Chemical Biological Defense Program
Science & Technology

“Science for the Warfighter”

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Chemical/Biological Technologies Directorate (RD-CB)
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The S&T Arm of the CBDP

Combatant Commands and Services

Required Capabilities

Prioritized Needs

S&T Gaps

Mature Technologies

Solutions
Warfighter S&T at All Levels

Current

Service Unique

Joint

Future
### Prioritized User Requirements

#### JRO Joint Priority List

1. Chemical Standoff Detection  
2. Biological Standoff Detection  
3. Chemical Point Detection  
4. Biological Point Detection  
5. Integrated Early Warning  
6. Radiological Standoff Detection*  
7. CBRN Reconnaissance  
8. Field Analytics  
9. Respiratory and Ocular Protection  
10. Biological Prophylaxis  
11. Radiological Point Detection*  
12. Percutaneous Protection  
13. Personnel Decontamination  
14. Battle or Operating Enviro Management Systems  
15. Chemical Prophylaxis  
16. Battle or Operating Environmental Analysis  
17. Fixed Site Collective Protection  
18. Equipment Decontamination  
19. Fixed Site Decontamination & Restoration  
20. Biological Therapeutics  
21. Expeditionary Collective Protection  
22. Radiological Prophylaxis*  
23. Medical Diagnostics  
24. Chemical Therapeutics  
25. Methods of Control of Contaminated People  
26. Medical Surveillance  
27. Radiological Therapeutics  
28. Hazardous Waste Control  
29. Remains Disposition  

* Not addressed in CBDP S&T

#### JPEO S&T Needs

1. Automated Multi-Platform Sample Preparation  
2. Integrated Early Warning  
3. Decontamination  
4. Medical Therapeutics and Prophylaxis  
5. Biological Point Detection/Identification  
6. Chemical Point Detection/Identification  
7. Improved Respiratory TIC/NTA Filtration  
8. Collective Protection  
9. Improved Radiological Detection/Identification  
10. Open Community of Interest (COI) Medical and CBRN Data Sharing  
11. CBRN Tactical Technologies  
12. Individual Protection (Improved MOPP)  
13. Information Systems (Data Backbone)
JSTO Mission and Vision

VISION
The JSTO will be the leading authority in Chemical and Biological Defense with recognized expertise in the development of future technology solutions that render the impact of chemical and biological hazards ineffective.

MISSION
The JSTO manages and integrates the development, demonstration, and transition of timely and effective chemical and biological defense solutions for the Department of Defense while serving as the focal point for science and technology expertise.

The JSTO will provide the most innovative capabilities by collaborating with mission partners, other government agencies, industry and academia.
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CBDP FY2008 President’s Budget

Goals
• Address future challenges (NTAs, emerging threats, transformational medical technologies) and improve the T&E infrastructure
• Provide advanced capabilities to the warfighter
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International Agreements

Multilatera

Bilateral

Australia
Belgium
Canada
Czech Republic
France
Germany
Hungary
Israel
Japan
Netherlands
New Zealand
Poland
Romania
Singapore
South Korea
Sweden
Switzerland
United Kingdom
Pretreatments

90% (18/20) Macaques Protected from Aerosolized Plague

Efficacy of the Plague Vaccine Candidate

Generation and Evaluation of PEGylated Recombinant Human Acetylcholinesterase as an Optimal OP-Bioscavenger

Recombinant Human Acetylcholinesterase

Novel Conserved Targets for Multi-Agent Biodefense Vaccines using High-Throughput Population Genomics

Stimulation of Broad Spectrum Protection via Toll-Like Receptors 7, 8 and 9

Immune Signalling Pathway

Transition mature candidates to advanced development; develop multiagent and molecular vaccines; improve effectiveness of vaccines and boost innate immunity to provide broad-spectrum protection; develop broad-spectrum chemical agent pretreatments
**Diagnostics**

