Leading Edge of Biodefense

The National Biodefense Analysis and Countermeasures Center

LTC George Korch
Deputy Director
National Biodefense Analysis and Countermeasures Center
Science and Technology Directorate
Department of Homeland Security

The President's Proposal

"The Department of Homeland Security will leverage the expertise of America's cutting-edge medical and biotechnological infrastructure to advance the state of knowledge in infectious disease prevention and treatment, forensic epidemiology, and microbial forensics………."

"The President proposes the establishment of a National Biological Weapons Analysis Center in the Department of Homeland Security to address relevant medical scientific issues, to include BW threat and risk assessments and to determine which countermeasures require priority research and development."

National Strategy for Homeland Security, July 2002

Homeland Security

Implementing the President's Concept:

DHS National Biodefense Analysis and Countermeasures Centers (NBACC)

Is established as an essential, new approach to integrate national resources for homeland security, supporting public health, law enforcement, and national security.

Scientific basis to assist Department of Homeland Security (DHS) implementation of the statutory [P.L. 107-296, Section 302(2)] mandate to develop national policy and strategic plans.

Scientific Biothreat Analysis

- **Biodefense Knowledge**
- **Bioforensic Analysis**
- **Bio-Countermeasures Test & Evaluation**

Homeland Security

NATIONAL STRATEGY

Where to set the priorities since resources will always be limiting ?

What is the nature of the threat (State, Substate, Criminal, Accidental)
How big an impact at which to set the threshold ?
    How much illness, death ?
    How much economic impact (consumer confidence, lost earnings, loss import-export, lost profit) ?
    How much political impact (social disruption, loss of confidence in government) ?
    How much "acceptable risk" (continuum – but must be debated and then clearly articulated) ?
    Who decides (scientists, policy makers, media, elected officials, public, perpertrators) ?
    How much recovery cost ?
    How well communicated ?
What is the acceptable strategy to mitigate the risk ?
    Political / Legal / Diplomatic
    Military
    Intelligence
    Public Policy
    Medical / Agricultural Response
    Engineering

How much information will we need ?
When will we know when it is enough ?

Causes impact in excess of threshold > NO
    ↓ **Yes**

Unable to protect beforehand > NO
    ↓ **Yes**

Unable to contain at acceptable cost > NO
    ↓ **Yes**

Highest priority – fully characterize to level that will reduce to "acceptable risk"

Homeland Security

Biothreat Agents Affecting Human Health: NIAID and DOD Perspectives

Category A

Bacillus anthracis
Clostridium botulinum toxin
Yersinia pestis
Variola major other pox viruses
Francisella tularensis
LCM, Junin virus, Machupo virus,
Guanarito virus
Lassa Fever
Hantaviruses
Rift Valley Fever
Dengue
Ebola
Marburg

Category B

Burkholderia pseudomallei
Brucella species
Ricin toxin
Staphylococcus enterotoxin B
Diarrheagenic E.coli
Shigella species
Listeria monocytogenes
Yersinia enterocolitica
Cryptosporidium parvum
Giardia lamblia
Toxoplasma gondii
West Nile Virus
California encephalitis
EEE
Japanese Encephalitis Virus

Coxiella burnetti
Burkholderia mallei
Epsilon toxin of C. perfringens
Rickettsia prowazekii
Pathogenic Vibrios
Salmonella
Campylobacter jejuni
Viruses (Caliciviruses, Hepatitis A)
Cyclospora cayatanensis
Entamoeba histolytica
Microsporidia
LaCrosse
VEE
WEE
Kyasanur Forest Virus

Category C

Emerging infectious disease threats (Nipah virus and additional hantaviruses).
Crimean-Congo Hemorrhagic fever virus
Tickborne encephalitis viruses
Yellow fever
Multi-drug resistant TB
Influenza
Other Rickettsias
Rabies

Red = DOD Threat Agents; believed to have been weaponized

Homeland
Security

Agents Affecting Human Health or Animal Health

Anthrax	Psittacosis	S A Hemorrhagic Fevers	Avian Tuberculosis	Duck Hepatitis virus
Foot & Mouth	Sheep and Goat Pox	Shiga-like RIP	Bovine cystercercosis	Epizootic Lymphangitis
Brucellosis	Rickettsia rickettsii	Lumpy Skin Disease	Dourine	Enzootic Bovine Leukemia
Rift Valley Fever	C perfringens toxin	Shigellosis	Enterovirus Encephalitis	Equine Piroplasmosis
BSE	Rabies	Hepatitis E	Equine Infect Anemia	Fowl Pox
Swine Fever	Ricin	Fowl Cholera	Equine Rhinopneumonia	Marek's Disease
Nipah	SEB	T2- mycotoxin	Infectious Bursal Disease	Hemorrhagic Septicemia
Hendra	E coli	Hydatid Disease	Maedi / Visna	Horse Mange
Botulinum	VSV	Herpes B	Nairobi Sheep Disease	Infect Bovine Rhinotracheitis
Influenza	Ebola/Marburg	Abrin	Paratuberculosis	Myxomatosis
Plague	Campylobacter	Malignant Catarrhal Fever	Theileriosis	Ovine Pulmonary Adenovirus
VEE/WEE/EEE	Bluetongue	Peste des petits	Alastrim (Variola minor)	Porcine cystercercosis
Rinderpest	Lassa	Avian Infectious Bronchitis	Menangle	Porcine resp & rep syndr
Glanders	Heartwater	Aujuszky's Disease	Avian Mycoplasmosis	Rabbit Hemorrhagic Dis
JE	Smallpox	Bovine Babesiosis	Bovine Anaplasmosis	Surra
NDV	Swine Vesicular Disease	Coccidiodes posadasii	Bovine Genital Campylobacter	Transmissible Gastroentero
Q Fever	Typhus	Contagious Equine Metritis	Contagious Agalactia	Trichinellosis
TBE	Yellow Fever	Fowl Typhoid	Dermatophilosis	Trichomonosis
Tularemia	Akabane	Pullorum		
Hantavirus	Shigatoxin	Conotoxin		
Salmonella	Contagious Caprine Pleuro.			
Microsporidia	Monkeypox			
CCHF	Dengue			
Bovine Tuberculosis				
African Horse Sickness				
Meliodosis				

