



# **Chemical Biological Defense Science and Technology**

Mr. J. H. Zarzycki  
CBD Reliance Panel Chair and  
Technical Director Edgewood Chemical Biological Center

# Outline



- **CB Reliance**
  - Drivers of S&T Investment
  - Program Plans and Structure
- **CB Non-Medical S&T**
  - Taxonomy
  - Thrust Areas and Opportunities

# Drivers of S&T Program Investment

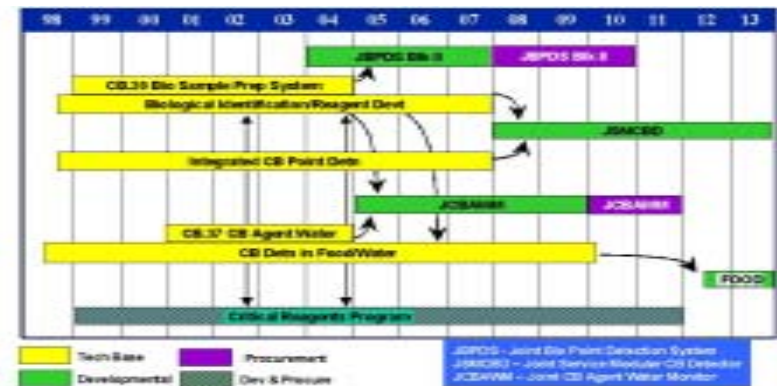
- **Joint Future Operational Capabilities**

- Developed and priority-ranked by user representatives
- Describe operational needs in general technical terms
- Address major operational functional capabilities of Contamination Avoidance, Battle Management, Individual Protection, Restoration Capability, Collective Protection
- Provide overarching strategic guidance



- **Mature development program**

- Identifies target dates / funding to focus technology transitions
- Temporary unfunding of many mature development programs in 04-09 POM
- Opportunity to ensure technology maturity determines transition dates

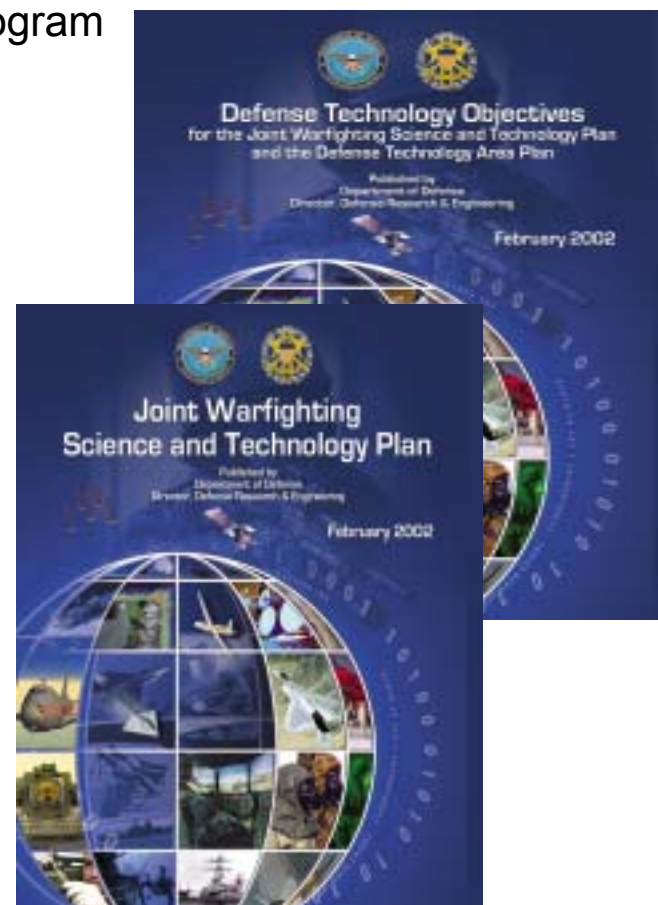


# FY2003 Joint Future Operational Capabilities

|  |   |
|--|---|
| <b>1 Battlespace Info Mgmt</b>         | <b>11 Equipment/Facilities/Area Decon</b> |
| <b>2 Medical Prophylaxes</b>           | <b>12 Transportable Col Protection</b>    |
| <b>3 Early Warning</b>                 | <b>13 Fixed Site Col Protection</b>       |
| <b>4 Point Detection</b>               | <b>14 Mobile Collective Protection</b>    |
| <b>5 Battlespace Analysis/Planning</b> | <b>15 Personnel/Casualty Decon</b>        |
| <b>6 Respiratory Ind Protection</b>    |   |
| <b>7 Med/Environ Surveillance</b>      |   |
| <b>8 Percutaneous Ind Protection</b>   |   |
| <b>9 Med Treatment</b>                 |   |
| <b>10 Med Diagnosis</b>                |   |

# CBD Program Plans

- **Defense Technology Area Plan (DTAP)**  
**Chapter II – CB Defense**
  - DTAP provides comprehensive view of DoD S&T program goals and strategies, capturing all high-priority S&T objectives (via Defense Technology Objectives)
    - 2 program areas – Medical & Non-Medical
    - 6 technology sub areas
    - 28 DTOs
- **Joint Warfighting S&T Plan (JWSTP)**
  - JWSTP focuses on Service- and CINC-identified Joint Warfighting Capability Objectives and the alignment of DoD S&T program against those objectives
    - Chapter XII Counter Proliferation of WMD
      - 4 DTOs I.06, I.07, I.08, I.09
    - Chapter XIII – Combating Terrorism
      - 1 DTO – L.07



# DTO Policy

- **DTOs are high priority S&T efforts**
- **A DTO states:**
  - What specific technology advancements will be developed and/or demonstrated
  - By what Fiscal Year
  - For what specific benefit
  - Stated quantitatively against one or two metrics solving what technical barrier
- **DTO policy: DTOs are the building blocks of the Defense S&T Program. They provide a means for:**
  - DoD S&T planning and programming
  - S&T program defense
  - S&T program articulation
  - Fulfilling GPRA requirements
- **The DUSD (S&T) will review the Department's S&T Program to ensure that key funded efforts are included as DTOs**

# CBD S&T Program Strategy

- **Overall goal:**
  - Develop and integrate technologies from the six sub areas into a comprehensive defense shield, such that the use of chemical or biological agents in the battlespace has little impact on operational effectiveness
- **Areas of emphasis:**
  - Address the Growing Threat from Proliferation and Genetic Engineering
  - Improve Situational Awareness:
    - Better sensors and decision tools
    - Network sensors – both CB and non-CB
    - Fuse sensor data with decision tools



Fig 2 AN/USQ 139  
Seismic sensor



# CBD S&T Program Strategy (Continued)

- **Areas of emphasis (Continued):**

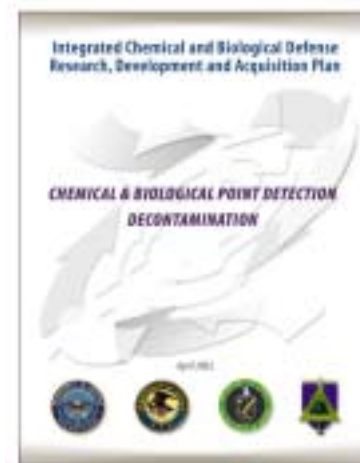
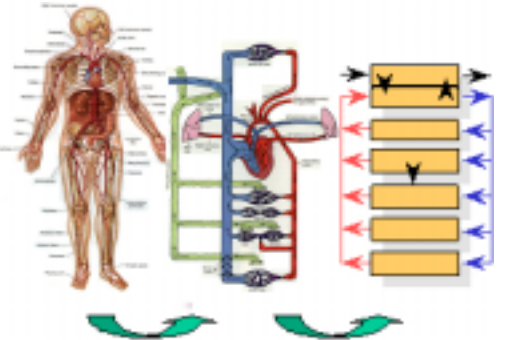
- Reduce the Logistics Burden:

- Single application tools; e.g., C&B sensor, all agent decon
- Regenerative filtration
- Vaccines
- Broad acting medical countermeasures; e.g., multiagent vaccines, and therapeutics

- Improved Understanding of the Threat Itself:

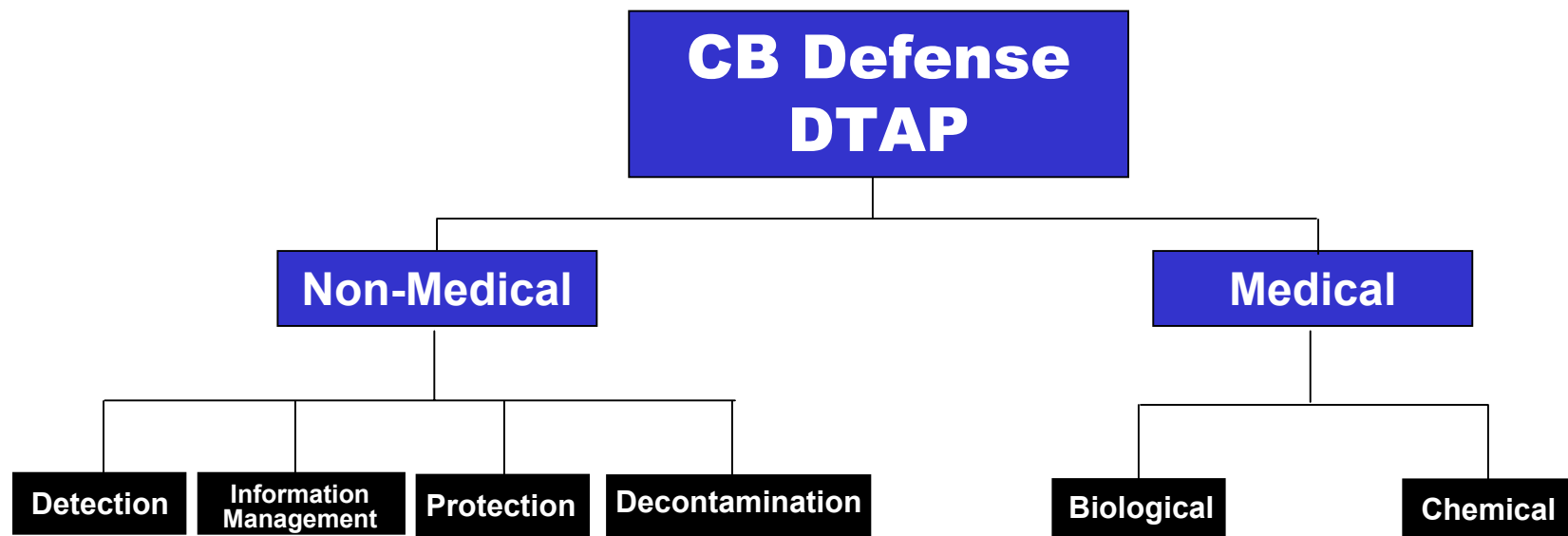
- Agent Environmental Fate
- Low level toxicological effects
- Aerosol physics

- Leveraging Investments Across National and International CBD Programs





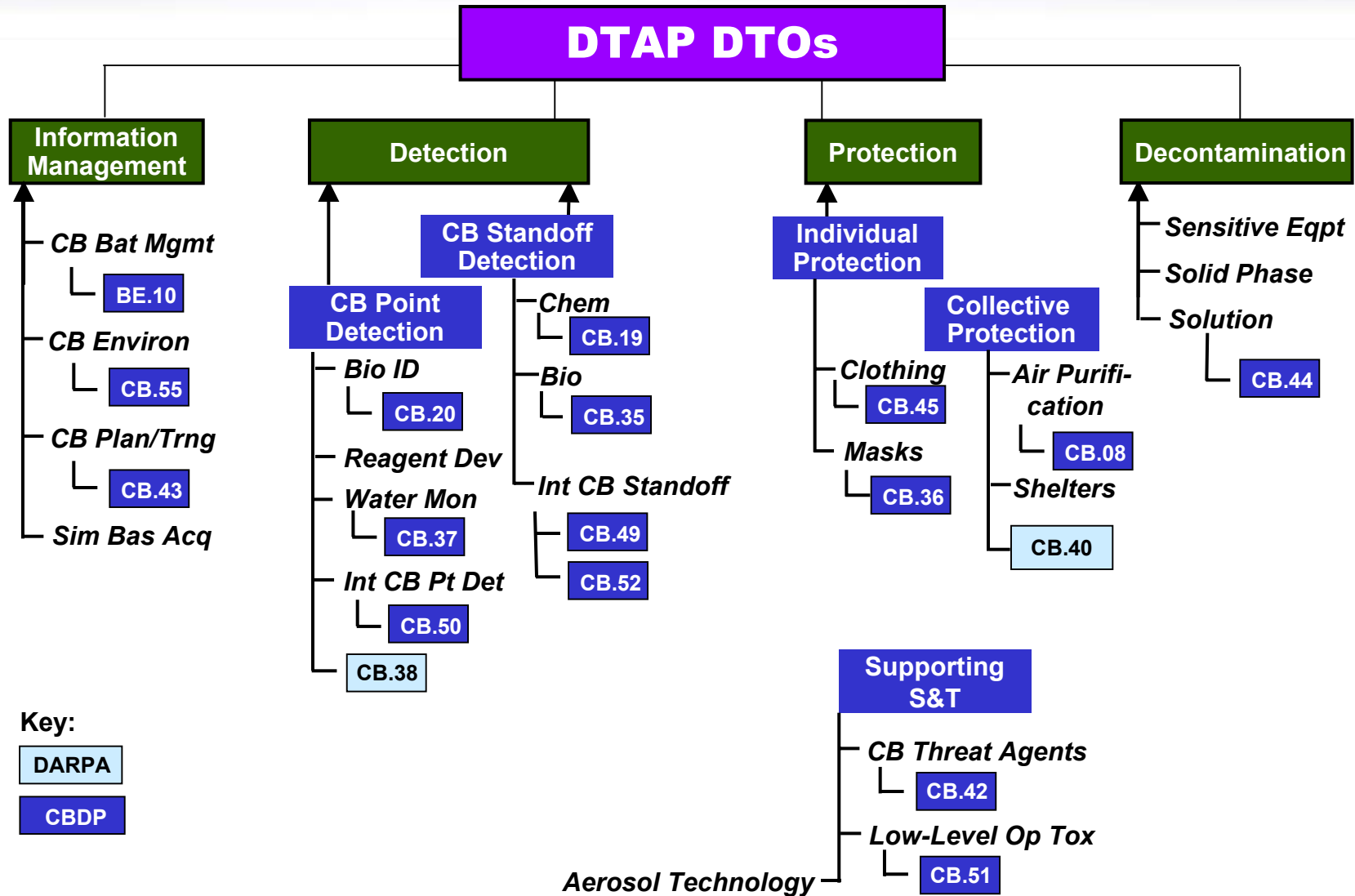
# CBD S&T: Overall Architecture



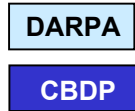


**DoD CBDP  
Non-Medical Science and  
Technology Program**

# Non-Medical S&T Program Taxonomy



Key:



# Non-Med CB S&T Funding Summary

| NMTB DTO picture as of 12-02 | FY03 |     | FY04 |      | FY05 |      | FY06 |      | FY07 |     |
|------------------------------|------|-----|------|------|------|------|------|------|------|-----|
|                              | 6.2  | 6.3 | 6.2  | 6.3  | 6.2  | 6.3  | 6.2  | 6.3  | 6.2  | 6.3 |
| Total DTAP DTOs by PE        | 40.3 | 3.3 | 39.3 | 10.0 | 32.2 | 17.8 | 18.0 | 10.6 | 5.5  | 0.0 |
| Total DTAP DTOs              | 43.6 |     | 49.3 |      | 50.0 |      | 28.6 |      | 5.5  |     |
| Total Program 6.2 + 6.3      | 96.0 |     | 88.0 |      | 86.5 |      | 82.9 |      | 86.2 |     |
| Fraction Program in DTOs     | 45.4 |     | 56.0 |      | 57.7 |      | 34.5 |      | 6.4  |     |

| FY03 funding profile |     |          |          |
|----------------------|-----|----------|----------|
| In-house             | OGA | Industry | Academia |
| 49%                  | 15% | 29%      | 7%       |



# CB Standoff Detection Thrusts

## Chemical Standoff Detection

Objectives: Develop and demonstrate passive and active concepts for remote detection, identification, ranging, and mapping of chemical clouds in all physical forms



Chemical Imaging Sensor



JS Warning ID Lidar

## Bio Standoff Detection

Objectives: Develop and demonstrate concepts for remote detection, identification, ranging, and mapping of biological particulate clouds



Short-range BSDS

## Integrated CB Standoff Detection

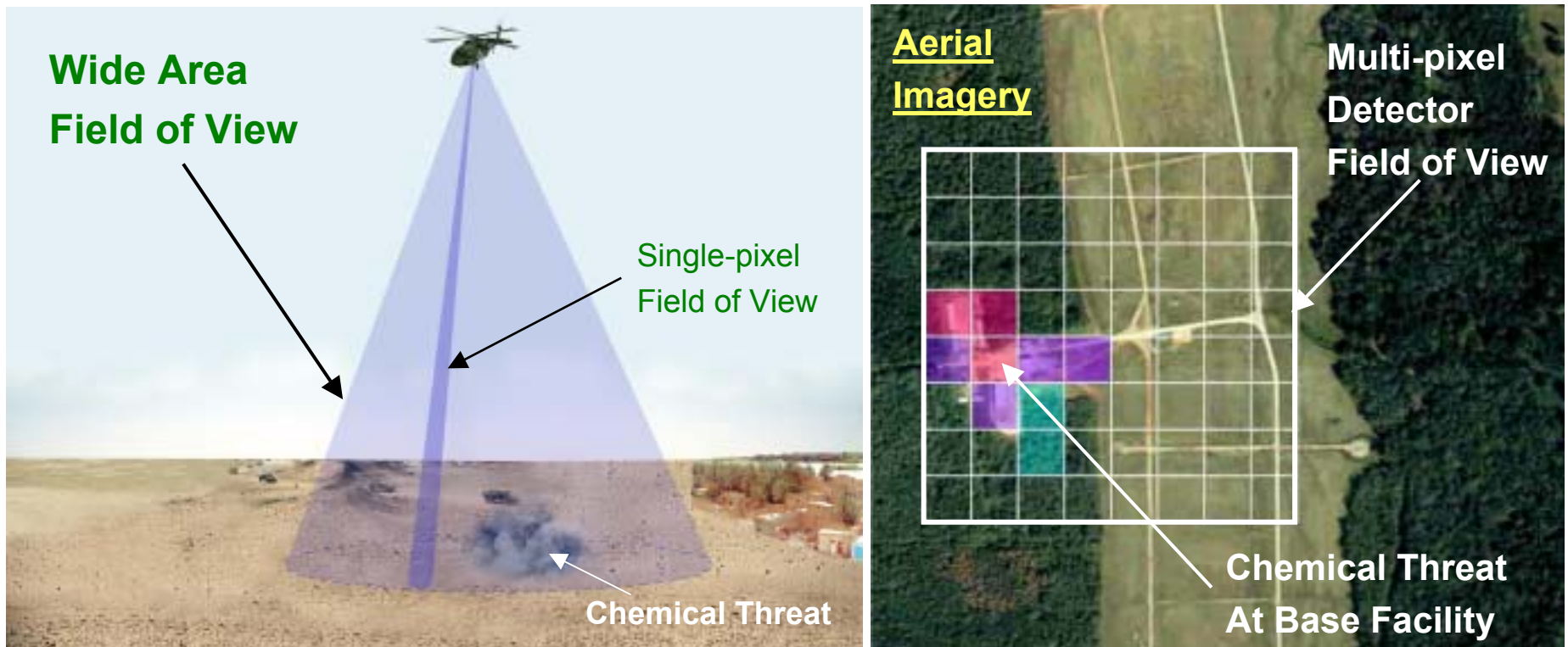
Objectives: Develop and demonstrate concepts for remote detection, identification, ranging, and mapping of chemical and biological clouds in all physical forms with a single sensor platform

**Merge capabilities into a single small platform**

**?**

# Wide Area Reconnaissance for Chemical Agents

## Wide Area Detection Concept



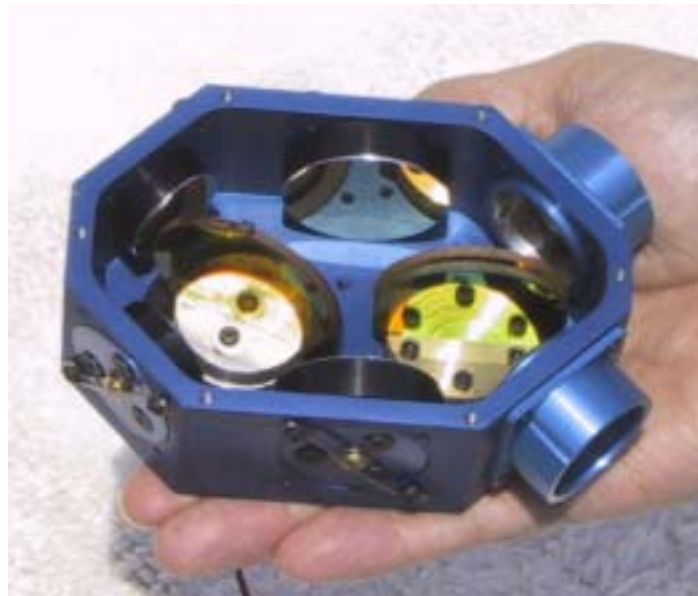
- Wide field of view covers more area than single-pixel sensors
- Snapshot of scene with minimal pointing / scanning

DTO CB.19

# Chemical Imaging Sensor

- **Accomplishments:** 16-pixel Chemical Imaging Sensor running at 360 scans/sec with real time processing of data demonstrated
  - New **imaging** sensor built to meet DTO objectives
  - New algorithms specific to imaging spectrometers

