# 712CD

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| **COMPOSITE GROUP:** | **POSTER:** |
| **SPECIAL SESSION 1:** | **TUTORIAL:** |
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# Medical Surveillance System & Medical Effect Modeling Thrust Areas

*Angel A. Fitzgerald, BChE, MS*
*Rashid A. Chotani, MD, MPH, DTM&H*

**Information Systems Science and Technology Capability Area, CBT**
**Chemical and Biological Technologies Directorate**
**Joint Science and Technology Office**
***Defense Threat Reduction Agency***

# Information Systems Technology Joint Acquisition Responsibilities

## Define The Need

**SHAPE**
**CBA Gaps**

- Integrated Early Warning
- Battlespace Analysis
- Battlespace Management

## Find / Build The Technology

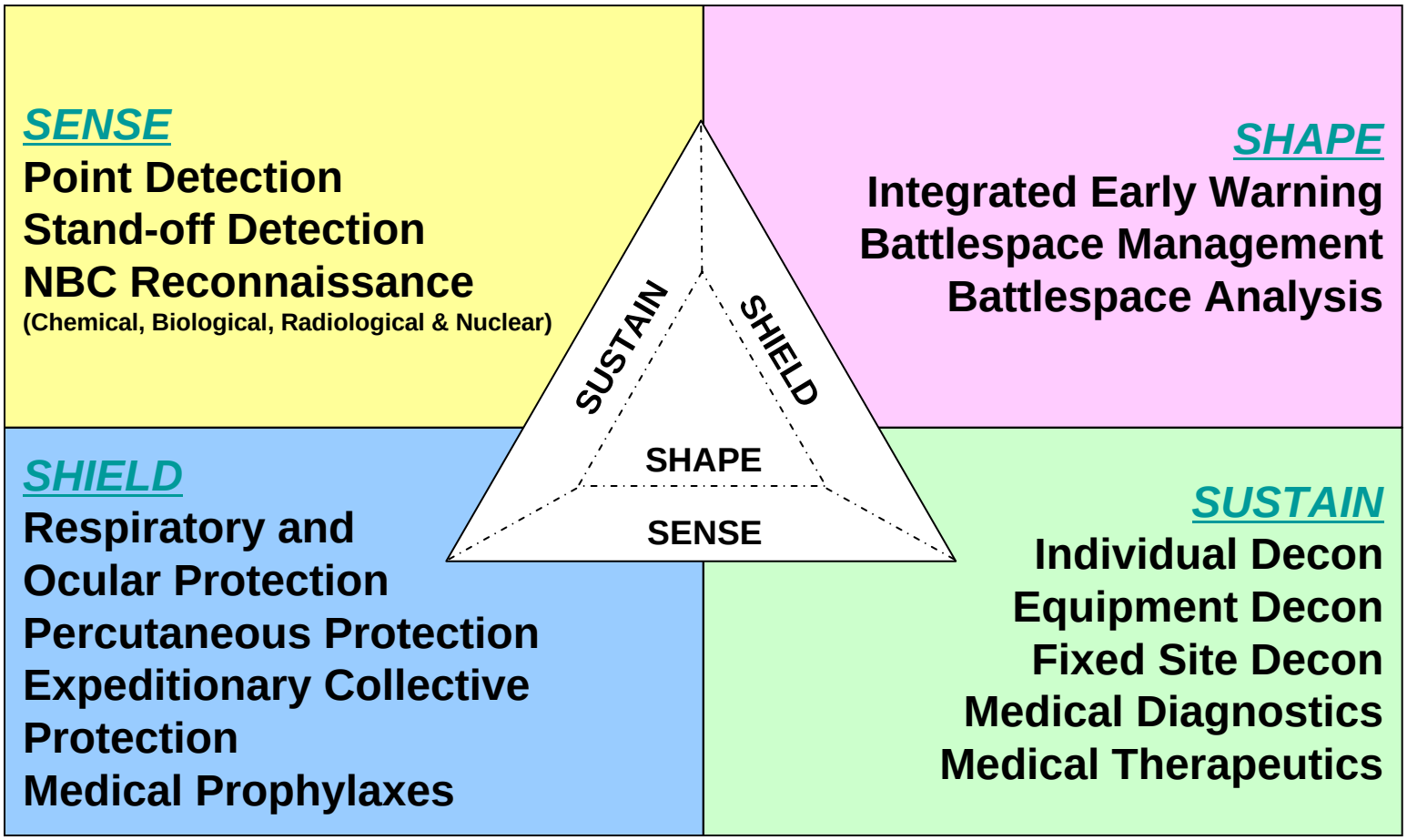
**Select, Evaluate & Manage S&T Projects**

Technology Transition Agreements

## Build The System

- JWARN
- JOEF
- JEM

# Joint Requirements Office Capabilities Summary



# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

## JRO CBRN Shape Core Capabilities Requirements

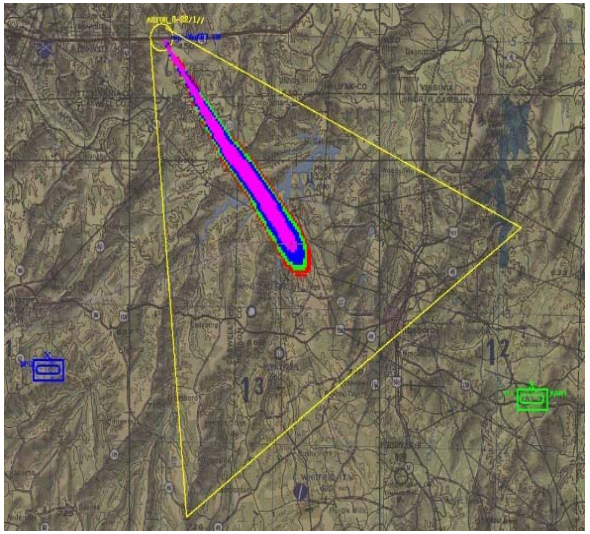
1. ***Integrated Early Warning***: **Includes the automatic and manual collection and fusion of information from all relevant CBRNE defense assets throughout the battlespace. It couples the detection capacities of the point, stand-off, and reconnaissance assets with the capacities of the battle management system to support timely decision-making related to situation awareness, joint force protection, restoration of operational tempo, and casualty treatment, care, and evacuation.**