Derived from DoD, NIAID, OCIE and others

Plant pathogens expands this list much further by several hundred !

What about Genetically Altered Pathogens ?

How to approach this systematically ?

How do we achieve balance in science between open scientific exchange yet guard against malfeasance and misuse ?

How will necessary work be accomplished relative to rules, regulations and treaties ?

How much investment in future threats, while "natural" threats are currently more likely ?

Homeland Security

Components of a Defense Strategy

NBACC Mission and Vision

VISION: To be the operationally focused, technical biological defense analysis center for homeland security—law enforcement, national security, medicine, public health and agriculture—across the spectrum of activity from technical threat and risk assessment, through prevention of technological surprise, to authoritative attribution.

MISSION: Support national security, law enforcement, and medical communities by improving our understanding of potential bioterrorism pathogens that may be weaponized, transported, and disseminated against U.S. targets for the purpose of improving our protection of human health and agriculture against biological terrorism, and sustaining homeland security through knowledge of the threat, prevention of surprise, and attribution of use.

Technical BTA Assessment
     Prevention of Technological Surprise
          Analysis and Attribution

Homeland
Security

The NBACC Pillars

A new approach to integrate national resources for homeland and national security

Biological Threat Characterization Center (BTCC)

– Provides laboratory-based, scientific data from the analysis and assessment of biological threats to human health and agriculture. Develops and applies models, materials, and validation processes to evaluate vulnerabilities and define risk.

Bioforensic Analysis Center (BAC)

– Provides definitive forensic examination of biothreat agents and related evidence and serves to integrate the forensic requirements for law enforcement, national security, and homeland security

Biodefense Knowledge Center (BKC)

– Evidence-based subject matter expertise to integrate, analyze, and distribute critical information assembled from multiple sources through a clearinghouse center

Agricultural Biodefense Center (ABC)

– Advances research-based solutions for prevention, detection, diagnosis and response to high consequence foreign animal diseases, such as foot and mouth disease. As part of the NBACC hub-and-spoke system, center is established at the Plum Island Animal Disease Center, NY
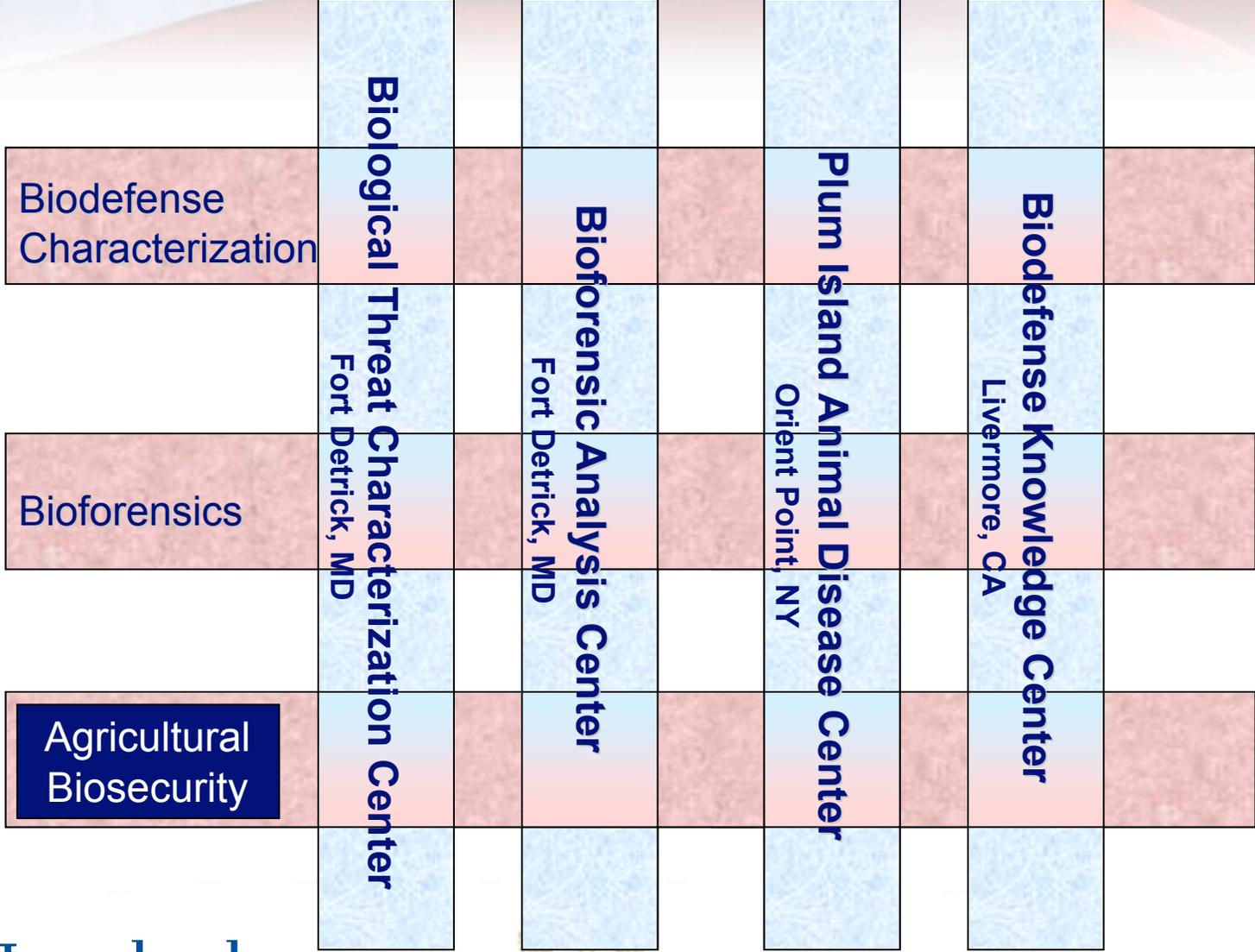
Homeland Security

