Modeling and Simulation of Healthcare Systems for Homeland Security Applications

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DISCLAIMERS

The findings expressed or implied in this report do not necessarily reflect the official view or policy of the U.S. Department of Homeland Security, U.S. Department of Commerce, or the United States Government.

Some software products may have been identified in context in this report. This does not imply a recommendation or endorsement of the software products by the authors or NIST, nor does it imply that such software products are necessarily the best available for the purpose.

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1. Document Purpose

Healthcare System models and simulations may be used to support analysis, planning, and training needs for the healthcare institutions, epidemics, and other healthcare-related emergencies. Simulation models may be used to understand healthcare systems, interdependencies with other systems, their vulnerabilities, and the impact of emergency incidents on the population and healthcare community. These models and simulations will also be used to support training exercises, performance measurement, conceptual design, impact evaluation, response planning, analysis, acquisition, conceptualizing and evaluating new systems, vulnerability analysis, economic impact, and determining interdependencies between healthcare and other infrastructure systems. The goal of this document is to capture the current knowledge and information resources that can serve as a common baseline for researchers and developers of models and simulations of healthcare systems for homeland security applications. This initial version of the document attempts to assemble relevant, publicly available information from a number of sources within U.S. Department of Homeland Security (DHS) and the modeling and simulation (M&S) communities.

This document is intended to help initiate the discussion of the current leading research, development, standards, and implementation issues within the Healthcare System M&S community, as it relates to homeland security. The document will be updated based on the input of domain experts across government, research, and commercial organizations. These experts will be invited to join together in a workshop to review and extend this document for its final publication. The workshop will focus on simulation and modeling activities and needs that support analysis, planning, and training for the healthcare systems as well as the integration of M&S applications with each other and other data systems. Issues to be addressed within the scope of this workshop include the establishment of consensus on:

- identification of subject matter experts
- definition of customer and user needs
- system requirements specifications
- recommended/approved modeling techniques and approaches
- identification of data sources, reference data sets, formats, and standards
- identification of appropriate model evaluation and accreditation practices

The workshop will also help identify the current leading research, development, standards, and implementation issues. Such analysis by the workshop participants may be found to be relevant by future efforts for developing standards, conducting research and development, and enhancing implementation policies and procedures for homeland security applications of M&S to improve the protection of critical infrastructure systems. A preliminary workshop that addressed modeling and simulation of healthcare systems was held in 2008, see [NIST 2010b] for further information.

This document provides a compendium of information that has been assembled that is relevant to the M&S of healthcare systems. Healthcare systems, as pertains to homeland security, are introduced in Section 2. Section 3 provides a general background on methodologies, models, and simulations. An initial set of high level user and customer needs for M&S applications in the healthcare system domain is presented in Section 4. Section 5 translates the high level needs to a representative set of M&S system requirements (a more detailed specification is currently under development in a related effort). The existing healthcare systems M&S resources and capabilities such as projects, tools, standards, and data sets that have been developed over the years to meet the needs and requirements are identified in Section 6. Section 7 presents a discussion of issues, concerns, and recommendations for advancing M&S for healthcare systems emanating from a comparison of current resources and capabilities with the needs and requirements. Section 8 concludes the document while section 9 provides list of references used.

Three additional documents have been prepared as a part of this effort. The other documents address M&S for critical infrastructure and key resources (CIKR), incident management, and releases of hazardous materials. To minimize redundancy between the documents, each document focuses on the M&S techniques that are most significant to the sectors mission and objectives. The CIKR document emphasizes modeling and simulation supporting analysis of systems (e.g., vulnerability, security), whereas the incident management document focuses more on training and exercises. The healthcare systems document addresses M&S for analysis, training, and exercises, but at a more detailed level than the previous two documents. The hazardous material releases document focuses on the more physical aspects of M&S associated with explosions, fires, plumes, and the flow of hazardous materials in building ventilation systems, bodies of water, and the soil. The authors recognize that each of the domains may employ all of the M&S techniques that have been identified in the other documents, but typically to a lesser extent.

The authors welcome identification of omissions as well as suggestions for improvements. Please contact the authors directly or submit comments or questions by e-mail to simresponse@cme.nist.gov.

## 2. Introduction to Healthcare Systems and Associated DHS Guidance

The *Healthcare and Public Health* sector consists of state and local health departments, hospitals, health clinics, mental health facilities, nursing homes, blood-supply facilities, laboratories, mortuaries, and pharmaceutical stockpiles. The Responsible Agency for the healthcare sector, as designated in the relevant DHS documents, is the Department of Health and Human Services. Organizations that may be involved in addressing sector issues and as well the development of models and simulations include: Center for Disease Control, Food and Drug Administration, Department of Homeland Security (border control for foreign viruses, agricultural pests, etc.), Social Security Administration, the U.S. Public Health Service, state and local agencies, academic institutions, and research hospitals.

The healthcare systems domain includes modeling of incident victims and existing patients affected by incidents; medical symptoms, physiological processes, and behaviors that patients may experience as the result of a natural disaster, terrorist attack, or epidemic; disease management operations and procedures; the impact of disasters, etc. on the environment as well as the food supply (pollution, contamination, etc.). Issues that may be addressed by simulation applications include: analysis of policies, evaluation of options and predictions concerning the state of public health, spread of communicable diseases, policies for intervention, triage and priority scoring for surgeries or other treatments, vaccination programs, cost-effectiveness analysis, medical emergency response, fatalities management, overall readiness of the healthcare system, hospitals and other related facilities/organizations, surge capacity, operational practices, logistic support systems, and elements of the pharmaceutical/equipment manufacturing sectors serving healthcare system needs.

Healthcare system models may be comprised of: representations of medical personnel and hospitals; constrained medical resources and work calendars; hospital facilities (operation theatres, intensive care units, beds); medical equipment, single use devices, and consumables; administrative documents and processes; medical procedures; the routing, status, and location of ambulances as well as other Emergency Medical Technician (EMT) resources and processes; the location, cost, status, quality, effectiveness, and dispensation of pharmaceuticals; and the logistics of industry practices and processes (climate controlled containers, other special needs). Models and simulations may be implemented as computer software, simulation-based training facilities (emergency and critical-care, medical/surgical patient care, maternity and pediatric rooms), and specialty devices (mannequins for various applications such as trauma, surgery and emergency care, disease diagnosis and treatment).

DHS addresses healthcare systems in two contexts: a) as a function included in the response to emergencies in the context of incident management, and b) as a critical infrastructure sector that should be protected against efforts to affect its operation.