Support JBAIDS block development strategy; exploit new technologies to provide rapid presymptomatic diagnosis; develop assays for rapid diagnosis of chemical agent exposure.
Therapeutics

Sulfur Mustard Inhalation Toxicity in Lung Epithelium and Macrophages - Protection by Macrolide Antibiotics

Evaluation of the Efficacy of Candidate Anti-vesicant Ophthalmic Treatments against Ocular Sulfur Mustard (HD) Injury

Smallpox Drug Evaluation Models to Meet US FDA Animal Efficacy Rule

Therapy for Smallpox and Other Orthopox Viruses

Nerve agent exposure induces significant changes in the phosphoprotein profile of the brain

Proteomic Analysis of Neural Signaling Pathways Involved in Nerve Agent-Induced Seizures and Subsequent Neuropathology – Identify Targets for New Neuroprotectant Development
Nano-enabled Diagnostics and Therapeutics

Advectus’s Nanocure™

- Nanoparticle-based formulation for the delivery of approved chemotherapeutic (doxorubicin) that does not cross the blood-brain barrier
- Outer layer attracts lipoproteins that camouflage them from the body
- Blood-brain barrier treats the particles as if they were low-density lipoproteins (LDL) - cholesterol

DNA-based diagnostics without PCR
- faster temporally
- diagnostically earlier
- more sensitive
- fewer false positives
Radiological Therapeutics

Objectives:

• Develop safe and efficacious radioprotectants (prophylaxes) and post-irradiation therapeutics for Acute Radiation Syndrome (ARS) for gastrointestinal and pulmonary tracts
• Develop a diagnostic chromosomal biodosimetry

Strategy:

• Accelerate transition of mature candidates to product development
• Leverage on promising candidates that are currently in preclinical development for radiation-oncology

Accomplishments:

• 2008: Selected Prochymal™ for FDA-approval
• 2008: Selected CBLB502 (Flagellin) for FDA-approval
An innovative approach using revolutionary technologies to expedite the development of products to counter emerging biological threats.
Transformational Medical Technologies Initiative (TMTI)

Goals
(QDR driven)

- Develop at least two platform technologies
  - Enabling technologies: Capability to rapidly develop new countermeasures

- Build integrated library: Genetic sequences of BW agents
  - Capability to rapidly sequence and characterize novel threats

- Develop two broad-spectrum countermeasures to Investigational New Drug filing

Approach

- Capability to respond to unknown threat is real priority

EVENT

Response: Genetic sequence

- Target Identification Platforms
- Host/Pathogen Targets

Countermeasure(s)

- Drug Discovery Platforms
- Drug Evaluation Platforms
- Manufacturing Platforms
DARPA Thrust: Accelerating Critical Therapeutics

Current Timeline (2004 NIH Roadmap)

- Pathogen Identification: 2 Weeks
- Target Discovery: 2 Weeks
- Candidate Therapeutics: 8-12 Weeks
- Pre-Clinical Evaluation: Situational
- Large Scale Manufacturing: 7-8 Years
- Safety and Efficacy Trials: Situational

DARPA Timeline

- Pathogen Countermeasures: 1-3 Years
- Rapid Vaccine Assessment: 7-8 Years
- Rapid Manufacture Of Vaccines And Biologics: 7-8 Years

In Silico Target and Therapy Discovery

Accelerated Insertion Methodology
Many technologies can identify a BW agent by its characteristic spectrum, however...

Biological Detection: “Traditional” Approaches are Insufficient
Biological Detection Systems

Current:

**JBPDS**
- UV-LIF trigger
- Virtual impactor sample collection
- Immunoassays - 10 agents
- 15 – 20 min response time

**JBSDS Incr I**
- IR/UV-LIF
- 5 km IR scatter particle detection
- 1 km UV-LIF bio discrimination

Advanced:

**Invitrogen**
- MAPP-DS

**ECBC**
- Tactical Biological Detector

**WANDER**
- IR depolarization ratio
- Potential bio discrimination

**DARPA FASTREAD**
- Femtosecond Adaptive Spectroscopy Techniques
- Spectral/temporal info in the backscattered signal
- Potential bio identification
Chemical Detection Systems