NBACC's Subordinate Centers

NBACC's Research Thrusts

	Biological Threat Characterization Center — Fort Detrick, MD	Bioforensic Analysis Center — Fort Detrick, MD	Plum Island Animal Disease Center — Orient Point, NY	Biodefense Knowledge Center — Livermore, CA
Biodefense Characterization				
Bioforensics				
Agricultural Biosecurity				

Homeland Security

NBACC Planned Capabilities

National Bioforensic Analysis Center

- Identification/Confirmation
- Process Validation
- Matrix Effects
- Sample Optimization
- Sample Processing
- Physical Evidence
- Training/Accreditation
- Sample Repository (Reference Standards)
- Novel Technology Assessment and Validation

Biodefense Knowledge Center

- Data Integration
- Database Management
- Analysis
- Training
- Information Dissemination
- Artificial Intelligence
- Data Visualization

Biothreat Characterization Center

- Basic Pathogenesis
- Susceptibility to Current Rx
- Aerosol Dynamics
- Novel Delivery of Threat
- Novel Packaging
- Simulation/Modeling (Epidemiology)
- Genetic Engineering
- Environmental Stability
- Bioregulators/Immunomodulators
- Assay Development
- Information Analysis for IC
- Genomics/Proteomics/Transcript
- Red Teaming
- Host Range Studies
- Aerosol Animal Model Development
- Support to Strategic National Stockpile (Pharmaceuticals and Biologics)

Plum Island Animal Disease Center

- Facility Operations & Maintenance
- Foreign Animal Disease (FAD) Agricultural Biosecurity R&D
- Advanced Development of Veterinary Biodefense Products
- FAD Confirmatory Diagnostics
- Microbial Forensics

Homeland Security

Concept of Operations

Biodefense integrator (human, animal, plant)