The National Incident Management System (NIMS) [DHS 2008a] and National Response Framework (NRF) [DHS 2008b] provide the relevant guidance for the incident management domain. Homeland Security Presidential Directive-5 (HSPD-5) [DHS 2003], called upon the Secretary of Homeland Security to develop a national incident management system (NIMS). The NIMS provides a systematic approach to guide all involved organizations through the entire life-cycle of preventing, protecting against, responding to, recovering from, and mitigating the effects of incidents while the NRF focuses on preparing for and providing a unified national response to incidents. NIMS, together with NRF and other documents, provides the structure needed to coordinate, integrate, and synchronize activities derived from various relevant statutes, national strategies, and Presidential directives to create a unified national approach to implementing the incident management mission (see Figure 1).
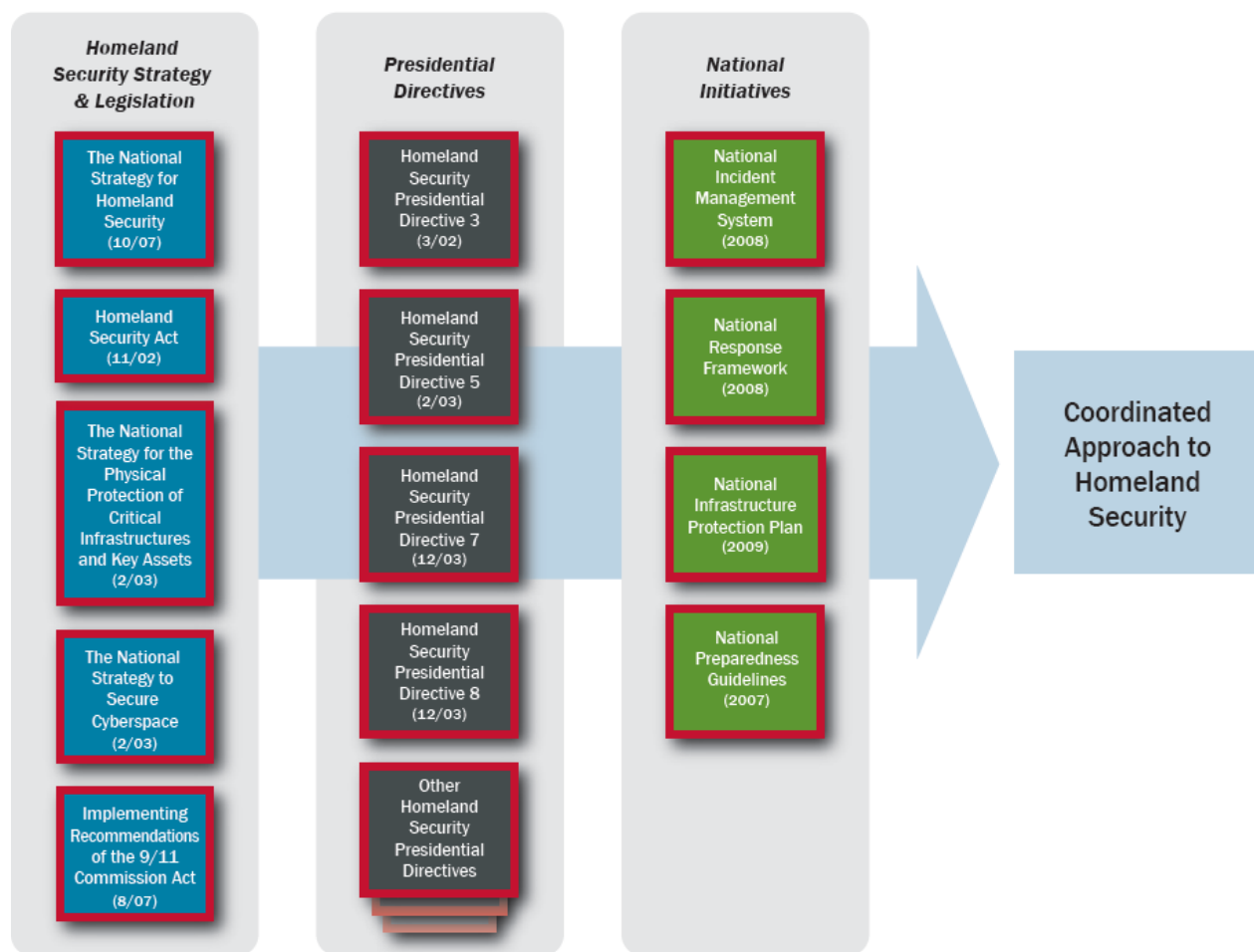
Figure 1: National Framework for Homeland Security (from [DHS 2009])

NIMS identifies that an incident may have a mix of implications including political, social, economic, environmental, public safety, public health, and financial, and hence require a coordinated response. For the healthcare systems perspective, the response includes collection of data on public health and environmental modeling using standard techniques. The public health information should be maintained

securely given the sensitive nature of data. The information may be collected for investigations and analysis to determine the cause, projecting the spread, and selecting countermeasures for public health events and disease outbreaks. Typically M&S application will be used for projections based on the collected information and for evaluating response strategies. Release of information on public health should be carefully managed by a public information officer.

NIMS defines the health and medical resource typing for resource management for incidents. The command staff may include a medical advisor for issues of medical and mental health services, mass casualty, acute care, vector control, epidemiology, or mass prophylaxis considerations, particularly in response to a bioterrorism incident. The command staff may also include public health specialists or radiation health specialist depending on the circumstances. Protocols should be developed for credentialing of volunteer management agencies such as the Red Cross, Medical Reserve Corps, etc. and by organizations such as hospitals. NIMS calls for setting up Area Command for public health emergencies since the impact may not be immediately identifiable, may be geographically dispersed and evolve over long periods of time.

In addition to concerns for the incident victims, the healthcare systems need to be concerned with the health of emergency responders. NIMS defines the need for addressing occupational health and mental issues for emergency responders including monitoring of immediate and long term effects of the incidents. The command staff should include a safety officer and/or an occupational safety and health specialist for monitoring and advising on the health and safety of incident personnel. The logistics section should include a medical unit for providing medical services to incident personnel.

The NRF [DHS 2008b] acknowledges that the responsibility for public health and welfare lies with the governments of the states, territories and tribal areas, and that they can request federal assistance if they anticipate their resources will be exceeded. Several federal departments do have the authority to declare disasters or emergencies. The Secretary of Health and Human Services (HHS) can declare a public health emergency. In a coordinated response, the states, territories and tribal governments should activate special response teams with a public health specialist should the incident warrant such action. The response is followed by short term recovery that includes providing essential public health and safety services. Restoration of healthcare services would usually include coordinating with private sector owner/operators. The NRF emergency support annexes provide primary operation level mechanism to provide assistance in functional areas including public health and medical services.