Current:

**ACADA**
- IMS
- Miosis level
- 1 min response

**JSLSCAD**
- FT-IR
- 1/2 km range
- 360 scanning

**JCSD**
- IR-Raman
- 40 mph

Advanced:

**JCAD**
- IMS
- Moisis level
- 2 lb

**ChemPen**
- MEMS
- FT-IR

**FirstDefender™**
- IR-Raman
- Bulk liquids
Detection Concepts Using Genomic Sequencing

Ibis Biosciences

Nanobiosym, Inc

- DARPA MOLDICE
Detection and Identification

Recent Accomplishments

- Lightweight Integrated CB Detection System
- Low Cost/Low Power UV Detection
- Optical Acceptance Measurements for Test & Evaluation Antigens
- Range Test Validation System
Hazard Mitigation (Decontamination)

- Decontamination Assurance Spray
- Energetic and kinetic
- Self-Detoxifying Surfaces/Reactive Coatings
- Smart Systems
  - Sense
  - Respond
  - Signal

OPH Enzyme

OPH binds and degrades chemical nerve agents

OPH Enzyme Immobilized in Mesoporous Silica

Increases shelf-life from hours to over 6 months

Current Decontamination CONOPS
**Hazard Mitigation (Decontamination)**

**Recent Accomplishments**

- Identified a candidate technology for intra-theater transportation of contaminated human remains

- Transitioned high performance liquid chromatography (HPLC) methodology for determining decon residual

- Developed a new ClO2 formulation with enhanced broad-spectrum chemical and biological hazard reduction efficacy

- Discovered an advanced surfactant system that will lead to development of environmentally-safe product for chemical removal augmentation

- Completed a “decon wipe” development for sensitive surfaces
Individual Protection

Carbon Nanotube As Chemical Sensor

DNA changes structure (electronic properties) to ions and chemicals

Nano-Fibers

Self-Detoxification

Reticular Chemistry

Nanomaterials for sensing, protection and decontamination
Protection
Recent Accomplishments

- Completed transition of end-of-service-life indicator for gas mask canister and novel closures for protective garments

- Focused individual protection mid-term efforts on low-burden and novel concepts to integrate with a developmental warfighting ensemble

- System demonstration of a catalytic oxidation air purification technology to support transition of this technology
Test & Evaluation Methodologies & Capabilities

Test Standard Development for Collective Protection Technologies

Characterization of Swatch Test CRMs

IPE Field Operations Effects Standard

TIC/Battlefield Contaminant Set Standard for IPE & ColPro

Standardized Procedure for Individual Protection Whole System Assessment

Improved Decontaminant Performance Evaluation Methodology

Body Region Hazard Assessment Model

Chem-Bio Agent Resistance Test (CBART)

Achieving Low-Level Detection of Residual Agent and Reaction Products

Decon Hazard Byproduct and Residual Agent Test Standards
Non-Traditional Agent (NTA) Facility

Notional Concept for NTA Facility

Personal Protective Equipment

Materials Compatibility Tests

Decon to Safe Levels for Disposal

Decontamination Efficacy Tests
Advanced Technology Demonstrations - FY07-FY10

- Hackensack University Medical Center Mobile Emergency Trauma Unit
- Biological Combat Assessment System (BCAS)
- CBRN Unmanned Ground Reconnaissance (CUGR)
- Expeditionary Biological Detection (EBD)
- Interagency Biological Restoration Demonstration (IBRD)
- Systems of Systems Decon
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Future Force Warrior Advanced Technology Demonstration – FY10

Helmet/Respirator Integration

Reticular Chemistry

Nano-Fibers

Self-Detoxification

Switchable Fabrics

Agent Detecting Fibers

Soldier-as-a-System-Ground (SaaS-G) Leader Concept

Demonstrate an integrated materials concept in FY2010 using thermal burden as an independent variable to achieve low-burden protection
Information Systems Technology

Bioinformatics: Key to Systems Biology and Medical S&T

Essential for:
- Expression analysis for molecular function interrogation – technology dependent (genomics proteomics, metabolomics)
- Data mining/Database management
- Machine learning
- Molecular structure & molecular interaction prediction
- Modeling biochemical pathways and biological networks

Modeling/Data Assimilation: Relevant to Physical S&T

Data Glove
Allows silent communication between soldiers through uniform (glove) based sensors.