- **Lightweight (less than 5 lbs.)**
- **Extremely small (5"x3"x2")**



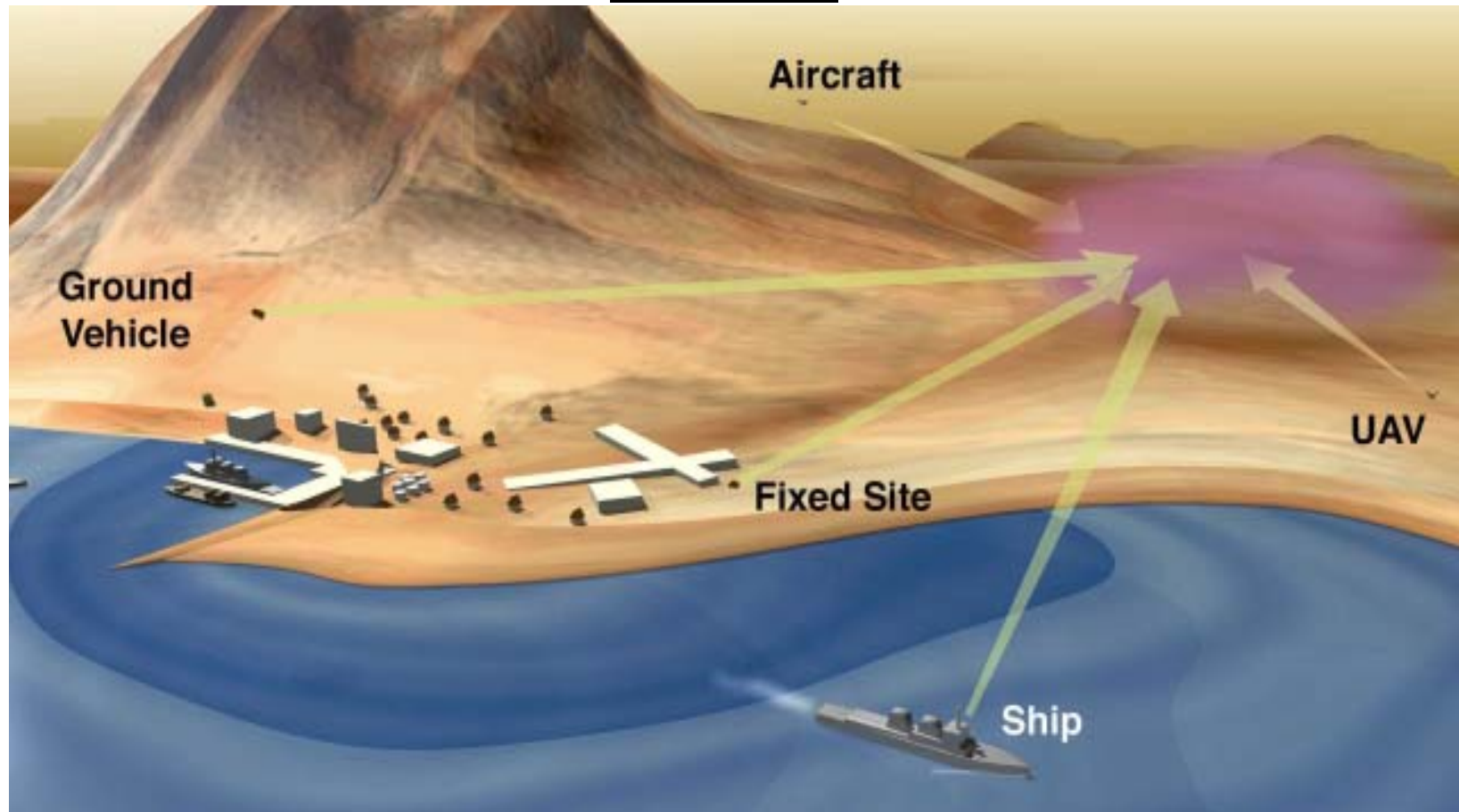
**Current Configuration of the Chemical Imaging Sensor**



DTO CB 35

# Standoff Biological Aerosol Detection

## Concept



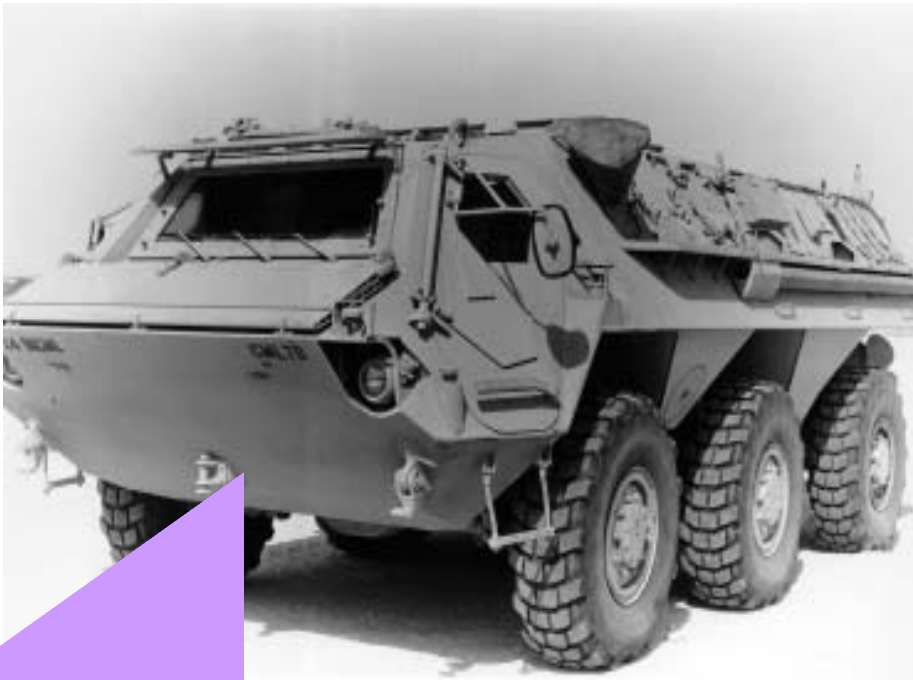
**Target cloud detected at source of event  
against ambient background**



DTO CB52

# Detection of CB Contaminated Surfaces

## Functional Concept



- Multi-platform applicability
- Goal of 0.5 g/m<sup>2</sup> set by PM-NBC Recon

# CB Point Detection Thrusts

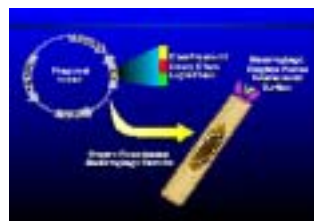
## Biological Identification

Objectives: Develop fully automated sample prep and analysis systems for unattended monitoring of air samples; transition FY04 to JBPDS



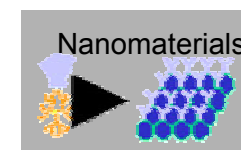
## Reagent Development

Objectives: Develop improved reagent candidates for implementation in fielded and developmental identifiers via Critical Reagent Program



## Detection in Water/Food

Objectives: Provide the capability to detect, identify, and quantify chemical and biological contamination in potable water



## Integrated Chem/Bio Point Detection

Objectives: Develop small, hand-size detectors to identify chemical agents and detect, discriminate biological agents



Optical fluorescence



Pyrolysis-GC/IMS

# DTO CB37

## CB Agent Water Monitor

- **New areas of funding**

- Sample capture, concentration and extraction
- Optimized, new, novel capture probes
- New signal processing, disparate sensor suite approaches
- New, novel sensing technologies and approaches
- Testing and validation methodologies

- **All have a commercial life after DoD**

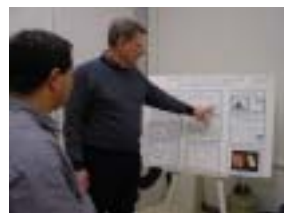
- CDC, EPA, American Water Works Association Research Foundation, Drinking Water Industry