The NRF Emergency Support Function (ESF)#8-Public Health and Medical Services specifically describes the federal coordinated response in case of a public health disaster or potential for one. It identifies HHS as the primary coordinator. The response addresses medical needs and other functional needs of people in the need of medical care. The ESF briefly describes the concept of operations and the organization for the ESF#8 response. It defines initial actions such as, assessment of public health/ medical needs, health surveillance, providing medical care personnel, equipment, and supplies, patient evacuation and care, and mass fatality management. National Oceanic and Atmospheric Administration (NOAA) and Interagency Modeling and Atmospheric Assessment Center (IMAAC) may be called on for support in case of hazardous material releases being the cause of the emergency. ESF#6- Mass Care, Emergency Assistance, Housing, and Human Services also calls for a large role for healthcare systems including emergency first aid and physical and mental health services for those in mass care. A number of other ESFs call for support roles dealing with public health.

The NRF also includes incident annexes that describe the specialized application of the response framework to specific situations. The incident annexes include those for biological, nuclear/ radiological, catastrophic, food and agriculture, and mass evacuation incidents. The focus of biological incident annex is on responding to human disease outbreaks of known and unknown origins with the HHS as the primary

agency coordinating the response. The actions identified in the incident annex include HHS working with partner organizations to evaluate the incident. While the annex doesn't specifically mention it, M&S can be used to predict the spread of the disease over time to help determine the areas and population at risk. All the other incident annexes include utilization of healthcare systems for caring for incident victims.

Related to the incident management context, the Homeland Security Presidential Directive-8 (HSPD-8) calls on DHS to develop mechanisms for improved delivery of Federal preparedness assistance to State, tribal and local governments [DHS 2008a]. Annex I to HSPD-8 provides guidance for planning and for the development of an integrated planning system. Fifteen national planning scenarios have been developed that may be used to help focus efforts to prepare for natural disasters, terrorist attacks, and other serious incidents. The national planning scenarios are *Improvised Nuclear Device; Aerosol Anthrax; Pandemic Influenza; Plague; Blister Agent; Toxic Industrial Chemicals; Nerve Agent; Chlorine Tank Explosion; Major Earthquake; Major Hurricane; Radiological Dispersal Device; Improvised Explosive Device; Food Contamination; Foreign Animal Disease;* and *Cyber Attack*. With the exception of cyber attack scenario, the rest of the scenarios will require the participation of the healthcare sector for preparedness, response and recovery. Also, a few of the scenarios, such as pandemic influenza and plague, require responses primarily involving healthcare systems. M&S tools and applications should, wherever possible, support the modeling of healthcare systems in the fifteen national planning scenarios defined by DHS.

DHS has developed specific plans for all the critical infrastructure and key resources sectors. The sector specific plan for Healthcare and Public Health (HPH) identifies HHS as the sector specific agency [DHS 2011]. HPH sector is responsible for 15 percent of the gross national product. About 85% of the sector's assets are privately owned and operated. The public health component of the sector is managed across all levels of government from local to national. The HPH sector's vision has been stated as to achieve overall resiliency against all man-made and natural threats. HHS supported establishment of two councils, a Health Sector Coordinating Council for private sector component, and a Government Coordinating Council for the government sector. The councils have established collaborative workgroups on different topics such as, research and development needs and capability gaps for the sector, and measures and metrics for progress towards infrastructure protection goals. The HPH sector R&D goals include strengthening of surge capacity modeling tools [HHS 2007], a goal that would strongly rely on M&S techniques.

3. Perspectives on Methodologies, Models, and Simulations

Concise Oxford Dictionary of Current English, 1996, defines Methodology as "a body of *methods* used in a particular activity." Methodology is principles of method, and such principles can be used to study and inform problem solving and decision-making. [Checkland 2000] describes a useful model linking methodology and the user of a methodology to problem solving:

> *'A problem-solving situation with three elements:*
> - *A user of methodology (this assumes that the user is familiar with the methodology)*
> - *Methodology as documented*
> - *Situation as perceived by the user*
>
> *Relationship and interactions between the three elements are encapsulated in the LUMAS model (Learning, User of methodology, Methodology formally described, Actual approach adopted, and real world problem Situation) shown in figure 2. A simple example narrative for the diagram may be: A user, U, appreciating a methodology, M, as a coherent set of principles and perceiving a problem situation, S, asks, "what can I do?" The User then tailors from M a specific*

approach, A, judged to be appropriate for S, and uses it in an attempt to improve the situation.
This generates learning, L, which may change the user, U or the methodology, M.

A methodology is, then, a logical framework that not only brings forth learning for an individual,
but does so in a consistent and systemic manner so learnings can be shared and passed on.'
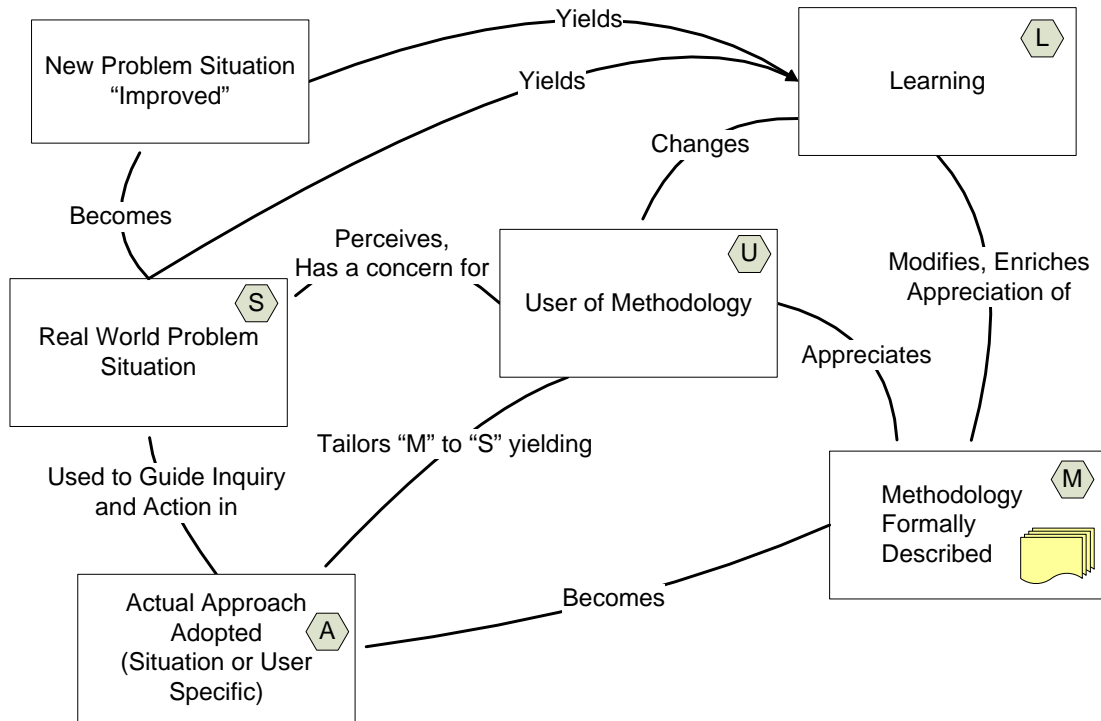
Figure 2: The LUMAS Model (from [Checkland 2000])