2. ***Medical Surveillance***: **Provides medical situational awareness and decision support to the commander in the theater of operations, in support of ongoing threat assessment and medical decision-making and planning. It includes the ability to rapidly identify, report and document CBRN agent threats through laboratory analysis in theater, to conduct medical surveillance for health outcomes of operational importance, and to conduct epidemiological analysis of medical events and patterns. The capability allows the execution of veterinary service support to food and water safety and the environmental surveillance mission in the CBRN hazard environment. It also includes surveillance of indigenous animal population for disease operational importance, and information support to ongoing threat assessment.**

3. ***Modeling and Simulation***: **Provides commanders at all levels with the ability to simulate CBRNE environment and effects to support battle management requirements of the JTF command and control structure within the context of military operations. Additionally, this provides a training capability to support virtual and reality-based individual and collective training, doctrine development, and assessment of acquisition and density of CBRNE defense material and the effectiveness of command and control within the joint forces. Also supports experimentation and exercise.**

# Joint Warning and Reporting Network (JWARN)


- JWARN Mission: Provide the Joint Force Commander with the capability to:
  - Report CBRN and Toxic Industrial Materials (TIM) hazard detection
  - Analyze the detections to enable identification of the hazard and the affected locations
  - Disseminate warning information to affected units in near real time

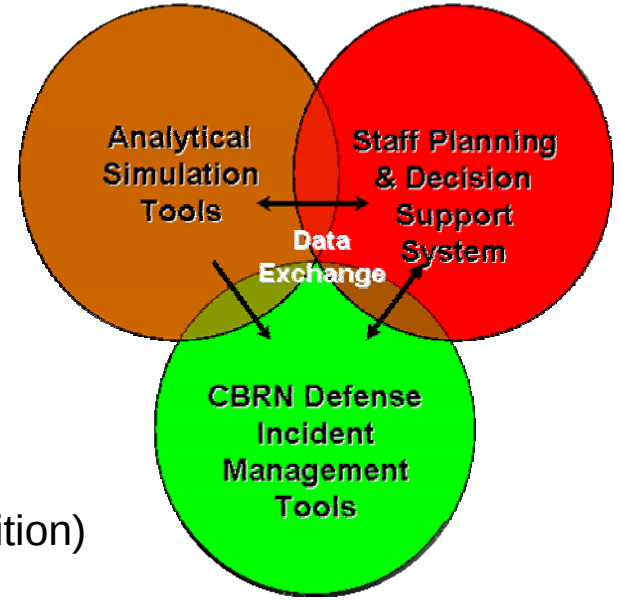


# Joint Effects Model (JEM)

- JEM is an ACAT III Modeling & Simulation Program that will provide a single, validated capability to predict the transport and dispersion of CBRN / TIC events and their effects
- JEM will be accredited for all uses currently supported by the three interim accredited DoD S&T Hazard Prediction Models
  - Legacy models HPAC, VLSTRACK, D2PUFF *Interim Accredited* for specific uses
    - VLSTRACK - weaponized CB attacks on military forces
    - HPAC - U.S. attacks on NBC facilities and for consequence management of terrorist NBC attacks
    - D2PUFF - U.S. chemical stockpile accidents and incidents
- JEM will be integrated with Service Command & Control Systems

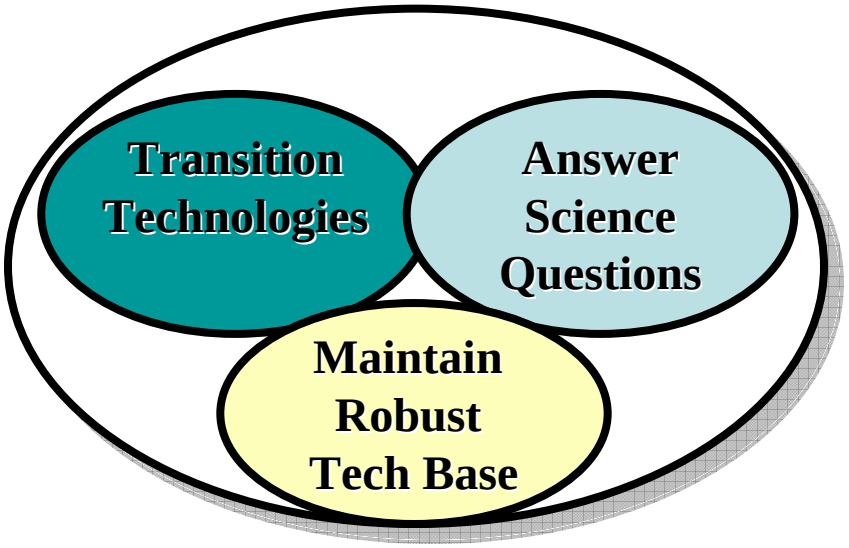
# Joint Operational Effects Federation (JOEF)

- Decision Aids for Deliberate and Crisis Planners
  - Assessment of Mission Capability Given CBRN Threat
  - Evaluation of Candidate Courses of Action
  - Sensor Employment
  - Logistics Requirements (Medical, IPE, CPE)
  - Personnel Readiness (Vaccination, Training)
- Decision Aid for Analysts
  - Value of Suggested Systems or Technologies (Acquisition)
  - Effectiveness of Existing or Proposed TTPs
- Decision Aid for Consequence Management Support
  - Checklists as Reminders of Operating Procedures/Equipment
  - Templates for Logging and Reporting