Operate in hub-and-spoke system

Obtain best talent through partnerships

Intelligence community coordinated laboratory support

Interconnecting centers to provide scientific support to address:
- Biothreat agent (BTA) net assessment
- BTA analyses to support attribution
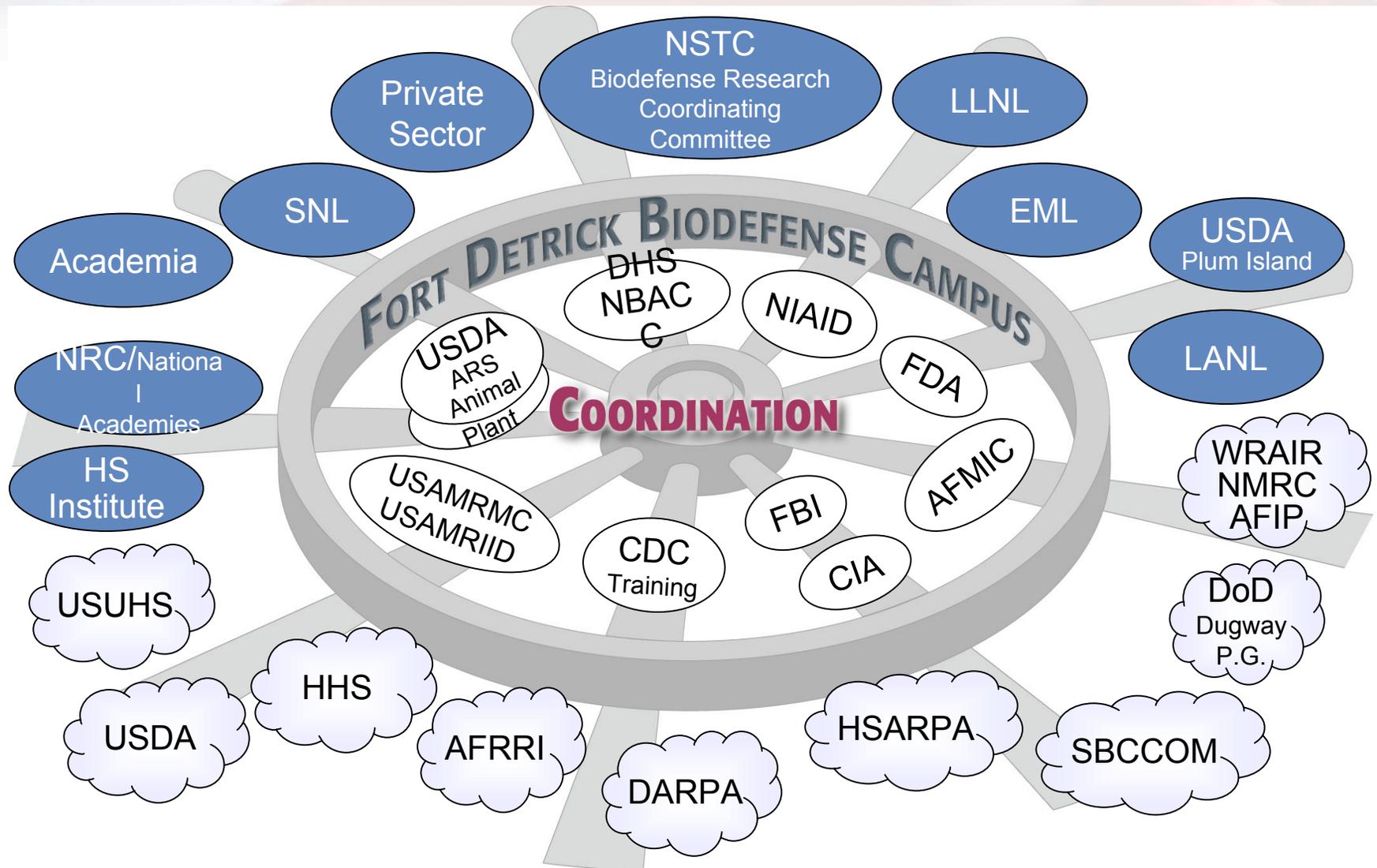- Data gap and vulnerability identification
- Countermeasure assessment

While technological advances in biological sciences have created potential for novel threats, information and capability to develop "defeat" strategies are insufficient

NBACC Hub-and-Spoke Concept

FORT DETRICK BIODEFENSE CAMPUS

COORDINATION

DHS NBACC
NIAID
FDA
USDA ARS Animal Plant
AFMIC
USAMRMC USAMRIID
FBI
CIA
CDC Training

Private Sector
NSTC Biodefense Research Coordinating Committee
LLNL
SNL
EML
USDA Plum Island
Academia
LANL
NRC/National Academies
WRAIR NMRC AFIP
HS Institute
DoD Dugway P.G.
USUHS
HHS
AFRRI
DARPA
HSARPA
SBCCOM
USDA

Security

14

Biothreat Characterization Center

Definition: The integrated analysis of the threat from hostile use of BTAs and friendly capabilities to respond to the threat.

Threat = Capabilities & Intent

Risk = Threat & Vulnerabilities

BTCC's purpose is to provide scientific support to the assessment of our vulnerabilities.

BTA Net Assessment–The foundation for developing the National BW Defense Strategy, Countermeasure Requirements, Planning, and Program Execution

Homeland Security

BTA Net Assessment–Technical Threat Assessment Task Areas

Acquire, Grow, Modify, Store, Stabilize, Package, Disperse

Assess criminal, terrorist, and state technical capabilities, methods, and devices for delivering BTA against U.S. targets

Assess the nature of nontraditional, novel, and nonendemic induction of disease from potential BTA

Provide high-fidelity models and simulations of disease transmission of BTA for threat assessment, countermeasure development, and emergency management

Assess and evaluate emerging technologies as they relate to BTA analysis and threat assessment

Apply Red Team operational scenarios and capabilities

Evaluate and predict U.S. vulnerabilities to foreign and domestic threats

BTA Analysis and Technical Threat Assessment

Characterize classical, emerging, and genetically engineered pathogens for their BTA potential

- Virulence, infectivity, pathogenesis, host response, and fate
- Potential for genetic modification
- Aerobiology, aerosol physics, and environmental stability (wet lab & models)
- Computational modeling of feasibility, methods, and scale of production
- Physical/chemical properties of dissemination and alternatives to aerosol dissemination (wet lab & models)

– Red Team operational scenarios and capabilities assessments

- Baselined on foreign and domestic intelligence collection (strengthens IC capabilities)
- Study and assess principles of BTA use and countermeasure effectiveness across the spectrum of potential attack scenarios
- High-fidelity modeling and simulation