Another perspective on methodology comes from the International Council on Systems Engineering
(INCOSE) where methodology is defined as "a collection of related processes, methods and tools"
[INCOSE 2008]. This is based on definitions from [Martin 1996]:

> *'Methodology can be differentiated from other related concepts using the following definitions*
> *from [Martin 1996]:*
> - *A Process (P) is a logical sequence of tasks performed to achieve a particular objective. A*
>   *process defines "WHAT" is to be done, without specifying "HOW" each task is performed.*
>   *The structure of a process provides several levels of aggregation to allow analysis and*
>   *definition to be done at various levels of detail to support different decision-making needs.*
> - *A Method (M) consists of techniques for performing a task, in other words, it defines the*
>   *"HOW" of each task. (In this context, the words: "method," "technique," "practice," and*
>   *"procedure" are often used interchangeably.) At any level, process tasks are performed*
>   *using methods. However, each method is also a process itself, with a sequence of tasks to be*
>   *performed for that particular method. In other words, the "HOW" at one level of abstraction*
>   *becomes the "WHAT" at the next lower level.*
> - *A Tool (T) is an instrument that, when applied to a particular method, can enhance the*
>   *efficiency of the task; provided it is applied properly and by somebody with proper skills and*
>   *training. The purpose of a tool should be to facilitate the accomplishment of the "HOWs." In*
>   *a broader sense, a tool enhances the "WHAT" and the "HOW." Most tools used to support*

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systems engineering are computer- or software-based, and are also known as Computer Aided Engineering (CAE) tools.

Closely associated with methodology is an Environment (E) that consists of the surroundings, the external objects, conditions, or factors that influence the actions of an object, individual person or group [Martin 1996]. These conditions can be social, cultural, personal, physical, organizational, or functional. The purpose of a project environment should be to integrate and support the use of the tools and methods used on that project. An environment thus enables (or disables) the "WHAT" and the "HOW".'

The interrelationship of processes, methods, tools, and environments is graphically represented in Figure 3.
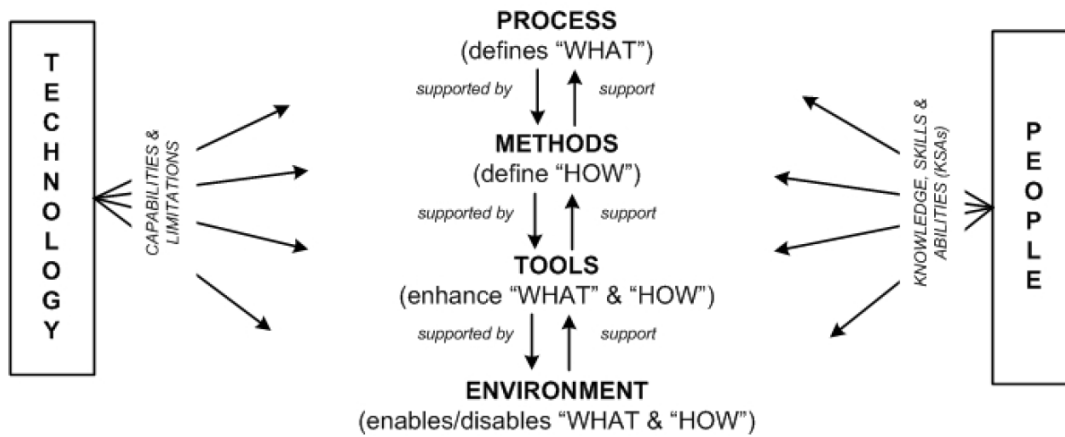
Figure 3: The Process, Methods, Tools, Environments Elements, and Effects of Technology and People (from [INCOSE 2008])

"Model" and "simulation" can be defined or classified in many ways. For example, the DHS Lexicon [DHS 2010] includes the following definitions:

- *Model*: approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system.

- *Simulation*: model that behaves or operates like a given process, concept, or system when provided a set of controlled inputs.

In addition, Department of Defense glossary [DoD 2010] provides the following definition.

- *Modeling & Simulation*: Modeling and Simulation (M&S): The discipline that comprises the development and/or use of models and simulations. M&S is highly dependent upon Information Technology as defined in DoD Directive 4630.05, Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS), May 5, 2004.

  a. The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably, but simulations generally execute models over time, space, events, or other processes.

The focus of this document is on computer models and simulations – computer implemented physical, mathematical, process, phenomenological or other types of models.   One perspective on the way in which computer models and simulations support methodology is modeled in Figure 4 (M in the LUMAS Model).

Examples of Methodologies:
• Policy Analysis
• Operations Research
• Systems Engineering
• Experimentation
• Statistics
• Test and Evaluation
• Computer Modeling and Simulation

M

METHODOLOGY

Behavioral

Modeling

Computer Modeling and Simulation

Mathematical Modeling

Data Modeling

General Knowledge (Epistemology)

Structural

Conceptual (language, images)
State Charts

Discrete Event System Specification
Discrete Time System Specification
Agent-Based Models
Cellular Automata
Neural Networks
Object-Oriented Models

Differential Equation Specified Systems (DESS)
Stochastic Models
Logic Models
Linear Programs

Parametric/Empirical Models
Uncertainty Models

Human-in-the-Loop (HITL)
Hardware-in-the-Loop (HWIL)
Finite Element Model (FEM)
Finite Volume Model (FVM)
System Environment Models

Mock-up/Prototype
Scale Models; e.g., ships, airplanes
Maps

Figure 4: Modeling in methodology

Models can broadly be divided into structural and behavior representations of systems, which could include mathematical or empirical modeling. Each of these types of models can be implemented using computer models for simulation and used to study questions of interest about a particular system. Various examples of model types are shown. This list of model types is not complete or exhaustive, but is meant to show typical applications of M&S that support methodologies such as operations research, systems engineering, experimentation, or other types of analysis.