# DTRA CB Mission

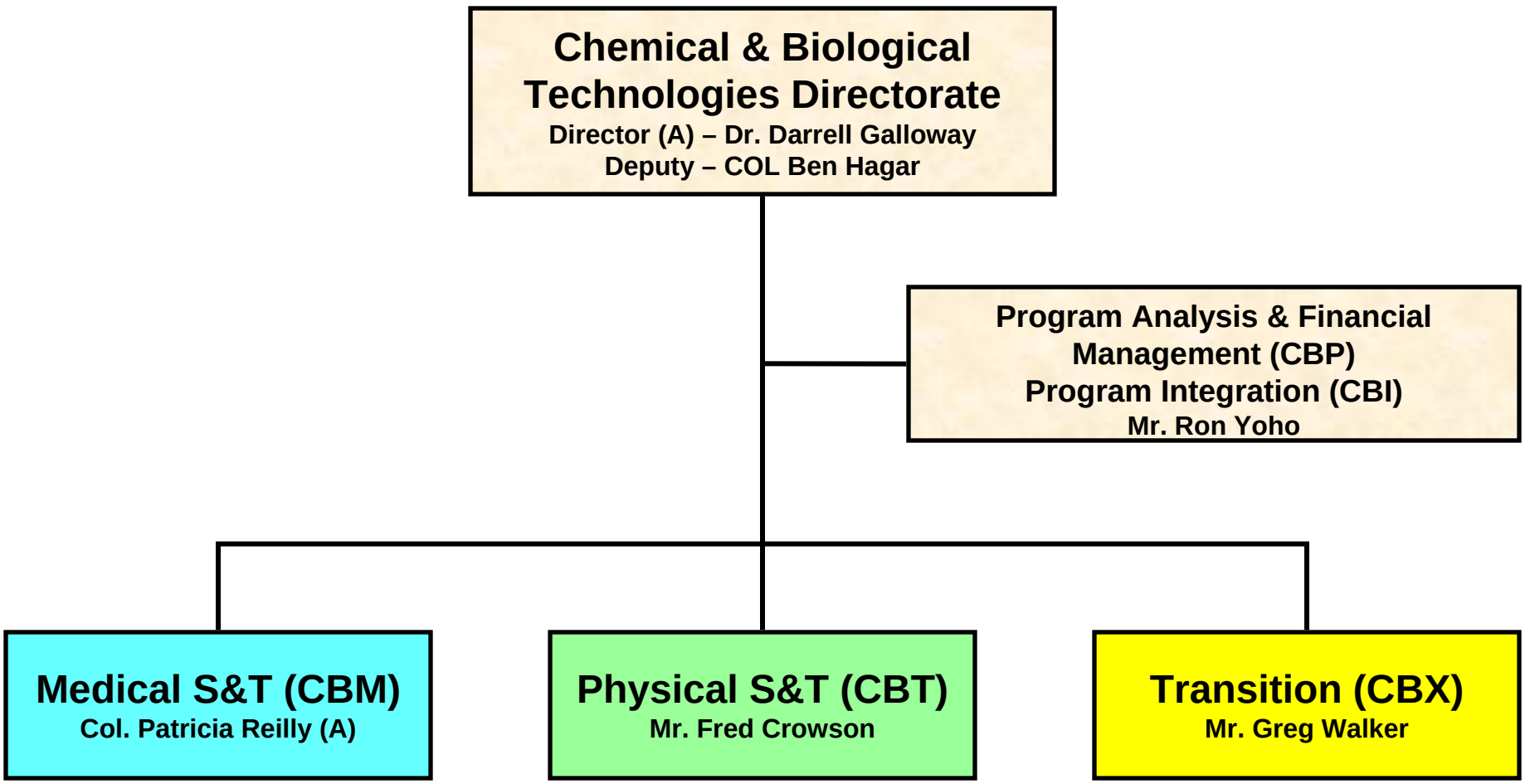
**Manage and integrate the development, demonstration, and transition of timely and effective chemical and biological defense solutions for the Department of Defense while serving as the focal point for science and technology expertise. The DTRA Chem Bio Technologies Directorate provides the most innovative capabilities by collaborating with mission partners, other government agencies, industry and academia.**