Navy



Military field water



Air Force



Reps from EPA and AWWARF



Reps from CHPPM, CEHR, Sandia, EPA

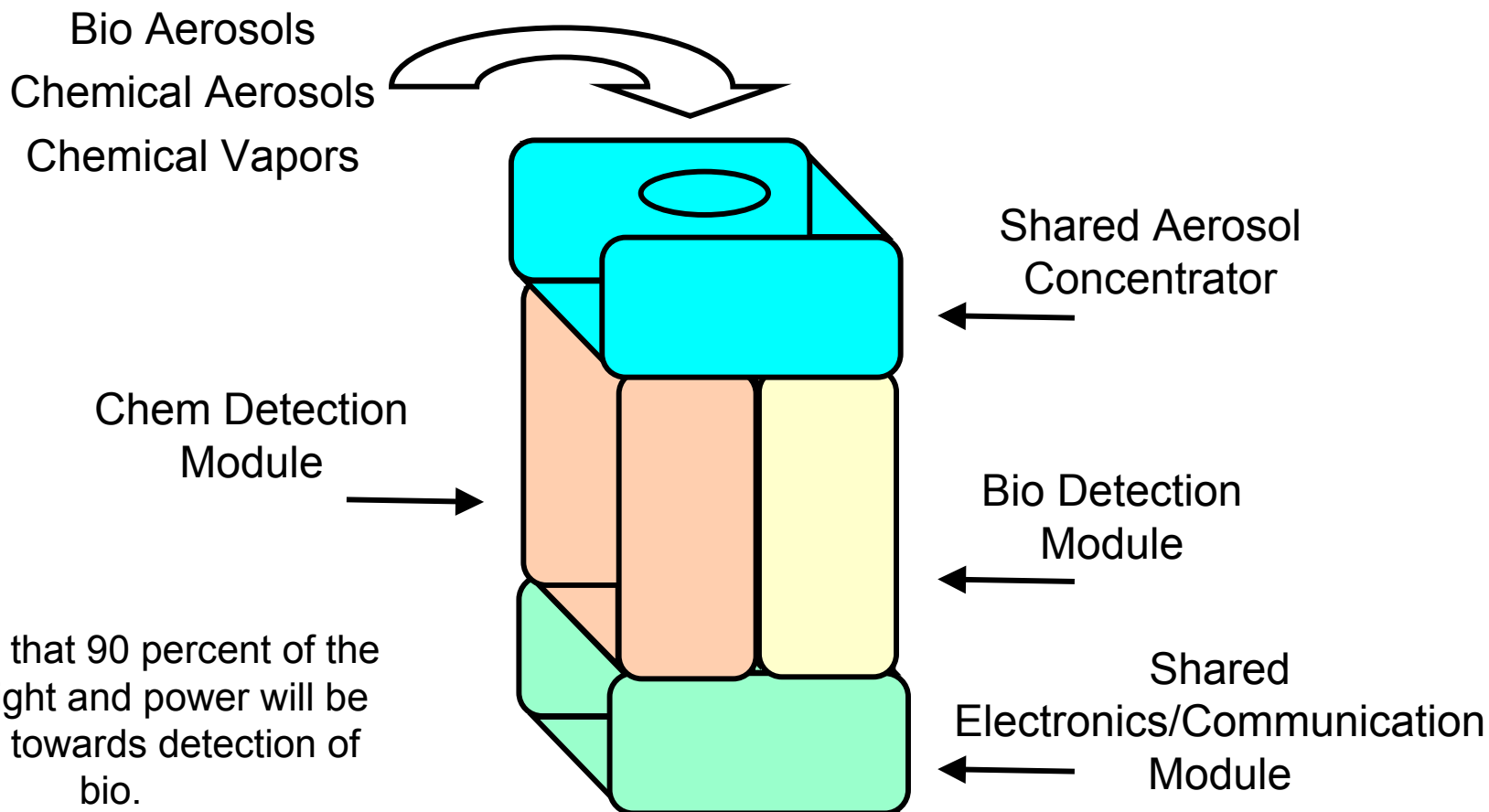


USGS

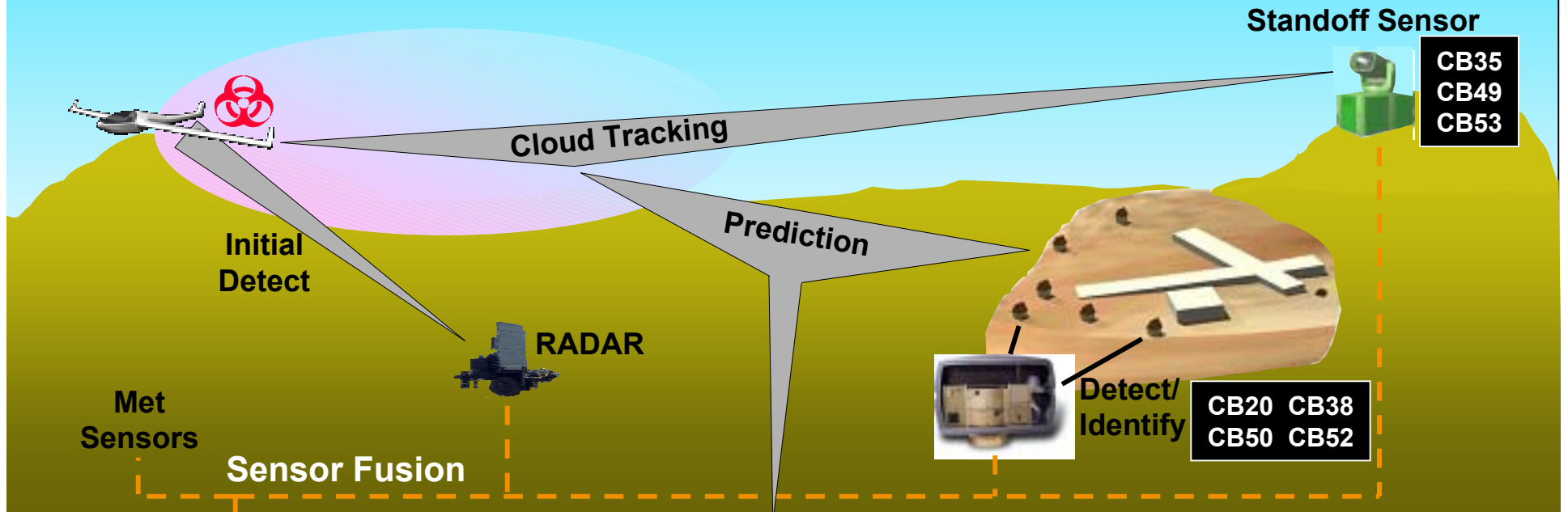
# DTO CB.50

## Lightweight Integrated CB Detection

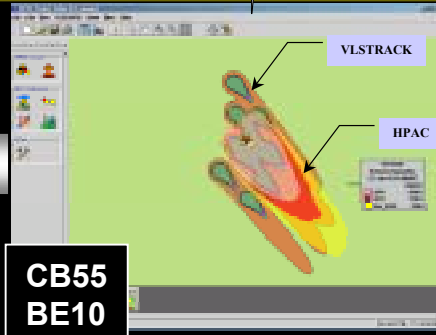
### Concept



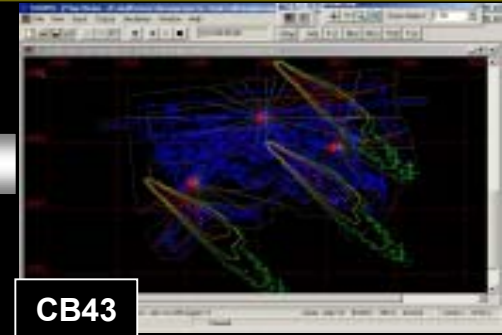
# The Situational Awareness Picture



**Visualization**



**Hazard Evolution**



**Operations Impacts**

# Information Systems Technology Thrusts

## CB Battle Management

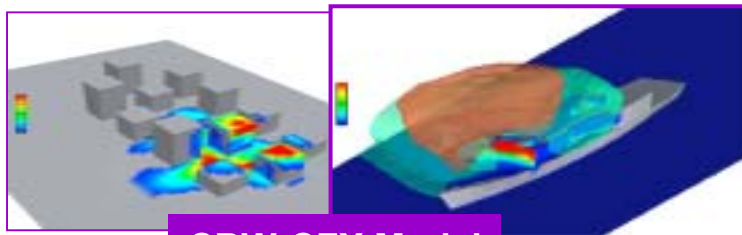
Objective: Develop sensor/data fusion and threat visualization architectures, as well as communications interfaces with command/control assets



