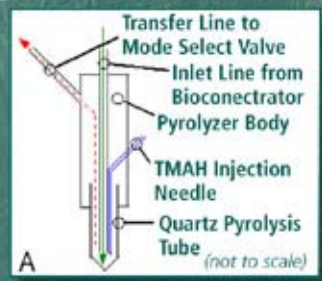
- Response Time:
  - Bio - < 4 minutes
  - Chem - < 45 seconds
- Rugged: Survive
  - Temperature:
    - -32^{o} to +49^{o} C (operate), -51^{o} to +71^{o} (store)
- Vibration and shock (wheeled vehicles)
- Radiation (from nuclear blast)
- Soldier friendly, easy to operate and maintain
- Self-diagnosing: BIT to diagnose to LRU

Block II CBMS Hardware

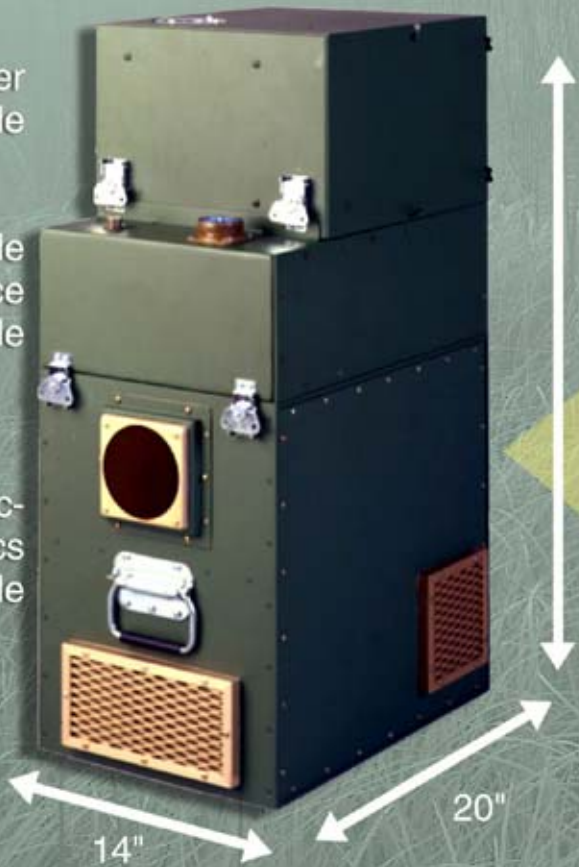




Pyrolysis Tube Exchange Handle
(hold pyrolysis tube in palce and lowers it for exchange)



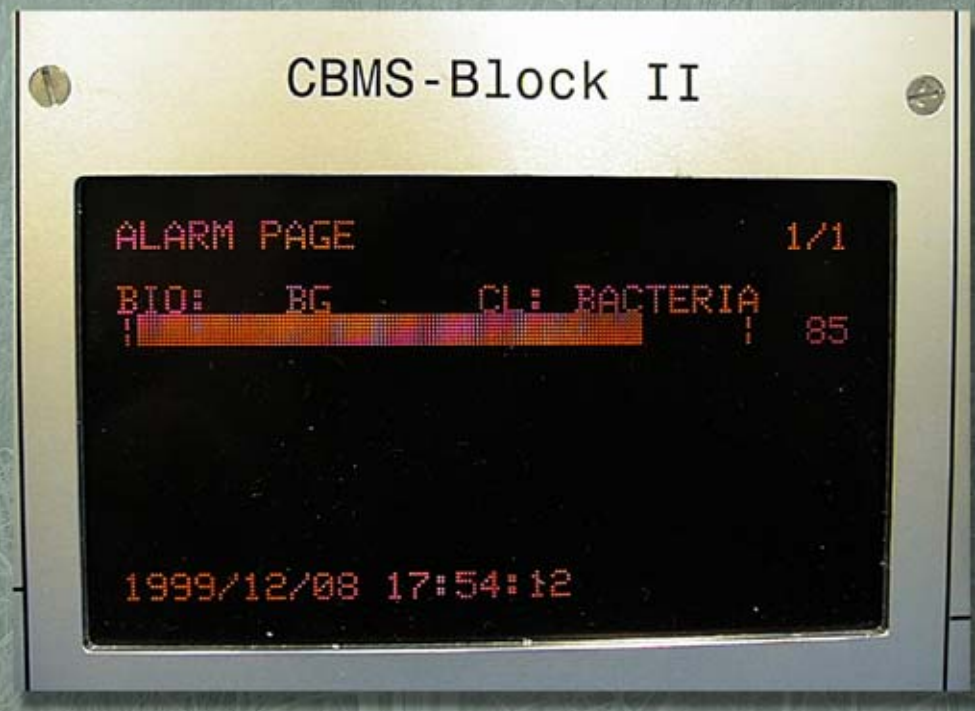
Block II CBMS Hardware (cont.)