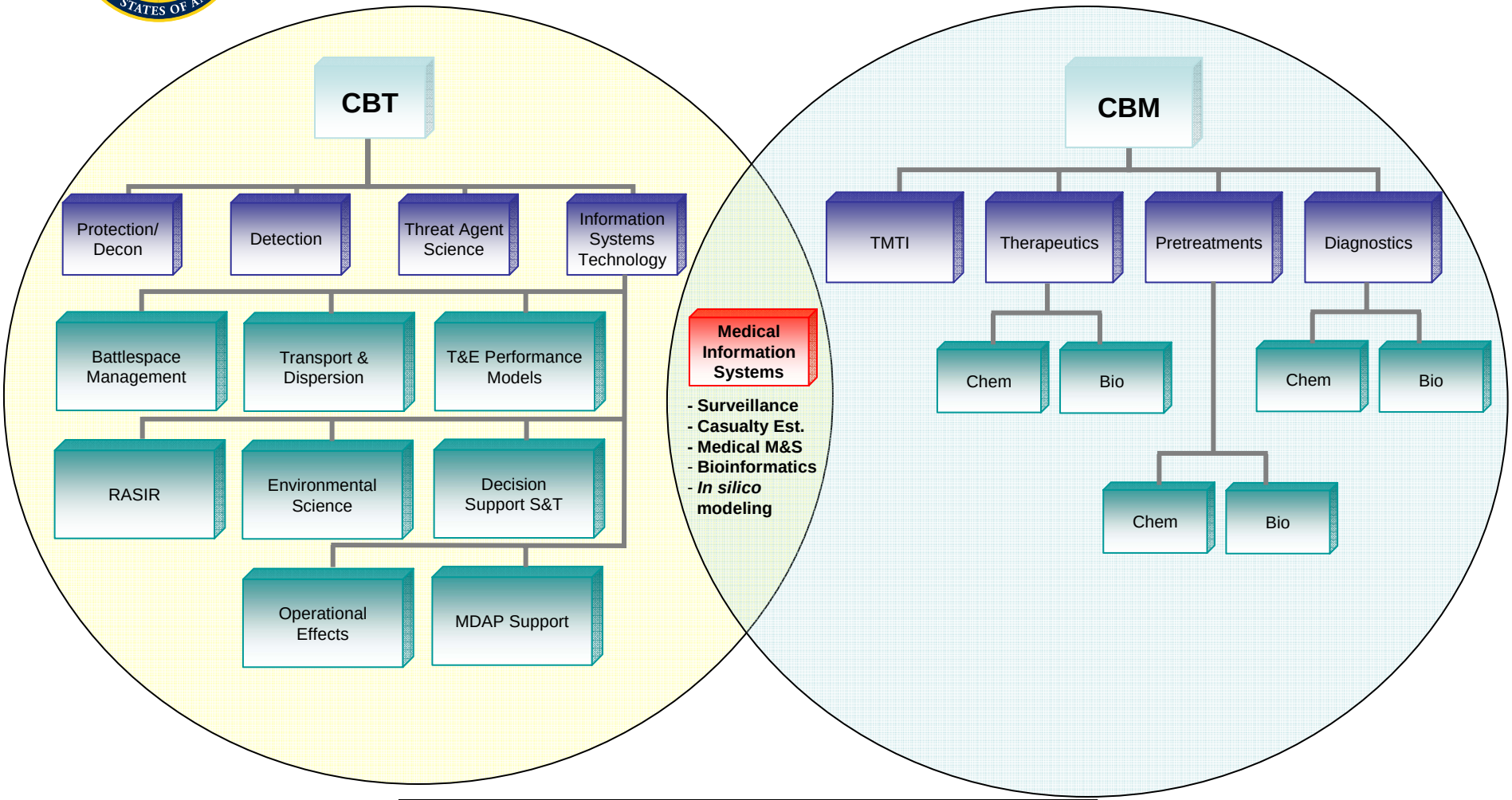

**Mission Space**

- *Maneuvering warfighters*
- *Installation protection*
- *Homeland defense*
- *Global war on terrorism*

# DTRA CB Taxonomy



# Medical Modeling: The Nexus Between the Medical and Physical Divisions




***CBRN Validated S&T Data Backbone***

# Acquisition Pull: The Technology Transition Paradigm

FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13

***Joint Warning and Reporting Network***

Increment 1: DT OA MS "C" IOC FRP FOC

- *InterLAN Socket Connection Manager*
- *Shared COP*

Increment 2: DT MS "C" OA IOC

- *JCID Thin Client Server*
- *JCID on a Chip*
- *SAVIOR*

JWARN Joint Warning and Reporting Network

***Joint Effects Model***

Block 1: DT OA MS "C" IOC OT → FRP FOC

*Rapid Wind & Pressure Calcs around Buildings*

Block 2: MS "B" DT OA MS "C" IOC OT → FRP FOC

- *GEDIS*
- *Urban Dispersion Model*
- *Agent Fate*
- *CB Source Determination*
- *TIC Source Emissions*
- *Release and Atmospheric Dispersion of Liquid Agents*
- *Multiscale Nudging*
- *Mass Consistency Wind Model*
- *Predicting Effects Due to Infectious/Contagious Diseases*
- *Waterborne Transport Models*

JEM

***Joint Operations Effects Federation***

- *Next Generation Modeling*
- *Internal Modeling for STAFFS*
- *C-IED*
- *IIMS*

Increment 1: MS "B" DT MS "C" IOC FOC Sustainment

- *Radiological Operational Effects*
- *NBC CREST*

Increment 2: EA/OA OT MS "B" MS "C" IOC FOC Sustainment

JOEF

▲ = technology insertion

# JSTO IST Taxonomy

| *Theme* | **Thrust Area** | ***Manager*** |
|---|---|---|
| *Network Architectures* | Battlespace Management | *Bill Ginley* |
| | S&T Data Backbone | *Eric Lowenstein* |
| | Rapid Assimilation of Sensor Information Research | *John Hannan* |
| | Medical Surveillance Systems | *Rashid Chotani* |
| *Hazard & Environmental Modeling* | Transport & Dispersion | *Rick Fry* |
| | Environmental Sciences | *Stephanie Hamilton* |
| *Simulation, Analysis & Planning* | Operations Effects | *Mark Fagan* |
| | Decision Support S&T | *Jessica Miller* |
| | Medical Effects Modeling | *Angel Fitzgerald* |
| *Systems Performance Modeling* | Test & Evaluation Performance Evaluation Models | *Laura Sears* |
| | Major Defense Acquisition Programs M&S Support | *Bill Zimmerman* |