Homeland Security

Biothreat Characterization Center Priorities

Develop a rigorous method to assess potential biothreat agents and determine most pressing data gaps (New Threat List)

Support to Strategic National Stockpile for rapid susceptibility testing of pharmaceuticals

Expand aerosol-challenge testing capacity for non-human primate models

Establish spoke operations at USAMRIID, WRAIR, selected commercial and academic centers

Establish food-borne risk analysis center to assess bulk food contamination parameters

Perform specified studies for national security customers

Develop strategy for defeating "Genetically-engineered" threats

Homeland Security

The Biodefense Knowledge Center

Designing the System

Create Enduring Capability

Enhance capability to rapidly respond to unfolding events

Develop user friendly interface for real-time analysis of specific information needs

Assist in identifying data gaps through tools that provide comprehensive connectivity to current information

Begin development of next generation technologies and computational algorithms to address the need for access to advanced machine-based analytic capability

Homeland Security

An Operational Concept for Biodefense Knowledge Center

Colloquium for building next-generation information analysis system
- BTA data accumulation
- Artificial intelligence platform
- Systems integrator

Establishes a single national clearinghouse for BTA knowledge

Responsive to all clients
- Senior leaders
- Scientists
- Responders

Automated updating through web-scanning methods

Use of an "Avatar" query interface

Homeland Security

Bottom Line Up Front
for a Biodefense Knowledge System

User Query-Based

Supported by Artificial Intelligence / Semantic Web Architecture

Real-time knowledge management biodefense decision support system

Homeland
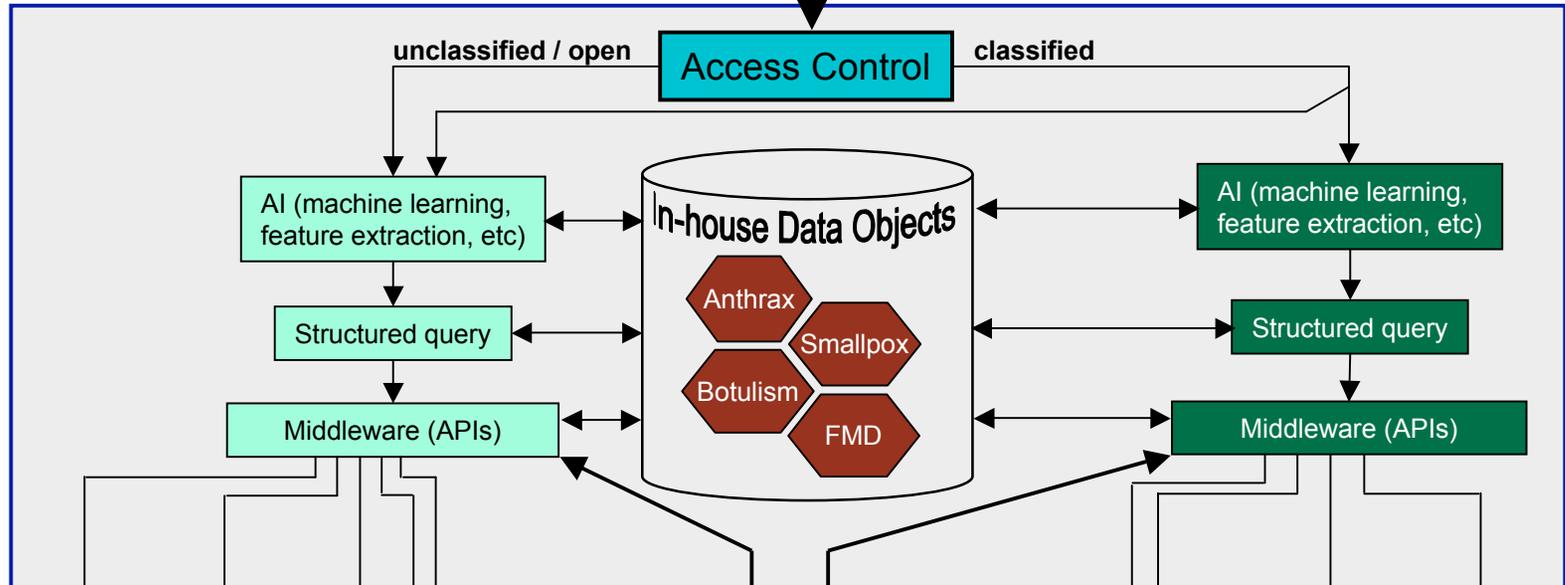Security

Biodefense Knowledge Center (Notional)
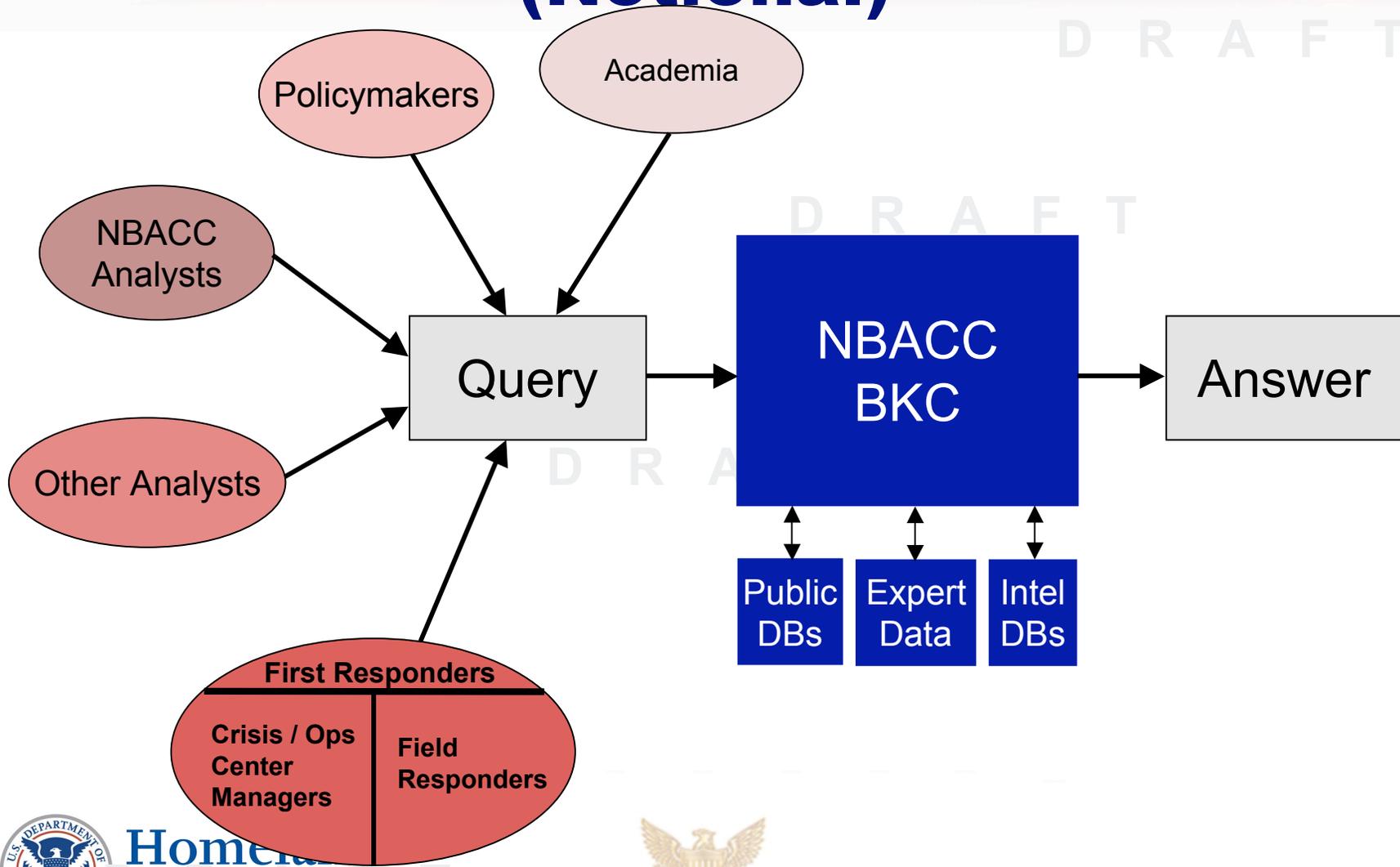
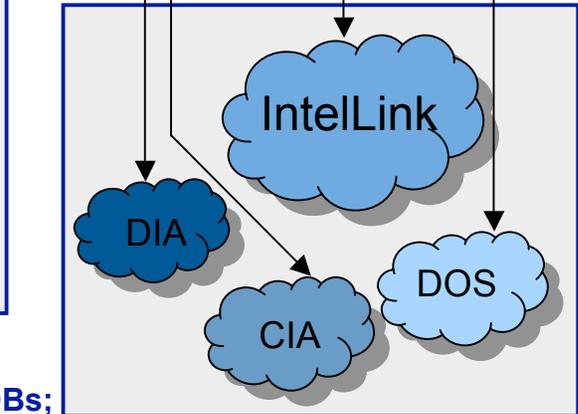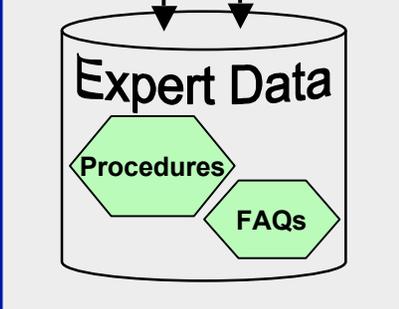# Biodefense Knowledge Center (Notional)

Natural Language Query

DRAFT DRAFT

BKC at NBACC Fort Detrick, MD

unclassified / open — Access Control — classified

AI (machine learning, feature extraction, etc)

In-house Data Objects
- Anthrax
- Smallpox
- Botulism
- FMD

AI (machine learning, feature extraction, etc)

Structured query

Structured query

Middleware (APIs)

Middleware (APIs)

Public Databases; Various locations

Pubmed

CDC

TIGR

ExPasy

NCBI

Expert Data
- Procedures
- FAQs

IntelLink

DIA

CIA

DOS
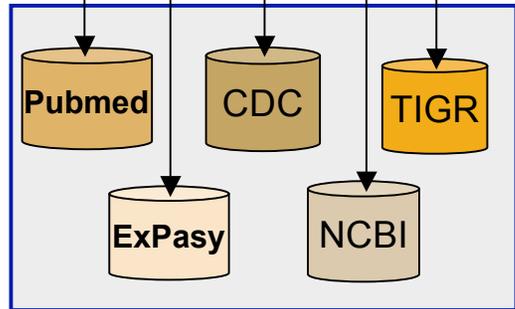
Homeland Security

Intel. DBs; Various locations

How to approach system design ?