The Soldier Operates the CBMS Via the SDU

Soldier Display Unit (SDU)

Alarm Message

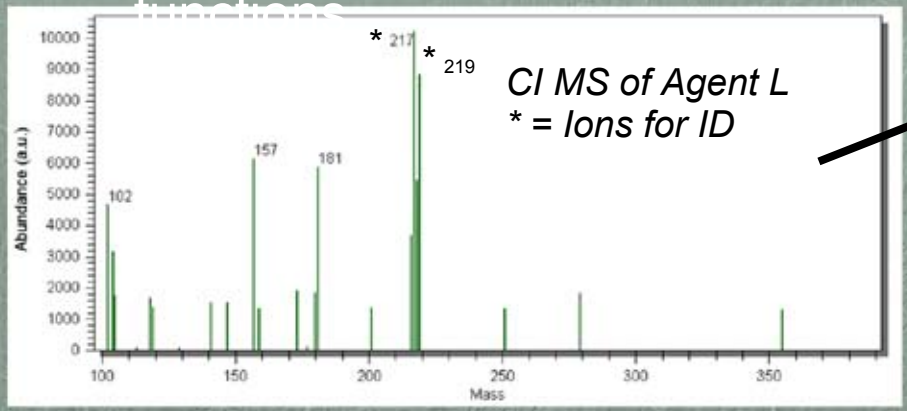


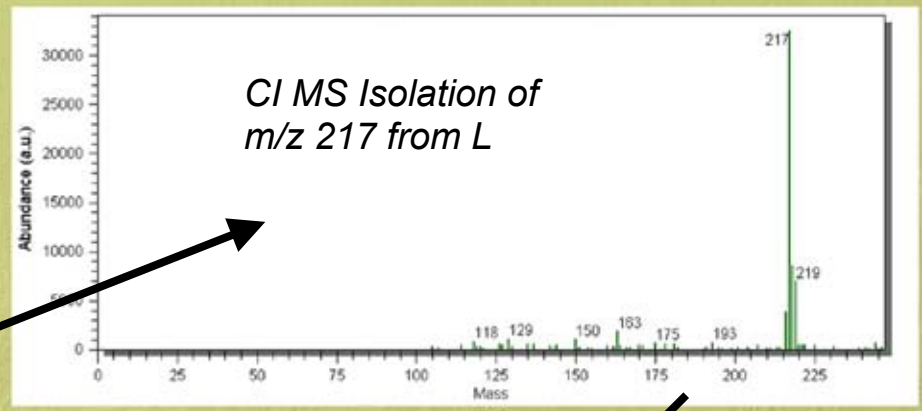
Chemical Agent Detection & ID

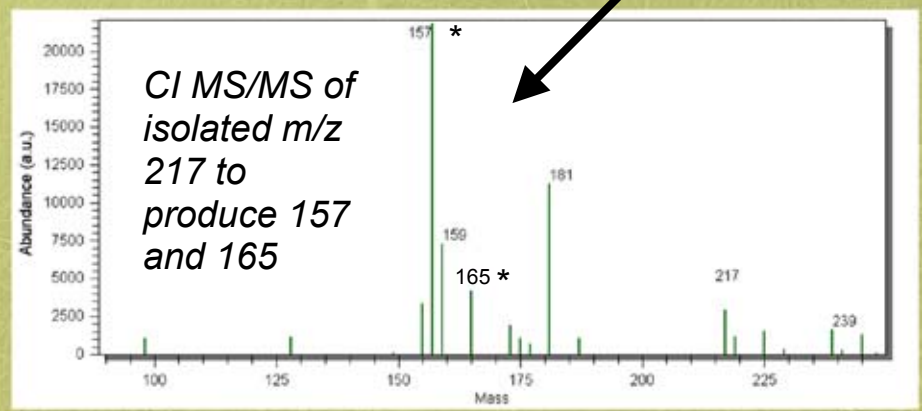
- Liquid agents on the ground sampled via Bruker ground wheels and chem probe. Agent vapors sampled by capillary line. Agents routed to the MS analyzer via the mode select valve and transfer line.
- MS runs multiscan function sequence
  - Full scan EI (w/ CI gas present)
  - Full scan CI
  - Six MS-MS scan functions
- For ID and alarm, compound must have parent ion(s) and product ion(s) above background.
- Unknown agent EI and CI spectra stored when encountered and assigned code for ID as unknown to allow alarm.

Block II CBMS - Chemical Agent Detection and Identification (cont.)