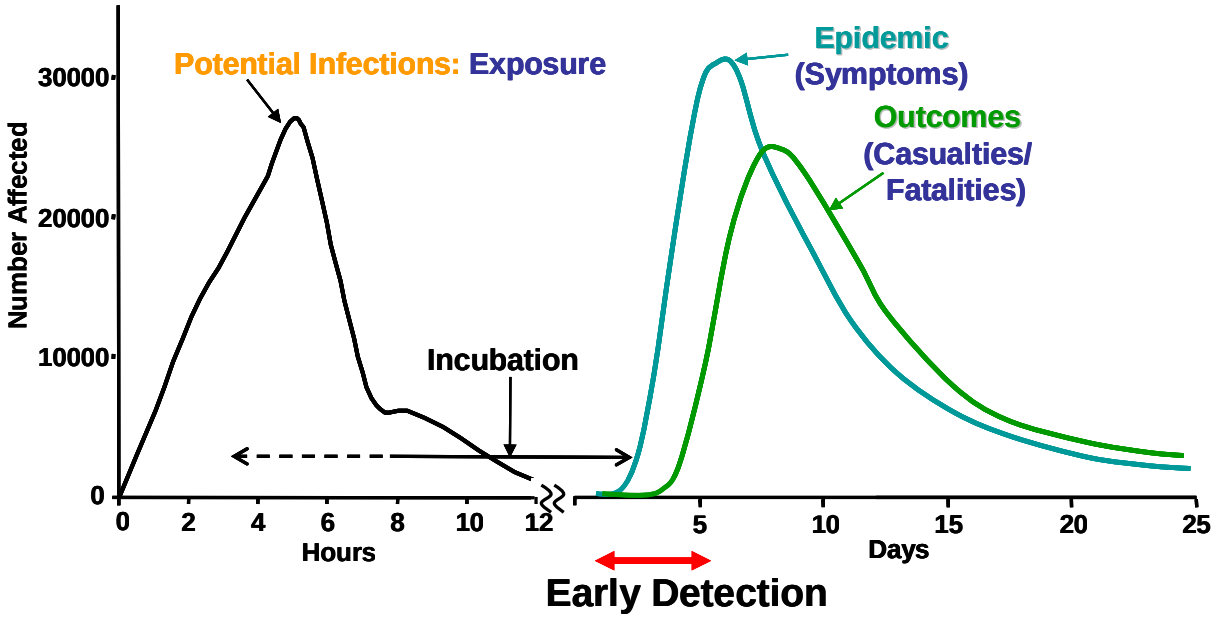
# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

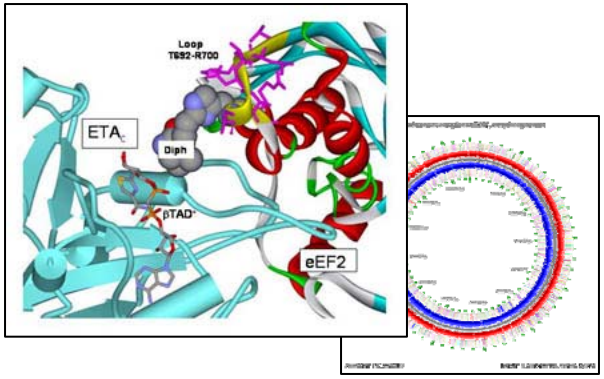
**Objective:** Combine integrated early warning detection and real-time epidemiology, medical & syndromic surveillance, and modeling & simulation to develop technologies and models that can identify anomalies related to infectious diseases in warfighters (and civilian populations if data is available) in-theater using bio-surveillance and early detection models. Furthermore, conduct casualty estimation and prediction of human performance in hazard environments.

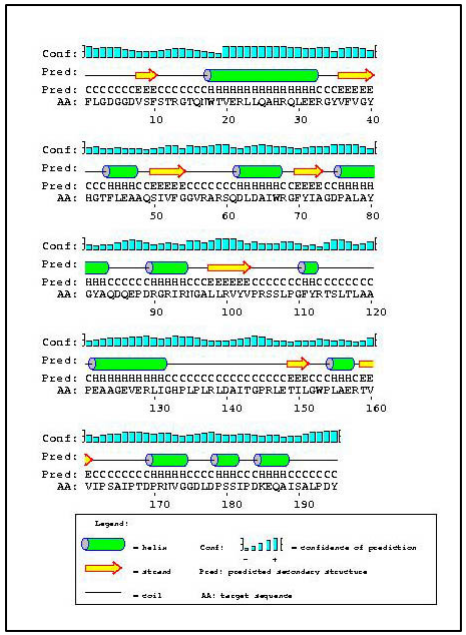
**Description of Effort:** Embark on novel technologies as well as evaluate, validate, support and assist in integration of existing initiatives. Develop the tools and modules to provide syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments for the Joint Effects Model (JEM), Joint Operational Effects Federation (JOEF), and the Joint Warning and Reporting Network (JWARN).

**Benefit to warfighter:** Minimize warfighter casualty due to infectious diseases, in particular biological WMDs. Provide increased awareness of medical impacts on warfighters to decision makers to allow for informed planning.

# Medical Surveillance Systems & Medical Effects Modeling Thrust Area



# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

## Major goals/milestones:

*Near Term (Through FY09)*

- Inventory and write-up of current early-detection/real-time epidemiological models for infectious diseases in particular bio-threat agents funded by DoD and user survey.
- Provide a well-founded model for casualty estimates in JEM involving infectious/contagious diseases, both bio-threat agent-induced and naturally occurring.
- Prepare casualty estimation and medical planning technology in the medical NBC-CREST deliberate planning tool for transition to JPM-IS in support for JOEF Increment I.
- Supporting & collaborating with existing efforts through DoD, HHS & DHS on surveillance and infectious disease propagation modeling.
- Develop medical automation and support tools.
- Address all JEM, JOEF and JWARN medical IS/IT requirements.

# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

## Major goals/milestones:

*Mid Term (Through FY11)*

- **Verification & Validation of current early-detection/real-time epidemiological models funded by DoD for use by the CBDP.**
- **Provide models for syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments for current programs of record (namely, JEM, JOEF, and JWARN).**
- **Furnish capability to model infectious/contagious diseases, both bioagent-induced and naturally occurring, for JEM.**
- **Provide capability of casualty estimation (morbidity & mortality) due to CBR agents for JOEF.**
- **Mature all JEM, JOEF and JWARN medical IS/IT requirements.**

# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

## Major goals/milestones:

*Far Term (FY12 & Beyond)*

- Identify the *gaps* in the DoD infectious disease modeling community.
- Provide capability to rapidly and accurately (with high sensitivity & specificity) model infectious/contagious diseases, both bioagent-induced and naturally occurring.
- Provide comprehensive medical test and evaluation model.
- Investigate genomic and proteomic modeling within the human body in order to investigate agent pathology.
- Perform modeling to enable predictive pharmacology and toxicology for therapeutic purposes.
- Provide comprehensive medical test and evaluation models to address all JEM, JOEF and JWARN medical IS/IT requirements.