Identify User Needs and Desires

Select One or Two Appropriate Model Systems

Identify Current and Potential Technologies

Provide Input through Discussion

Identify Challenges
- Classified vs. Unclassified
- Access Controls for Users
- Quality Control: Disreputable, Outdated or False Data Sets
- Access to Private Databases
- Cultural Shifts in Datasharing (Intellectual Property)
- Open vs. Closed Operational System Architecture

Homeland Security

Principal Customers

Intelligence Community

National Policy / Decision Makers

- Elected and Appointed Leadership
- Scientific Policy Leadership

First-responder Community

Biodefense Science and Technology Professionals

Homeland Security

Potential Data Bins in System

Taxonomy / Evolution / Biodiversity / Biogeography

Gene sequence and Organization

Protein Inventory

Metabolic Pathway Inventory

Virulence Inventory (direct, indirect)

Transformation / gene transfer mechanisms

Extrachromosomal inventory

Reproductive strategy

Environmental niche dimension (environment, vector space, tissue space)

Survival in environment (fate, predator/prey)

Survival in host (immune evasion mechanisms)

Transmission Dynamics (rate of spread, ID/LD50, maintenance cycles)

Survival in vector systems (vector, biotic, abiotic)

Host response / pathology (infection kinetics, gene expression, early signatures)

Production characteristics (process, scale, packaging, delivery, excipients)

Medical Countermeasure Space (prophylaxis, treatment, diagnostics, tissue decontamination, medical operation systems, models for development of products)

Environmental Countermeasure Space (decontamination, spread, detection, detection response systems)

Regulatory Countermeasure Space (laws, law enforcement, prosecution, international cooperation)

Intelligence Countermeasures (signatures, HUMINT/MASINT)

Technical Countermeasures (lab infrastructure, models, training base, professional capability, technology development pace, information archiving)

Systems Countermeasures (organizational linkages, feedback and spiral improvement, communication, risk-assessment profile)

Homeland Security

Coordination Across Government

Other similar systems in development
- CDC
- DOD
  DTRA
  Homeland Security
- NIAID

Homeland Security

Benefit of
Biodefense Knowledge Center

Fosters innovation and excellence, creates and disseminates high-impact knowledge that advances the state of the art

Provides analysis, tools, and models that can be adapted to meet the needs of the nation, organizations, and individuals

Relevant scientific knowledge for understanding and expanding the technology

Allows government to reduce the risks inherent in adopting new technology

Supports innovations that improve productivity, streamline operations, and enhance public services

Examines how technology can help reduce government spending and reduce the cost of doing business with government

Leverages the benefits of each individual project through a planned program of information dissemination and technology transfer

Homeland Security

"What are the pressing biological threats/ issues for the nation and the world, and how do we resolve them?"

Plum Island Animal Disease Center

Plum Island is a critical asset to the nation's economic and national security.

Protecting the nation's agriculture is an essential part of homeland defense and a shared mission with USDA.

The science conducted at PIADC is vital to the nation.

DHS and USDA are cooperating on a national agricultural biosecurity strategy

DHS will operate the facility in a secure and professional manner.

DHS is committed to positive community relations including mutual aid agreements.


Homeland Security

Priorities for ABC

Develop capacity to perform "advanced" development of veterinary medical countermeasures

- Perform clinical trials with promising vaccines and drugs for High Consequence Foreign Animal Diseases
- Establish validated diagnostic assays for FAD's

Investigate technologies to create host resistance to FAD's

Establish a microbial forensics capability at PIADC

Upgrade current facility

Homeland Security
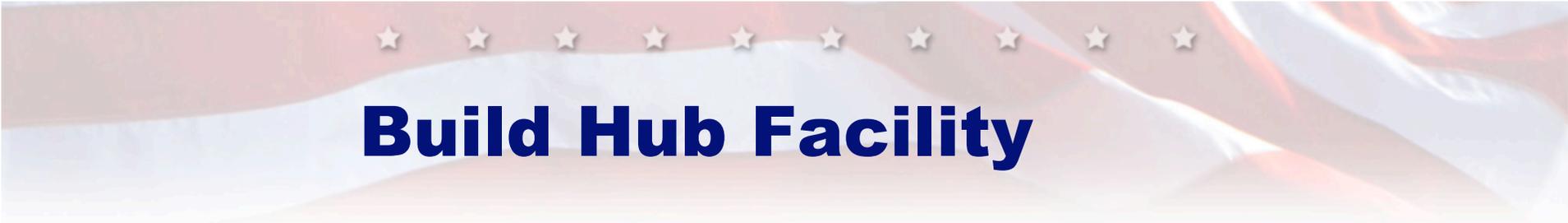
Build Hub Facility

Current funding appropriated for a $ 130 M facility

Will contain BSL-2, 3 and 4 capability

Will have fully operational forensics "case-work" dedicated laboratory for attribution studies