- Detection and identification by full-scan and Tandem Mass Spectrometry (ms/ms) multi-scan functions







Both parent ions in CIMS and product ions in ms/ms are required for identification

Block II CBMS - Chemical Agent Detection and Identification

- Lab testing

CW agents are applied to the petri dish for sampling via the probe

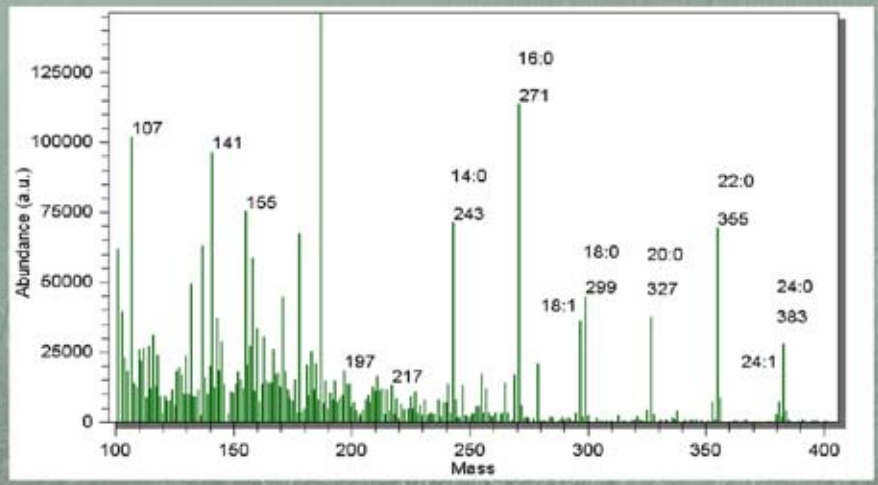
Summary of Chem Performance Test Results

- Sensitivity determined for 23 nerve, blister, choking, and tear agents and agent simulants.
  - Best sensitivity was for agent GA: 18 correct IDs for 20 replicates at 13 ng.
  - Least sensitivity was for low-volatility agents (e.g., DM); mainly a chem probe sampling issue.
- Correctly ID VX, GD, and HD in 2 to 400-fold mass excess of of fog oil, jet propellant, and diesel fuel.
- Survived exposure of probe membrane to 500 to 13,000-fold mass excess of DS2 and still correctly ID VX, GD, and HD