Q36/Q37

## CBW Environment

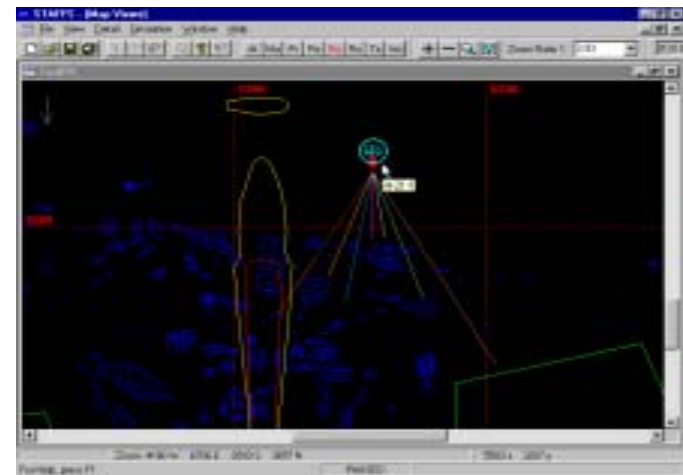
Objective: Develop models to track evolution of CB threats from vapor, liquid, and solid agents across range of scales from individual to theater



CBW-CFX Model

## CB Planning/Analysis

Objectives: Develop models to describe effects of CBW events on operations and improve planning for CBW events



## Simulation Based Acquisition

Objective: Models supporting development of CBD equipment

# Individual Protection Thrusts

## Clothing

Objectives: Develop garments that provide increased CB agent protection and decreased impediment to wearer's performance

### Challenges:

- Self-Detoxification
- Membranes/fabric interfaces
- Durability



## Masks

Objectives: Demonstrate concepts that enhance respiratory and head protection against CB agents

### Challenges:

- Adsorbent materials
- End-of-service life indication
- TIC/TIM removal



# Future Warrior System

- Advanced lens system with improved vision, field-of-view, chemical resistance, and durability. (NGGPM/NGAM)
- Next generation mask system with improved protection, reduced weight and bulk, reduced thermal burden, and improved system integration. (NGGPM/NGAM)
- ESLI with improved user confidence and safety and reduced logistics. (JSGPM & NGGPM/NGAM)
- Advanced filter system with improved protection and reduced breathing resistance. (NGGPM/NGAM)



- Improved system integration with suit, mask, helmet, gloves, boots, body armor, weapons, etc. (JSLIST Upgrade)
- Reactive clothing materials with increased protection, reduced doffing hazard, and reduced logistics burden. (JSLIST Upgrade)
- Cool, lightweight CB duty uniform based on nanofiber or membrane technology with increased mission duration and a reduced logistics burden. (JSLIST Upgrade)



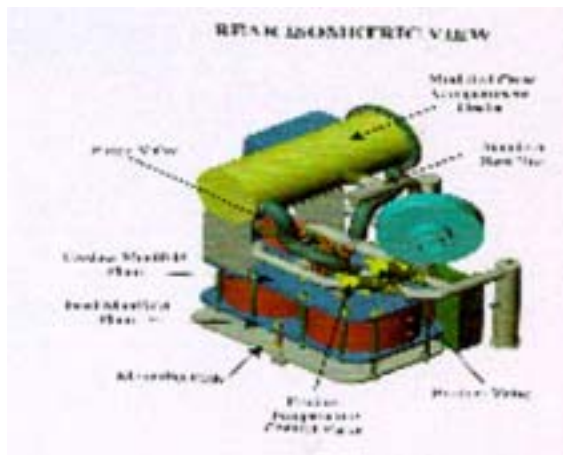
# Collective Protection Thrusts

## Filtration

Objectives: Develop filtration approaches that reduce frequency of filter changes and are applicable to all toxic materials

### Challenges:

- Residual life indicators
- Filter regeneration
- Biological filtration



## Shelters

Objectives: Develop collective protection shelters with improved environmental isolation against threats from CB and toxic materials

### Challenges:

- Hermetic seals
- Rapid deployment
- Self-detoxifying materials



# Decontamination Thrusts

## Solution Chemistry

Objectives: Develop decon systems that supplement or replace existing systems used for immediate, operational and thorough decon and to replace DS2 and aqueous bleach in thorough decon applications.



## Enzyme Reactants

Objectives: Develop and demonstrate a new generation of CB warfare agent decontaminants that are non-toxic, non-corrosive, non-flammable, environ. safe and lightweight.

Sub-thrust  
to solution  
chemistry

## Sensitive Equipment

Objectives: Decontaminate sensitive equipment, interiors of combat vehicles and aircraft, and interiors on the move.



## Solid Phase

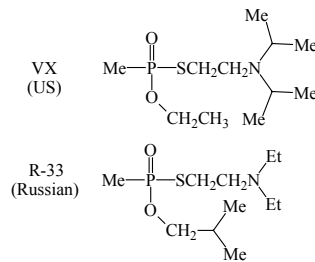
Objectives: Investigate and validate cost effective deactivation and destruction of CW agents rapidly by solid matrices. Extend technology to areas beyond sorbent decon.



# Supporting Science and Technology Thrusts

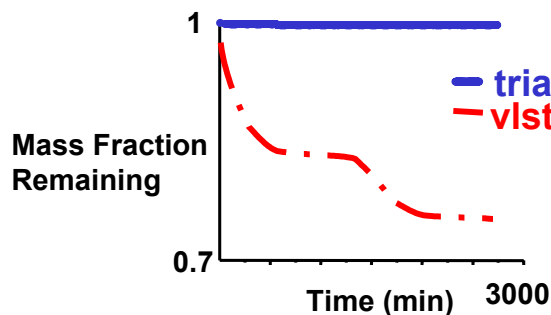
## Threat Agents

Objectives: Maintain awareness of evolving threat agent materials and conduct R&D studies to validate and characterize, and to assess fate of CB materials in environment



## Environmental Fate

Objectives: Develop a chemical agent hazard predictive model from data acquired through archive, laboratory, wind tunnel and field studies

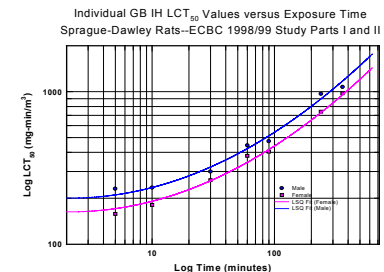


Sub-thrust to threat agents

VX on Concrete

## Low-Level Operational Toxicology

Objectives: Develop sound values for exposure levels having physiological impact below acute response levels to guide development of detectors and protective equipment



## Aerosol Technologies

Objectives: Characterize and test developmental air samplers/collectors; evolve new concepts toward next-generation small air samplers

# Small Business Innovation Research (SBIR)

- All companies with less than 500 employees eligible
- *Program consists of –*
  - Phase I feasibility study up to \$70K (w/ \$50K option)
  - Phase II development effort up to \$730K
  - Phase III commercialization effort with funding coming from a third party (either private or government)
  - Phase II+ continuing effort with government matching private investment up to \$250K
- *CB defense topics can be found in –*
  - DOD SBIR solicitation 0x.1(open Oct-Jan)
  - Solicitation 03.1 included 20 CBD Topics
  - Annual CBD Budget = \$9M
- *Army topics can be found in –*
  - DOD SBIR solicitation 0x.2 (open May-Aug)
  - Includes 1-2 Topics addressing CBD or smoke/obscurants