# Medical Surveillance Systems & Medical Effects Modeling Thrust Area

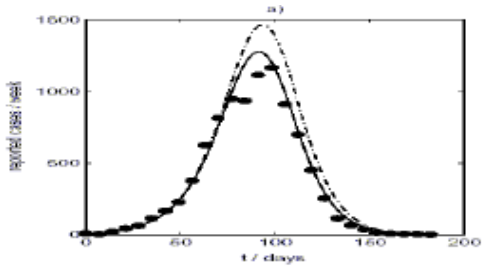
## FY07 Projects:

| Number | Title | Goal |
|---|---|---|
| CB07MSB100 | Predicting Effects Due to Infectious/Contagious Diseases for JEM | NEAR-TERM |
| CB06MSB095 | NBC CREST Transition to JPM-IS | NEAR-TERM |
| CB06MSB096 | Medical Modeling of Particle Size Effects for Inhalation Hazards | NEAR-TERM |
| BO07MSB001 | Integrated Medical Effects Modeling to Enhance Warfighter Protection and Performance | MID-TERM |
| BO07MSB002 | Infectious Disease Analysis Capability (IDAC) | MID-TERM |
| CB07MSB003 | Low-order Multiphysics Models of Complex Biological Organisms | FAR-TERM |

# Predicting Effects Due to Infectious/Contagious Diseases for JEM

**Objective:** Provide a well-founded model for casualty estimates in JEM involving infectious/contagious diseases, both bioagent-induced and naturally occurring.

**Description of Effort:** The team will extend homogeneous mixing models for secondary infection with plague, smallpox, and influenza to account for heterogeneous mixing among sub-populations and predict the spread of disease among interacting populations for use in JEM.




Prediction of influenza outbreaks US winter 2001-2002
[Saramaki and Kaski, 2004]

**Benefits of Proposed Technology:** Provide more realistic casualty estimates for contagious diseases, both bioagent-induced and endemic; maintain consistency with modeling by DHHS/NIH.

**Challenges:**
- Establish a computationally fast-running alternative to agent-based models like EpiSim
- Validation of the model with real-world data, detailed models, and subject matter expertise

**Maturity of Technology:** Homogeneous mixing models have been demonstrated in NBC CREST; TRL 4.

**Capability Area:** Information Systems / MSS&MEM

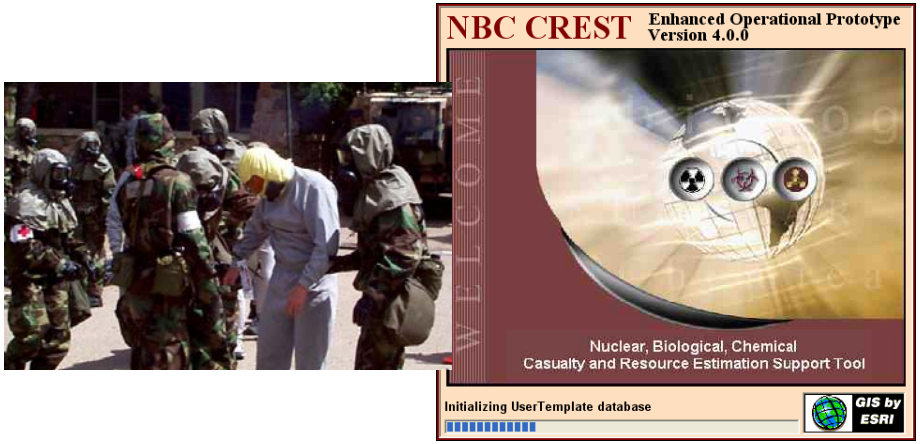
**Major Goals/Milestones by Fiscal Year:**
- FY07: Create secondary infection models for disease spread based on small-world networks and an extension of the SEIR model to account for heterogeneous mixing among sub-populations
- FY08: Validate models with real-world and simulation data
- FY09: Incorporate models into JEM and verify

**PI Contact Info:** Dr. Gene McClellan, 703-816-8886 x-140, gene.mcclellan@ara.com

# NBC CREST Transition to JPM-IS

**Objective:** The objective of this effort is to prepare casualty estimation and medical planning technology in the medical NBC CREST deliberate planning tool for transition to JPM-IS in support of JOEF Increment I.

**Description of Effort:** NBC CREST human response models for CBRN agent exposure, based on NATO's Allied Medical Publication 8 (AMedP-8), will be implemented in an object-oriented form for transition to JPM-IS. Software will be tested, verified, validated, and documented for transition. The NBC CREST stand-alone version will be verified and validated for application by JPM-IS.




**Benefits of Proposed Technology:** NBC CREST medical planning technology contributes time-dependent human response models to JOEF for estimating the task effects of CBRN exposure and for estimating the patient streams. The medical resource requirement estimates and medical course of action analysis of NBC CREST provide medical-related MOP/MOEs for JOEF.

**Challenges:** Achieving a broad-based validation process.

**Maturity of Technology:** TRL 4 – Legacy CBRN human response models are integrated in NBC CREST Version 4.0, but in relatively primitive form; not robust or easily maintained. TRL 6 – NBC CREST Version 4.0 is an operational prototype, components of which were incorporated in the JOEF Prototype.