Although M&S capabilities are tools in many different methodologies, M&S using computers is itself a methodology with supporting processes, methods and tools. Figure 5 illustrates a simplified, generic process for development of computational M&S capabilities to address a non-trivial engineering or scientific problem from the perspective of an M&S developer.   The process shown in Figure 5 also maps to the LUMAS model as shown in the figure. This process is also applicable to simpler problems where trivial steps may be combined. Also, the M&S developer may be the problem solver and consumer of the M&S results such as an engineer addressing a systems design question or a program manager doing a "what if" analysis to assess the risk to a program.

The first step in the process includes the model or code developer (U) developing a clear understanding of what problem situation (S) the consumer of the M&S results is trying to address. A conceptual model of the system or problem serves as a framework in developing and implementing the appropriate computer

modeling capability (A) using the M&S methodology (M) to address the question at hand. With a clear conceptual model in mind, developers have a number of choices to make in generating results:
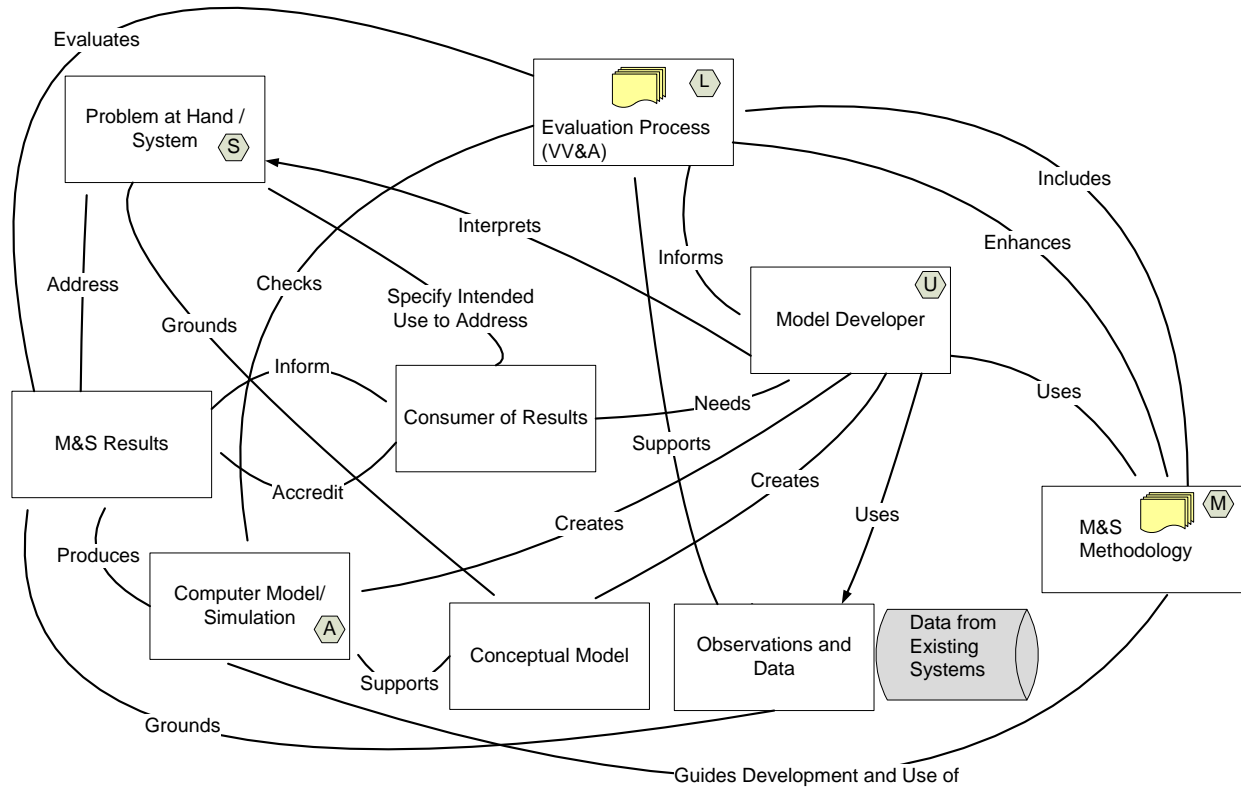
Figure 5: Computer Modeling and Simulation – Developer's Perspective

- What data, knowledge, theories, or models are available or applicable to address the problem at hand?
- Is the data, knowledge, or understanding sufficient in both quality and quantity to address the problem at hand, or will additional data or observations be required to support development?
- What is the risk of using erroneous results, e.g., will these results be the only input to a decision, or will other sources of information be available to support decision making?
- How can the conceptual model be expressed mathematically or physically?
- What boundary and initial condition should be used?
- What modeling paradigm or approach would be most appropriate to implement the analysis?
- Given the developers' experience, what particular codes or capabilities would be most suitable for implementing the model, considering software, hardware, and other constraints and limitations?
- Given the code or computer capability has been developed, have any mistakes or errors been made in completing this or in entering the data?
- Given there are no mistakes or errors found in developing the capability or entering the data, are the results realistic, and do they make sense?
- What approach should be used to ensure that the results are correct?
- How do uncertainties and approximations affect the computational results?
- Given that everything else is correct, are the results suitable to address the problem at hand?
- How should the results and associated uncertainty be present for use in decision making?

M&S capabilities are used to model only selected aspects of a system and the models are implemented in a computing environment; therefore, the models need to be critically evaluated to ensure that the results are credible for their specific intended use, and this is typically done using an evaluation process (L) which is included in the M&S methodology (M) and informs the model developer (U) of the quality of the M&S capability and results in addressing the problem at hand (S).

Evaluation of M&S capabilities and results should take into account the many factors that affect the quality of the results including the level of understanding or knowledge of the issues being addressed and the experience level of model developers. Several organizations have developed processes and guidelines to address the credibility of M&S capabilities. For example, DoD has a process for documentation, evaluation, and certification of M&S results known as Verification, Validation and Accreditation (VV&A) that is defined in a recommended practice guide [DoD 2006]. The DoD process is implemented in policy, which develops a common understanding of the major steps in the VV&A process defined as below [DoD 2009]:

- *Verification.* The process of determining that a model implementation and its associated data accurately represents the developer's conceptual description and specifications.
- *Validation.* The process of determining the degree to which a model and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model.
- *Accreditation.* The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose.

All M&S capabilities should complete verification and validation (V&V). M&S capabilities used as the primary input to critical decision making, e.g., on cost, schedule, or performance of the system, should be formally accredited to certify that the results are credible for their intended use. Analysts and decision-makers need to be aware of these sorts of issues when presented with computational modeling and simulation results.