CBRN Modeling
Utilizing current IT to log, evaluate, synthesize disparate sources of CBRN information and develop predictive models

Data Backbone
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Information Systems Technology
Recent Accomplishments

JWARN Component Interface Device (JCID) software-based sensor system

Common CBRN Software Services

Sensor Alert Verification for Incident Operational Response (SAVIOR)

NBC CREST

Rapid Assimilation of Sensor Data

Environmental Sciences

Modeling the Atmospheric Chemistry of TICs

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Basic Research

Nocera, MIT – Ultrasensitive Chem-/Bio-Optical Sensors on Small Scales
Developed blue semiconductor nanocrystal laser, micro laser cavities for chemosensor, and induced chemical sensitivity of nanocrystal quantum dots (Nocera: 2007 Mack Award, ACS Harrison Howe Award)

Mirkin, Northwestern U. – Molecular Machines
Developed supramolecular catalysts for acyl transfer reactions; designed flexible type of supramolecular allosteric catalysts and MOFs, pseudo-rotaxane supramolecular structures

Goldman, NRL – Development and Testing of Recombinant Single Domain Antibodies
Developed hyper diversified shark new antigen receptor display library to be used against toxins. Expressed sdAb and variants characterized in terms of stability and regenerability (Goldman: 2006 Alan Berman Research Publication Award)

Whitman, NRL – Biophysical Fluid Dynamics Near Surfaces
Developed total internal reflection fluorescence microscopy system to image single fluorophores, developed non-equilibrium biomolecular molecular dynamics (BioNEMD) computational capability (Whitman: Nanotech Briefs Magazine’s Nano 50 Award)

Calculation of the time required for DNA molecules at 1 fM to diffuse to a sensor surface versus sensor size.
Environmental Fate of Agents

Sorption / Penetration
Porosity
pH/Age
Moisture Content

Substrate Mediated Reactions

Dry Concrete - 22 Weeks
Wet Concrete - 6 Weeks

Contact/Residual Agent Measurements

Dental Dam (Contact)
Substrate (Residual)

Vapor Resurgence
Threat Agent Science

Low-Level Chemical Agent Exposure Effects

Increase in severity and loss of performance effectiveness.

KEY: ■ no estimate; ■ low; ■ high; ■ moderate; ■ moderately low

Science-Based Exposure Standards for Deployed Forces
Threat Agent Science

Computational chemistry and biology enables full spectrum real time response
Chemical / biological threats target central nervous system (CNS) to impair sensory, motor and cognitive function
  - Biological neurotoxins
  - Chemical nerve agents
  - Nano-enabled?

Warfighter performance studies – “cognitive readiness”
  - Understanding cognitive functions under stress during CW/BW event
  - Understanding molecular processes of neuron and brain function after exposure CW/BW agent
Summary

• User’s needs and priorities are met by providing timely scientific information and technology transitions

• Processes are in place that find and fund sound science and innovative approaches from concept to advanced development including international collaborations

• Test and evaluation methodology and capability development and procedures for FDA approval are an integral part of the S&T program

• Projects align with spiral upgrades and transition technologies to meet S&T needs of acquisition programs
“New ideas pass through three periods:

✓ It can't be done.
✓ It probably can be done, but it's not worth doing.
✓ I knew it was a good idea all along!"

— Arthur C. Clarke

“If we knew what we were doing, it wouldn’t be called Research.”

— Albert Einstein