**Capability Area/Thrust:** Information Systems / MSS&MEM

**Major goals/milestones by fiscal year:**

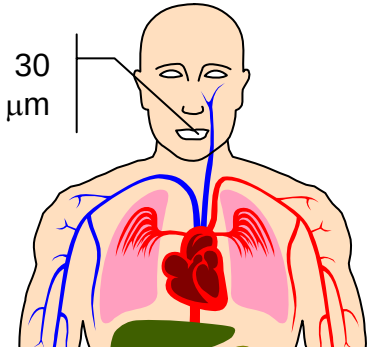
- FY06 – Transition present AMedP-8 chemical and biological models from NBC CREST to JOEF; Verify NBC CREST 5.0 for utilization by JPM-IS
- FY07 – Transition TIC/TIM and AMedP-8 nuclear models from NBC CREST to JOEF
- FY08 – Transition long-term radiological effects models to JOEF; provide V&V documentation for all transitioned CBRN human response models

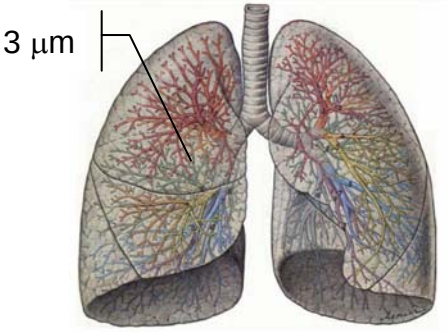
**PI contact info:** Dr. Gene McClellan 703-816-8886 x-140, gene.mcclellan@ara.com

# Medical Modeling of Particle Size Effects for Inhalation Hazards

**Objective: Develop medical models for the influence of aerosol particle size on the health effects of inhaled CBRN hazards to improve hazard assessment, particularly in urban environments.**

**Description of Effort: This effort will link existing models of the respiratory tract and of the particle size distribution (PSD) of atmospheric aerosol hazards to estimate location of inhaled CBRN agent deposition in the body. The Team will quantify the dependence of the health effects of the agents on deposition site. Models will be implemented and tested in coordination with JSTO and JPM-IS for transition to Programs of Record.**




**Benefits of Proposed Technology: Will enhance the fidelity of CBRN health effects in modeling and simulation tools such as JEM, JOEF, and NBC CREST, for casualty estimation and medical planning. Particle size effects are expected to be especially significant in urban areas and in building interiors.**

**Challenges: Gathering sufficient data on the PSD dependence of health effects for a wide range of CBRN agents.**

**Maturity of Technology:**

**TRL 6 - Respiratory tract models.**

**TRL 3 – PSD-dependent disease models.**

**Capability Area/Thrust: Information Systems / MSS&MEM**

**Major goals/milestones by fiscal year:**

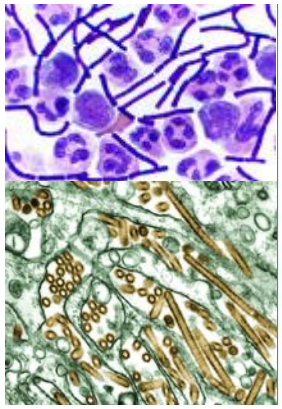
- **FY06 – Select and implement a respiratory tract model; Develop a prototype PSD health effects model**
- **FY07 – Develop a biological and a chemical agent human response model accounting for PSD effects; implement and test in coordination with JSTO and JPM-IS**
- **FY08 – Develop, implement and test additional agent response models accounting for PSD effects; deliver Verified and Validated (V&V) software**

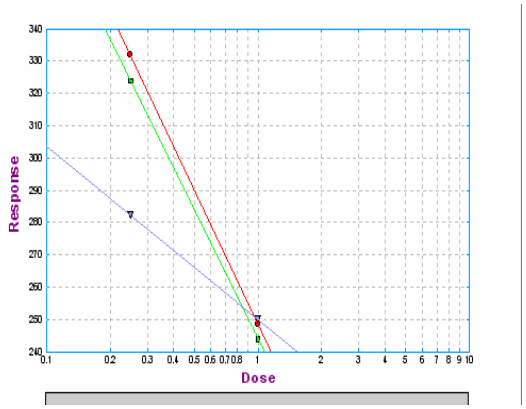
**PI contact info: Dr. Gene McClellan 703-816-8886 x-140**

# Integrated Medical Effects Modeling to Enhance Warfighter Protection and Performance

**Objective:** Conduct systematic assessment, application, and development of medical effects modeling to support DTRA efforts to advance state-of-the-art in high-visibility science area of paramount national importance by enhancing CB Defense against biological warfare agents and emerging infectious disease threats at the operational level

**Description of Effort:** Interdisciplinary program to assess, apply, and develop medical effects modeling. Effort focuses on: identification of existing model capabilities and their match with end-user requirements, scenario-based modeling exercise assessment, gap analysis and S&T roadmap development, and model integration.






**Benefits of Proposed Technology:** Fills information gaps for key areas relevant to preventing or minimizing adverse impacts and aids development of effective countermeasures against exposures to BW/BT agents and/or pandemics.