[Balci 1998] developed a taxonomy and describes the use of different methods to evaluate M&S capabilities and results based on software testing approaches. Figure 6 identifies these verification, validation, and testing methods or techniques which can be used to support an evaluation process such as VV&A.

In addition to the use of recommended practices for conceptual modeling and ensuring model credibility, model developers should employ recommended practices for a number of other aspects. [Jain 2011] recommends best practices for modeling, simulation, and analysis for homeland security applications for the following aspects:

1. conceptual modeling
2. innovative approaches
3. software engineering
4. model confidence/ verification, validation and accreditation (VV&A)
5. use of standards
6. interoperability
7. execution performance
8. user friendliness and accessibility

Verification, Validation and Testing Techniques

Informal	Static	Dynamic	Formal
Audit	Cause-Effect Graphing	Acceptance Testing	Induction
Desk Checking	*Control Analysis*	Alpha Testing	Inductive Assertions
Documentation Checking	Calling Structure Analysis	Assertion Checking	Inference
Face Validation	Concurrent Process Analysis	Beta Testing	Lambda Calculus
Inspections	Control Flow Analysis	Bottom-Up Testing	Logical Deduction
Reviews	State Transition Analysis	Comparison Testing	Predicate Calculus
Turing Test	*Data Analysis*	*Compliance Testing*	Predicate Transformation
Walkthroughs	Data Dependency Analysis	Authorization Testing	Proof of Correctness
	Data Flow Analysis	Performance Testing	
	Fault/Failure Analysis	Security Testing	
	Interface Analysis	Standards Testing	
	Model Interface Analysis	Debugging	
	User Interface Analysis	*Execution Testing*	
	Semantic Analysis	Execution Monitoring	
	Structural Analysis	Execution Profiling	
	Symbolic Evaluation	Execution Tracing	
	Syntax Analysis	Fault/Failure Insertion Testing	
	Traceability Assessment	Field Testing	
		Functional (Black-Box)Testing	
		Graphical Comparisons	
		Interface Testing	
		Data Interface Testing	
		Model Interface Testing	
		User Interface Testing	
		Object-Flow Testing	
		Partition Testing	
		Predictive Validation	
		Product Testing	
		Regression Testing	
		Sensitivity Analysis	
		Special Input Testing	
		Boundary Value Testing	
		Equivalence Partitioning Testing	
		Extreme Input Testing	
		Invalid Input Testing	
		Real-Time Input Testing	
		Self-Driven Input Testing	
		Stress Testing	
		Trace-Driven Input Testing	
		Statistical Techniques	
		Structural (White-Box)Testing	
		Branch Testing	
		Condition Testing	
		Data Flow Testing	
		Loop Testing	
		Path Testing	
		Statement Testing	
		Submodel/Module Testing	
		Symbolic Debugging	
		Top-Down Testing	
		Visualization/Animation	

Figure 6: Taxonomy of Verification, Validation, and Testing Techniques (from [Balci 1998])

4. Needs Analysis Overview

Modeling and simulation should be used to support the needs of various managers, analysts, service providers, and first responders within the homeland security community. Most importantly, it must support the planning and response needs of the National Infrastructure Protection Plan (NIPP) partners including the Department of Homeland Security and other federal, state, local, tribal, territorial, and private sector organizations. The high level needs identified below have been derived from the National Infrastructure Simulation and Analysis Center (NISAC) mission statement, as well as a number of other DHS documents, and outside sources. An initial list of high level user/customer needs for healthcare M&S follows:

- Provide simulation and analysis capabilities to a wide range of users that will enhance the understanding of vulnerabilities, risks, and event consequences to healthcare systems.
- Provide M&S capabilities to help establish priorities and potential mitigation strategies for protecting and/or isolating the impact of events on the population and healthcare systems.
- Provide models of the normal operations of healthcare systems, as well as the effects of epidemics, natural disasters, and terrorist attacks upon them to support analysis, planning, and response activities of homeland security healthcare system partners; predict economic impacts of disasters and other relevant healthcare events; support planning for facility defense and security, selection and placement of healthcare monitoring devices and system sensors to update status information, damage assessment, coordinated shutdown, and accelerated recovery of healthcare systems; establish healthcare models, simulations, and data sets that support the national planning scenarios.
- Provide decision-makers the ability to assess policy, investment, and resource allocation options that address healthcare systems needs – near and long term.
- Provide an integrating function that includes the identification and modeling of healthcare system interdependencies; supported interdependencies should include physical, geographic, cyber, and logical [Rinaldi 2004] enables the integration of national, regional, local systems and data sources; brings together disparate users, information providers, and individual infrastructure sector leaders.
- Move towards predictive capabilities that use science-based tools to understand the behavior and expected performance of interrelated infrastructures; predictive capabilities should support various conditions, healthcare systems, and event parameters such as time of day for events, level of demand for the healthcare system, system weaknesses, capacity of facilities, mobilization resources, surge capacity, temporary support organizations, their systems, and functions.
- Provide education and training to public and private decision-makers on how to cope effectively with crisis events.
- Establish virtual capabilities that provide portals for nation-wide remote access and communications to healthcare-related modeling, simulation, and analysis capabilities; identify data and interfaces needed for each healthcare model and event type; provide standard formats for the import and export of data between the portal and external data sources; help plan for the backup and/or remote siting of critical data sources outside of regions affected by events, e.g., hurricane disaster areas.

Other possible application scenarios that may help to define M&S user needs and system requirements for healthcare systems include:

- Resource planning, capacity analysis, & deployment
- Care prioritization and management
- Patient diagnosis, treatment, and other medical processing models
- Emergency medical response operations
- Layout of hospital facilities, departments, and processes
- Flow of health care documentation and information
- Mass preventative measures
- Public health strategies (quarantines, vaccinations)
- Coordination with other government agencies, HMOs, and other organizations
- Laboratory test procedures and identification of biological agents
- Decontamination and treatment for radiation exposure
- Media interactions for healthcare-related preventative activities and emergency incidents

5. Requirements Specifications

This section translates the high level needs discussed in the previous section to a set of requirements. The requirements are intended to be common across all healthcare systems and hence at a high level. These requirements will serve as the starting set that may need to be enhanced for specific healthcare system for unique intended use. A separate document with a more detailed set of common requirements is being developed in a related effort.

5.1.   Intended Use

Healthcare systems models and simulations will be used by healthcare organization managers, emergency planners, first responders, doctors and nurses, support and training personnel to:

a) Analyze the resource requirements, behavior, and performance of healthcare systems.
b) Conduct training exercises, drills, emergencies, tests, alerts, and support real world incidents (natural disasters, terrorist attacks, and epidemics).
c) Determine the readiness of healthcare systems to respond to various types of emergencies.
d) Model past incidents for education, training, and analysis purposes.