**For access to further information, solicitations <http://www.acq.osd.mil/sadbu/sbir/>**

# Small Business Technology Transfer (STTR)

- Small business must team with a research institution
- Program consists of
  - Phase I feasibility study up to \$100K
  - Phase II development effort up to \$500K
  - Phase III commercialization effort with funding coming from a third party (either private or government)
- CB defense topics can be found in –
  - DOD STTR solicitation (open Jan-Apr)

**For access to further information, solicitations <http://www.acq.osd.mil/sadbu/sbir/him>**

**Current solicitation closes 16 April.  
Includes 13 CB defense-related topics**

# Army CB Defense Topics

## From FY03 STTR Solicitation:

- Biocidal Textiles for Soldier Protection and Homeland Defense
- Biofilm Remediation for Restoration of Contaminated Army Sites
- Improved Kit for Chemical Detection
- Early Detection of Neurotoxic Effects with a Wearable Monitor
- Narrow-Band Infrared Obscurants for Survivability
- Enhanced Vapor, Aerosol, and Particulate Sampling System for Optical Trigger Technologies
- Obscurant Dissemination
- Metabolic Bio-inspired Batteries
- Optical Communication Techniques for Improving Standoff Detection of Chemical and Biological Agents
- Nanocapsules for Biological Warfare Agent Detection and Neutralization for Immune Buildings
- Electrospray Fluorescence Dosimeter for Biological and Chemical Detection
- Optimized Fluorescent Transgenic Bioreporters
- Production of Ready-to-use DNA-based Diagnostics Kit for Dengue Virus Detection

# Broad Agency Announcements

- **<http://www.sbccom.apgea.army.mil/RDA/baa02.htm>**
- **Technology areas covered:**
  - Biotechnology
  - Early Warning and Detection
  - Modeling, Simulation, and Analysis
  - Aerosol Technology
  - Smoke/Obscurant Munitions
  - Collective Protection
  - Biological Point Detection
  - Respiratory Protection Technology
  - Decontamination
  - Chemical Point Detection
  - Flame and Incendiary Technology
  - Biological and Chemical Countermeasures to Terrorism
  - *Non-Lethal (future)*



# **Back-Up Slides**



# DTO CB 35

## Standoff Biological Aerosol Detection

FY03 Objective: Initiate construction and characterization of breadboards

| <b>System</b> | <b>Technology</b>                 | <b>Construct / Characterize</b>   | <b>Sensitivity &amp; Range<br/>(TRE Data Point, Not Limit)</b> |
|---------------|-----------------------------------|-----------------------------------|--|
| CATSI         | Passive: 7-11 um;<br>single pixel | Existing Chem System              | BG, 10e6 ppl*, 3 km<br>*particles per liter of air             |
| IMSS          | Passive: 3-5, 8-<br>12 um; imager | Existing Chem System              | BG, 10e6 ppl, 3 km   |
| HISPEC        | Passive: 8-11 um;<br>single pixel | Construct / modify System for Bio | BG, 10e6 ppl, 1km  |
| AIRIS         | Passive: 8-11.5 um;<br>imager     | Existing Chem System              | BG, 10e6 ppl, 3 km   |
| FAL           | Active: 9-11 um                   | Existing Chem System              | Ovalbumen, 10e4 ppl, 2 km                                      |
| LaSen         | Active: 3.2-3.6 um                | Existing Chem System              | TBD, test in 2003  |

# DTO CB49

# Integrated CB Standoff Detector

|  |                                      |
|--|--------------------------------------|
|  | Proven Capability                    |
|  | Possible Capability / Need More Data |
|  | Limited Capability                   |
|  | Unrated                              |

## Candidate Technologies

| Technology                   | Chemical Agent ID |              | TIC ID |              | Biological Agents |    | Aerosol/Rain Particle Size |
|------------------------------|-------------------|--------------|--------|--------------|-------------------|----|----------------------------|
|                              | Vapor             | Aerosol/Rain | Vapor  | Aerosol/Rain | Bio/Non Bio       | IP |                            |
| CO2 LWIR DISC/DIAL           |                   |              |        |              |                   |    |                            |
| CO2 conv MWIR DISC/DIAL      |                   |              |        |              |                   |    |                            |
| SS conv MWIR DISC/DIAL       |                   |              |        |              |                   |    |                            |
| FTIR                         |                   |              |        |              |                   |    |                            |
| Hyperspectral LWIR           |                   |              |        |              |                   |    |                            |
| Passive MWIR                 |                   |              |        |              |                   |    |                            |
| SS conv LWIR DISC/DIAL       |                   |              |        |              |                   |    |                            |
| SS conv SWIR - LWIR          |                   |              |        |              |                   |    |                            |
| SS conv UV-LWIR              |                   |              |        |              |                   |    |                            |
| Active LWIR Polarization     |                   |              |        |              |                   |    |                            |
| Active MWIR Polarization     |                   |              |        |              |                   |    |                            |
| Passive LWIR Polarization    |                   |              |        |              |                   |    |                            |
| Brillouin Scattering         |                   |              |        |              |                   |    |                            |
| mmW, sub-mmWave, Terahertz   |                   |              |        |              |                   |    |                            |
| Time Resolution UV LIF       |                   |              |        |              |                   |    |                            |
| Spectral Resolution UV LIF   |                   |              |        |              |                   |    |                            |
| UV LIF                       |                   |              |        |              |                   |    |                            |
| Polarization UV LIF          |                   |              |        |              |                   |    |                            |
| RADAR                        |                   |              |        |              |                   |    |                            |
| Filtered FLIR                |                   |              |        |              |                   |    |                            |
| Nuclear Quadrapole Resonance |                   |              |        |              |                   |    |                            |
| Multi-photon Spectroscopy    |                   |              |        |              |                   |    |                            |
| Acoustics                    |                   |              |        |              |                   |    |                            |
| Far-IR (12-25 microns)       |                   |              |        |              |                   |    |                            |
| Raman                        |                   |              |        |              |                   |    |                            |
| Broad Band Lidar             |                   |              |        |              |                   |    |                            |
| UV LIF / FTIR                |                   |              |        |              |                   |    |                            |