**Challenges:**
- Identify appropriate medical effects models
- Develop realistic set of threat-based scenarios
- Extend CBRN data model to meet requirements of this effort
- Model integration

**Maturity of Technology:** TRL 3 by 4Q FY11

**Capability Area/Thrust:** Information Systems / MSS&MEM

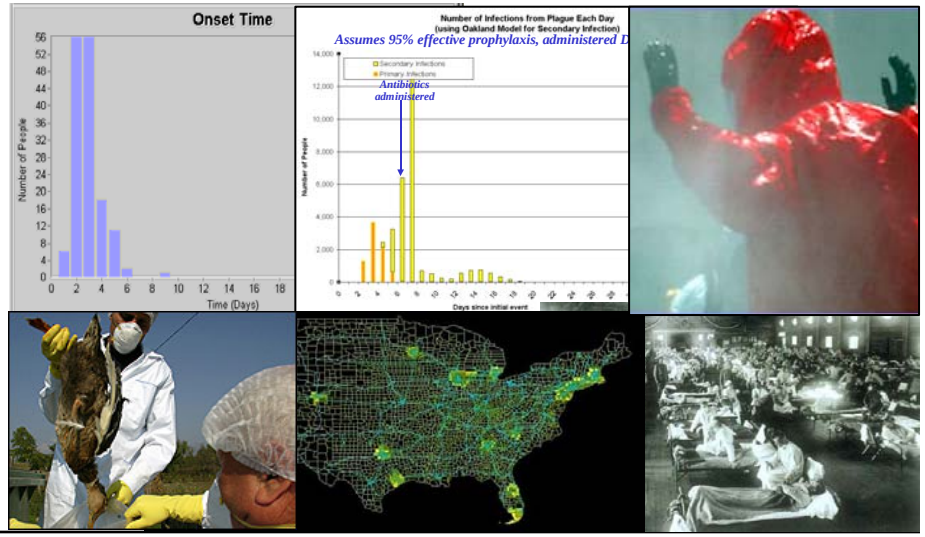
**Major goals/milestones by fiscal year:**
- FY07-FY08: Identify existing model capabilities & user requirements
- FY08-FY09: Scenario-based assessment exercises
- FY09-FY10: Gap analysis; S&T roadmap development
- FY10-FY11: Model integration

**PI contact info:** Dr. James L. Regens, 405-271-2070, larry-regens@ouhsc.edu

# Infectious Disease Assessment Capability (IDAC)

**Objective:** Investigate application of geographic and numeric estimations of biological agent and infectious disease spread enabling warfighters and first responders to plan, respond, and evaluate courses of action.

**Description of Effort:** IDAC will investigate and develop technology to estimate of specific courses of action (i.e.: prophylaxis, quarantine, blockade) relative to a responding and mobile populous. IDAC will also estimate medical resources that DoD will be asked to support for both military and civilian populations. Investigations will provide immediate capability from R&D for an impending pandemic influenza. Concurrently, IDAC will evaluate military efficacy leading to migration to a Program of Record.




**Benefits of Proposed Technology:** This will be the first operational employment of high performance computations of disease spread, movement, and response at the individual level. DTRA will provide immediate capability via R&D emersion into this developmental process. This effort leverages over twenty years of DoE (LANL), DHHS (NIH's MIDAS) and academic (VT/VBI) work. DTRA is employing best of breed efforts and computational leads in this community.

**Maturity of Technology:** Technical Readiness Level (TRL) 2

**Capability Area/Thrust:** Information Systems / MSS&MEM

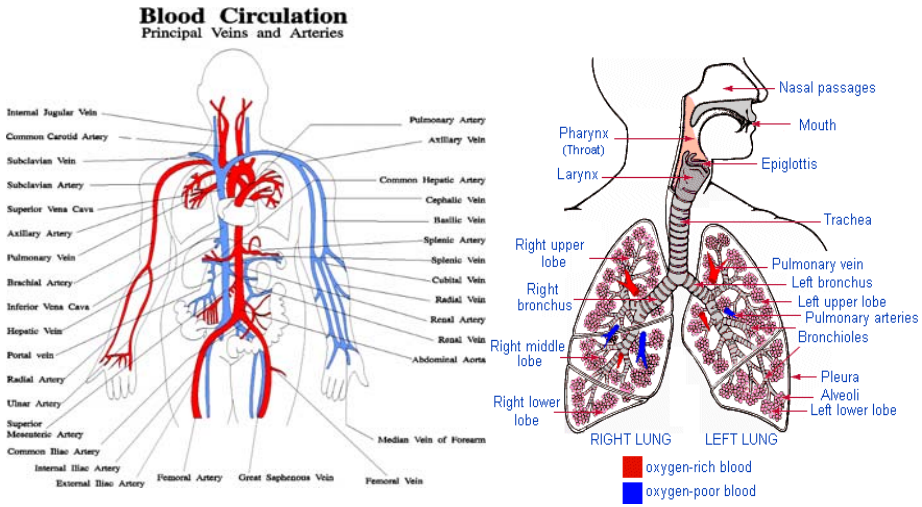
**Major goals/milestones by fiscal year:**
- FY06: Initial Development ($2.8M)
- FY07: Initial CONUS Investigation & Demonstration ($4M)
- FY08: Initial OCONUS Investigation ($3.2M)
- FY09: Decision Point – Migration to Program of Record (?)

**Contact info:** Mr. Matt Holm (RD-RDI), 703-767-2916, Matthew.holm@dtra.mil

# Low-order Multiphysics Models of Complex Biological Organisms

**Objective:** Accurate representation of the coupled behavior of physiological systems in biological organisms using coupled one-dimensional computational fluid mechanical models.

**Description of Effort:** The Pulsed Fluid Equations (PFE) developed for this project model physiological systems in biological organisms as 1D liquid or gas flows. Special attention is given in the model to capturing 2D viscous effects and branching effects. Multiple PFE representations of physiological systems (e.g. the respiratory and circulatory systems in the human body) are coupled to form a computational representation of a biological organism at the desired level of description.




http://www.worldinvisible.com/images/apolog/body/bloodjci.gif

**Benefits of Proposed Technology:** One goal is to develop faster-than-real-time smart medical computing systems that can be, e.g., tuned to a particular patient's physiology and used predictively during surgery. No such technology exists today.

**Challenges:**
- Code currently being developed

**Maturity of Technology:** The Technical Readiness Level is 1

**Capability Area/Thrust:** Information Systems / MSS&MEM

**Major goals/milestones by fiscal year:**
- Complete code
- Complete code verification
- Apply technology to study actual system

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# *Discussion, Recommendations & Way Ahead*