Will house biodefense analysts along with scientists

Will increase national capability for aerosol-challenge studies

Will address critical national shortfall in ability to conduct sensitive studies under biocontainment

Environmental Baseline Survey and Environmental Impact Statements are in process

Potential completion by FY08

Homeland Security

Proposed Fort Detrick Biodefense Campus (Notional) Layout
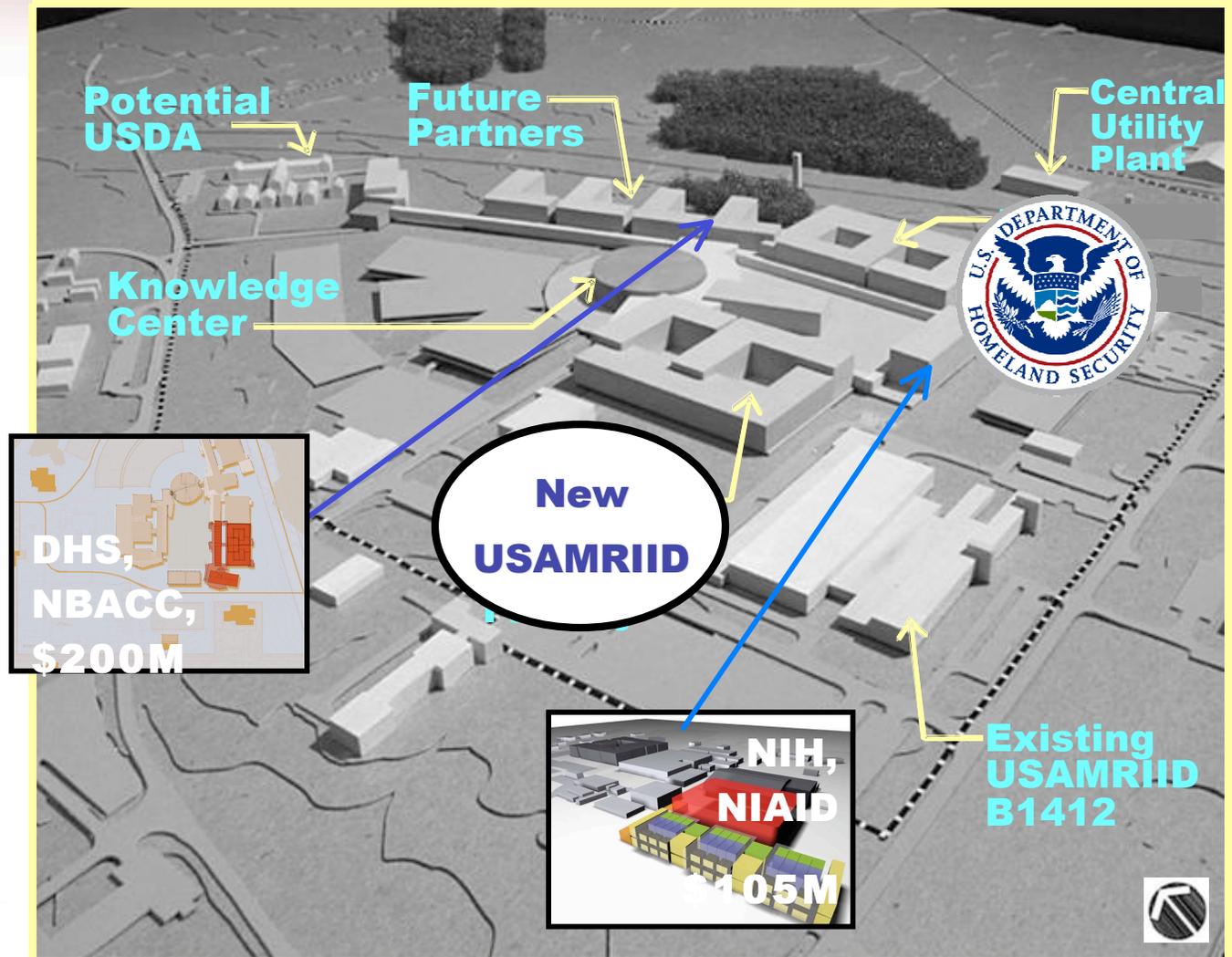
New National Biodefense Campus

Already at Detrick
- DoD, USAMRIID
- DoD, AFMIC
- National Cancer Institute
- Department of Agriculture

New Tenants, New Construction
- Department of Homeland Security, National Biodefense Analysis and Countermeasures Center (NBACC), **FY04/05 $200M**
- NIH, National Institute for Allergy and Infectious Diseases (NIAID) **FY04 $105M**

Future Interagency Partnering

Potential USDA

Future Partners

Central Utility Plant

Knowledge Center

DHS, NBACC, $200M

New USAMRIID

NIH, NIAID $105M

Existing USAMRIID B1412

Homeland Security

34