Biological Agent Detection & ID

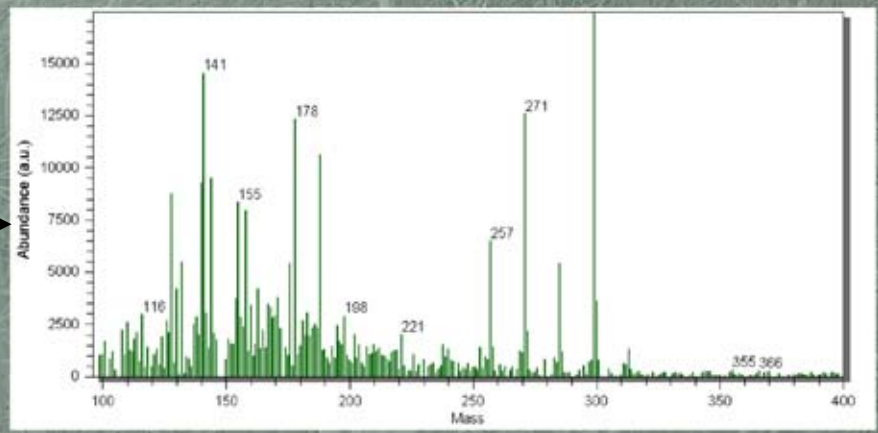
- Collection of 2-10 um bioaerosol sample via biosampler.
- Automated injection of TMAH and heating (350^{o}C) to lyse cells, saponify and methylate fatty acids and other biomarkers. Biomarkers transferred to MS analyzer via mode select valve and transfer line.
- MS runs full scan CI MS of biomarkers.
- Bioalgorithm ID agents via linear discriminant analysis.
- Biocycle completed in less than 4 min.

Block II CBMS - Biological Agent Detection and Identification (cont.)



- Spectrum of Gram Negative bacteria at 31 ACPLA; 3.2 um Particles; washed

- Spectrum of crude protein



Block II CBMS - Biological Agent Detection and Identification

- Lab testing

CBMS in Bio Laboratory

Ink Jet Aerosol Generator delivers bioaerosol to CBMS

Summary of Bio Performance Test Results to Date

- Bioalgorithm has very good resolving power.
- Differentiated target agents, including two strains of one bacteria.
- Differentiated among crude preparations of two toxins (plus pure versions).
- No alarms on blanks, even with much greater “diet” of samples than would be encountered in the field.
- Initial tests suggest 25 ACPLA sensitivity specification will be met.

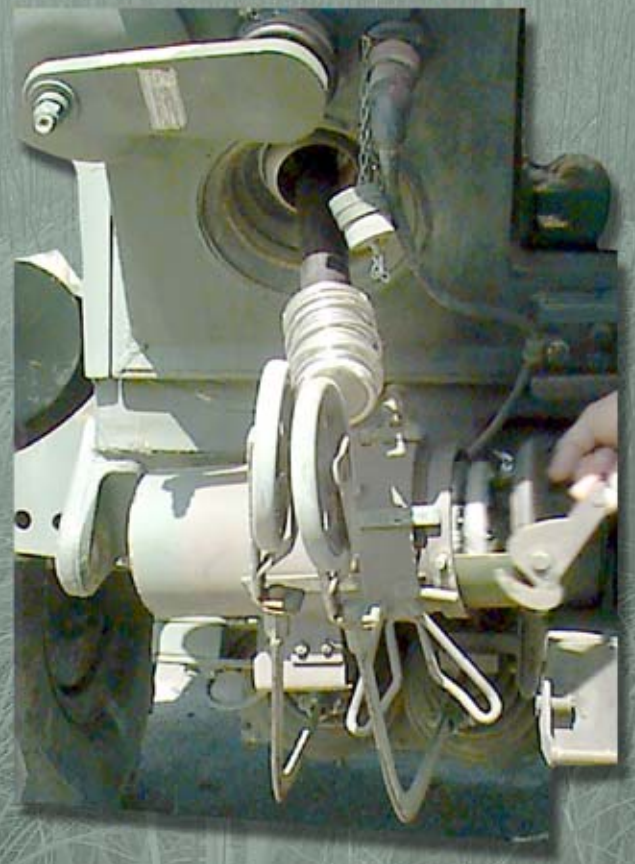
Block II CBMS Platforms

- Joint service lightweight nuclear biological chemical reconnaissance system (JSLNBCRS)

- A light armored vehicle (LAV) is also planned

Block II CBMS Platforms (cont.)

- Interim Armored Vehicle (U.S. Army)



Ground Sampling System for Chemical Agents

The Next Generation...

- Detects and identifies bacteria, viruses and toxins *a priori.*
  - Without calibration in the lab.
  - Agent identification capabilities expand continually.
- Smaller, lighter package with less power draw
  - Eventually, a man-portable device.