5.2.   Functional Requirements

This section identifies possible functions that may be included in healthcare system models and simulations.

a) Provide functions to create high level models of healthcare system operations and evolutions over time to support system performance and resource analysis.
b) Provide training and exercise simulations for healthcare personnel that provide functionality for various incident and exercise parameters, exercise control, and after action reviews.
c) Provide various types of training implementations including tabletop exercises, 2D and 3D computer gaming, immersive virtual reality environments, training facilities, and mannequins.
d) Provide capabilities to refine simulations based on actual incident data, hospital usage data, medical assessments, and field measurements.
e) Support representations of geography, buildings, disease exposure and spread, lethality levels, healthcare institutions, equipment, personnel, victims, patients.
f) Support the integration and/or distributed execution of interrelated models including epidemics, hazardous material release exposure and hazard effects, critical infrastructure systems, incident management systems, and weather.
g) Identify regions where the exposed population will experience life threatening, serious long-lasting, or notable effects from incidents.

5.3.   Data Requirements

This section identifies input and output data types that may be supported for healthcare models and simulations.

a) Structure of healthcare organizations and inventory of resources
b) Standard healthcare processes and procedures (e.g. triage and treatments)
c) Message logs and incident time lines
d) Specification of the incident area including event types and parameters, timing of events, schedule of responder and healthcare personnel activities, population, terrain and buildings in affected areas

e) Demographics data: population location, density, and attributes by time of day
f) Meteorological data: observed and forecast weather conditions that may affect an incident including wind speed, direction, and precipitation
g) Plume data hazardous material releases and explosions
h) Support of appropriate data standards in model implementations, training and exercise simulations, e.g., SCORM – Shareable Content Object Reference Model [ADL 2011]

5.4. User Interface Requirements

This section identifies user interface capabilities that may be supported for healthcare system models and simulations.

a) Provide capabilities to configure simulation runs with specific incident types and associated parameters, affected populations, responder and healthcare system resources, weather conditions, and geographic regions.
b) Generate graphical views of incident, responder, and healthcare system activities over a 2D or 3D representation of area of interest at different levels of resolution.
c) Provide user control mechanisms that affect rapid execution/playback of simulation runs to move forward and back to desired points in time.
d) Use various DHS standard symbology, maps, and representation schemes to display incident parameters, resource locations, and timelines.
e) Provide virtual reality interfaces to support 3d gaming for healthcare exercises.
f) Provide exercise controller interfaces to effect the initiation, execution, as well as playback of exercise simulations for after action reviews and hot washes.
g) Provide interfaces to generate still image and video files that can be used to transfer results for viewing or playback using other software tools.

5.5. Performance Requirements

This section identifies possible performance considerations for healthcare system models and simulations.

a) Support time scaling of models and simulations and abilities to move forward rapidly in time to focus on events of interest (real-time for training and faster than real-time to support analysis during actual incidents and planning).
b) Provide for updates from real time epidemic, incident, meteorological databases and observations.
c) Share model predictions with other software applications.
d) Provide capabilities for interoperable networked implementations at different sites by different organizations.

5.6. Credibility and Evaluation Requirements

This section identifies approaches that may be used to evaluate and determine the credibility of healthcare models and simulations.

a) Conduct walkthroughs of simulation models of healthcare simulations and models with experienced healthcare personnel, incident managers and first responders.
b) Compare results and predictions of healthcare system models against past events using historical data.
c) Conduct side by side training exercises using conventional techniques (e.g., tabletop exercises) and computer-based simulations to compare effectiveness in achieving intended goals such as training objectives, realism, and exercise resource requirements.

6. Identification of M&S Resources

This section identifies existing M&S resources that support emergency healthcare systems and are possibly relevant to meeting some of the needs and requirements presented in sections 4 and 5. Resources that primarily support other M&S areas or domains, e.g., incident command, are not included. The section is divided into:

- Projects, Facilities, and Capabilities (6.1)
- Simulations, Models and Tools (6.2)
- Relevant Standards and Guidelines (6.3)
- Data Sources (6.4)

The term "simulation" is used to include a wide variety of modalities in healthcare area. The Center for Immersive and Simulation-based Learning (CISL) at Stanford School of Medicine [Stanford 2010] defines the following simulation modalities in the healthcare context: standardized patient actors, part-task physical trainers, virtual reality and visualization, desktop simulation and virtual worlds, and mannequin-based simulation. Modeling and simulation (M&S), the focus of this report, has been defined to focus on computer based simulation and hence aligns primarily with the desktop simulation and virtual worlds and overlaps somewhat with the virtual reality and visualization modalities in CISL list. The sub-sections below hence primarily provide information relevant to the selected focus.

6.1. Projects, Facilities, and Capabilities

A number of projects and facilities focus on healthcare simulation. However a majority of them focus on standardized patient actors, part-task physical trainers, and mannequin-based simulation. A preliminary list of projects, facilities and capabilities that include the categories of our interest, i.e., desktop simulation and virtual worlds, and virtual reality and visualization, is provided below.

Center for Integration of Medicine and Innovative Technology (CIMIT) – CIMIT focuses on health care technologies, providing the resources and infrastructure to address technology application issues at the national and international level. CIMIT acts as a bridge between individual investigators and implementation of their ideas. It connects the investigators with a team of experts, and provides a nurturing collaborative environment to help the idea grow towards multiple uses, multiple partners, and multiple programs to address complex patient care problems. The work of simulation group at CIMIT includes building desktop simulation tools such as the Real-time Incident Preparedness Simulation (RIPS) [CIMIT 2010].

Complex Incident Response Training System (CIRTS)-Combat Medics (CM) project – MYMIC LLC is developing CIRTS-CM under a Small Business Innovation Research Phase II contract award in early December 2009. CIRTS-CM is a simulation game based training system for scene and patient management care following blast injuries sustained from explosives including Improvised Explosive Devices (IEDs). Eventually, CIRTS-CM support will expand to other medical domains, such as training combat lifesavers, individual soldiers and marines, military combat support hospitals, civilian emergency medical technicians, other emergency first responders and incidents other than IEDs [MYMIC 2010a].

NIH Center for Biomedical Computation at Stanford (Simbios) – Simbios is the NIH Center for physics-based Simulation of Biological Structures. Simbios provides infrastructure, software, and training to help biomedical researchers understand biological form and function as they create novel drugs, synthetic tissues, medical devices, and surgical interventions. Simbios is investigating a wide scale of biological structures – from molecules to organisms. Driving biological problems include RNA folding, protein

folding, myosin dynamics, cardiovascular dynamics, and neuromuscular biomechanics. Simbios is developing and disseminating the SimTK core simulation toolkit, an open-source software that includes capabilities for modeling the geometry and physics of biological systems. To ensure utility and accuracy, the software and training material is being developed and tested in close collaboration with biomedical scientists. Simbios has developed OpenSim, an application for advanced neuromuscular modeling that uses the SimTK toolkit, and is making it openly available [SIMBIOS 2010].