CB-35  
Leverage

DTO CB52

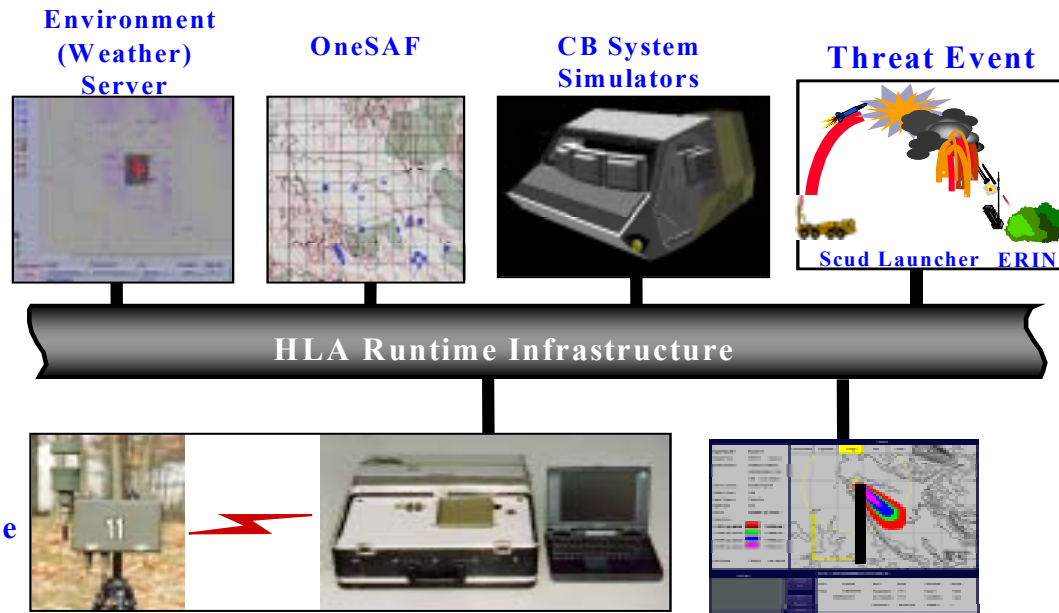
# Detection of CB Contaminated Surfaces

## Preliminary Technology Down-selection

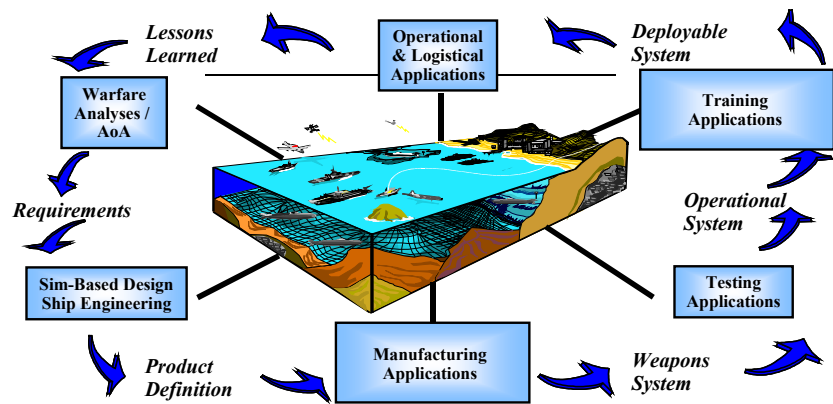
|         | Wavelength Band | Technology                       | Equipment Currently Available | Data               |                      | Previous Surface Work |
|---------|-----------------|----------------------------------|-------------------------------|--------------------|----------------------|-----------------------|
|         |                 |                                  |                               | Chemical Detection | Biological Detection |                       |
| Active  | LWIR            | Thermoluminescence               | Breadboard                    |                    |                      | YES                   |
|         |                 | DISC/DIAL                        | Brassboard                    |                    |                      | SOME                  |
|         |                 | Polarization                     | Breadboard                    |                    |                      |                       |
|         | MWIR            | DISC/DIAL                        | Brassboard                    |                    |                      |                       |
|         |                 | Polarization                     | Breadboard                    |                    |                      | YES                   |
|         | NIR             | Raman (1.06μm/FT system)         | Commercial                    |                    |                      |                       |
|         |                 | Scattering (2.0μm)               | Commercial                    |                    |                      |                       |
|         |                 | LIBS (1.06μm)                    | Commercial                    |                    |                      |                       |
|         | VIS             | Surface Enhanced Raman (VIS/NIR) | Breadboard                    |                    |                      | YES                   |
|         |                 | Raman                            | Commercial                    |                    |                      |                       |
|         | Ultraviolet     | Fluorescence                     | Breadboard                    |                    |                      |                       |
|         |                 | Raman <250                       | Breadboard                    |                    |                      |                       |
|         |                 | Time Resolved                    |                               |                    |                      |                       |
|         |                 | Polarization                     |                               |                    |                      |                       |
|         |                 | Multiband                        | Resonance Enhanced Raman      | Breadboard         |                      |                       |
|         |                 | Brillouin Scattering             | Breadboard                    |                    |                      |                       |
|         |                 | Surface Enhanced Raman           | Breadboard                    |                    |                      |                       |
| Passive | LWIR            | FTIR                             | Breadboard                    |                    |                      | SOME                  |
|         |                 | FLIR                             | Breadboard                    |                    |                      | SOME                  |
|         | MWIR            | FTIR                             |                               |                    |                      |                       |
|         |                 | Polarization                     |                               |                    |                      |                       |
|         | NIR             | FTIR                             |                               |                    |                      |                       |
|         | Hyperspectral   |                                  |                               |                    |                      |                       |
| T       |                 | Thermo IR                        | Breadboard (construction)     |                    |                      | SOME                  |

|                  |
|------------------|
| <b>Collected</b> |
| <b>Acquiring</b> |

# Simulation Based Acquisition

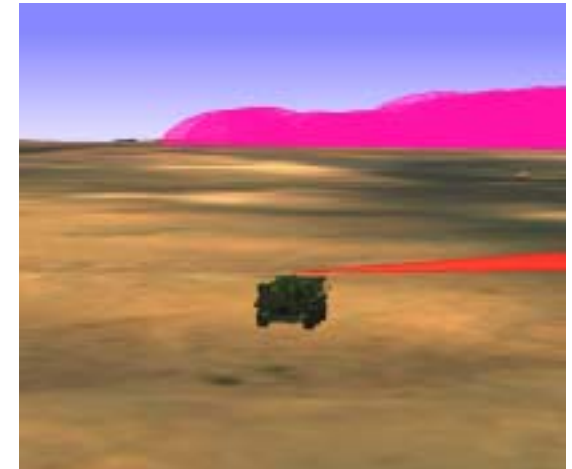


## Virtual Prototype System



Applied at All Phases of the Acquisition cycle

## Virtual Environment

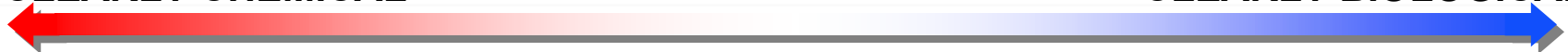


*Vision: Conceive, Design, Build, Test, Train, Operate and Interoperate a System in a Computer Before Cutting Metal; Then, use for Life Cycle Support.*

# CBW Threat Agent Spectrum

**CLEARLY CHEMICAL**

**CLEARLY BIOLOGICAL**



**SYMPTOMS APPEAR IN SECONDS TO MINUTES**

**SYMPTOMS APPEAR IN HOURS TO DAYS**

**CW**

**BW**

**CLASSIC CHEMICAL**

**EMERGING CHEMICAL**

**BIOREGULATOR**

**TOXIN**

**PATHOGEN**

BLOOD

PROTECTION  
DEFEATING

PAIN

PLANT

BACTERIA

VESICANT

SLEEP

BACTERIAL

VIRUSES

NERVE

PHYSICAL  
INCAPACITANT

BLOOD  
PRESSURE

VENOM

RICKETTSIAE

PSYCHOLOGICAL  
INCAPACITANT

ENHANCERS

MOOD

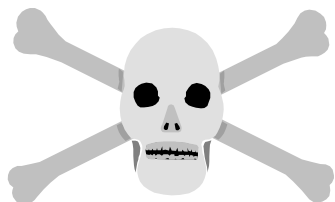
MARINE

GENETIC  
ENGINEERED  
MICRO-ORGANISMS

CHOKING

ALGAL

**MID-SPECTRUM**



# Toxic Industrial Chemicals (TICs)



Refinery in Pancevo, Yugoslavia



Fuel Depot in Smederevo, Yugoslavia

TICs – Any chemical with  $LCt_{50}$  less than  $100,000 \text{ mg-min/m}^3$  and produced in quantities exceeding 30 tons annually at one facility



Bhopal

# An Integrated Materiel Approach to Counter the Threat