National Capital Area Medical Simulation Center – The SimCenter is part of the Uniformed Services University of the Health Sciences (USUHS) located in the Forest Glen Annex Silver Spring, Maryland. It has facilities for simulating medical procedures that are high risk or high consequence for patient safety. The simulations allow healthcare personnel develop and maintain the cognitive and psychomotor skills necessary to perform medical tasks safely and effectively. The Virtual Medical Environment Lab at the center includes surgical, emergency room and field hospital simulations, medical gaming as well as large-scale simulations designed to train medical teams in battlefield and natural-disaster scenarios [USU 2010].

National Center for Collaboration in Medical Modeling and Simulation – The NCCMMS is a joint project of Eastern Virginia Medical School (EVMS) and Old Dominion University (ODU) and a variety of academic, governmental and commercial partners. Its mission is to improve both the quality and quantity of medical care available to U.S. military forces. This is accomplished by providing a collaborative environment where basic and applied medical modeling and simulation research can be undertaken by EVMS and ODU researchers within the context of a comprehensive academic medical center that provides a convenient clinical test bed for new technologies and approaches. The center has access to the expertise of the large U.S. military medical community as represented by the Naval Medical Center, Portsmouth, the Uniformed Services University of the Health Sciences, and other military medical facilities. Projects at NCMMS include homeland security, emergency training and response, and gaming simulations [EVMS 2009].

Medical Emergencies Simulation Lab, Institute for Simulation and Training, University of Central Florida – The lab builds on simulators developed by others to create sophisticated medical simulation capabilities that can enhance military, civil defense, and crisis management training. For example, the lab developed HLA-compliant software packages that allow simulated casualties generated during combat exercises to queue up for treatment by combat medics using a human patient simulator. The playing-field-to-emergency treatment model also has been used to train EMTs in civilian mass casualty exercises [IST 2009].

6.2.   Simulations, Models and Tools

A number of healthcare and epidemic modeling tools have been developed through the efforts of federal agencies, universities, research organizations and commercial companies. This section lists existing tools that have been identified through Internet searches and site visits to organizations involved in M&S of healthcare systems. The tools are arranged alphabetically based on their developer's acronyms, or in some cases, abbreviations assigned by the authors for purposes of the readability of this document. Similar to the previous sub-section, the focus is on models and tools for desktop simulation and virtual worlds, and virtual reality and visualization.

Tool Acronym	Brief Description
Code Orange	BreakAway developed a training simulation called "Code Orange" for the Washington Hospital Center to train staff in the job roles they would have to assume in a mass casualty incident. Based on job descriptions and tasked outlined in the

	Hospital Emergency Incident Command System (HEICS) protocol, this simulation allows users to assume roles in triaging patients outside the hospital and inside the ER [Breakaway 2010].
CVMDM	Community Vaccination and Mass Dispensing Model (CVMDM) simulates the allocation and distribution of pharmaceutical materials across a jurisdiction and the dispensing of those materials through points of dispensing (PODs). Given a request time for initial supplies from the Center for Disease and Prevention Control's Strategic National Stockpile, estimated resupply intervals, population size and age distribution, and POD personnel resources, the model calculates the estimated start time for public vaccinations, POD queue times and throughput, and operation closure. Linked with a disease progression submodel, CVMDM tracks and reports the number of infections and fatalities based on disease characteristics and the performance of prophylaxis supply logistics and PODs [ANL 2011].
EDS	ED Simulator (EDS) is a tool for Emergency Department throughput, staffing, patient flow, and efficiency analysis. EDS combines the power and analytical capabilities of simulation with database and data analysis technologies. It is designed to be used at the unit Manager level as a tool for ongoing process analysis, continuous process improvement, and accurate, objective internal benchmarking. It is based on MedModel simulation "engine" [ProModel 2010a].
Edsim	Edsim is a semi-reusable product to quickly model and test alternative design scenarios for existing and proposed hospital emergency departments. It meets the needs of hospital administrators to improve Key Performance Indicators (KPIs), such as patient length of stay (LOS), bed utilization, elimination of bottlenecks, etc. Edsim is also useful for predicting performance of proposed emergency departments before finalizing architectural designs [Ferrin 2007].
EDSIM	Emergency Department SIMulation (EDSIM) was developed through a cooperative effort involving the University of California, Davis, Medical Center (UCDMC) Department of Emergency Medicine and the UCDMC billing department using the Extend Suite v.5 modeling platform developed by Imagine-That, Inc. It provides modules that are connected by conduits that carry data elements representing patients, staff, orders, laboratory results, images, etc. It combines continually updated job queue prioritization and mid-task preemption capabilities that together allow the model to capture the chaotic nature of ED staff activity [Connelly 2004].
ED Simulation	ED Simulation is a desktop application designed specifically for quickly modeling and simulating Emergency Departments. It reduces the programming by pre-building Emergency Department workflow processes. Its applications include: minimizing patient waiting times and ED overcrowding, identifying workflow "bottlenecks," evaluating the effect of patient arrival and symptom mix, and testing disaster preparedness scenarios [Loud Squirrel 2011].
EpiSimS	The epidemic simulation engine, EpiSimS is a C++ application that runs on high-performance computing clusters. It is stochastic agent-based discrete event model that explicitly represents every person in a city, and every place within the city where people interact. A city or region is represented physically by a set of road segment locations and a set of business locations. EpiSimS can simulate various

	pharmaceutical and non-pharmaceutical interventions, including panic-based stay-home behavior, therapeutic and prophylactic use of antivirals, contact tracing, vaccination, wearing of masks, social distancing behaviors (increased inter-personal separation, hand washing, cough etiquette, etc.), household quarantine, and closures of schools [LANL 2010].
GameTT	Games For Team Training (GaMeTT) is an immersive avatar based, virtual environment designed for distributed medical team training. Participants log in to GaMeTT from their own office or homes to work collectively towards team training objectives, optimizing the time available for training and the opportunity for team interaction. GaMeTT utilizes game-based technology to produce visually engaging scenes, user friendly interfaces, and intuitive user commands. The tool is suitable for distributed medical teams such as the Disaster Medical Assistance Teams (DMAT) that are comprised of 35 volunteers who come together from different parts of the country to form a team in case of a disaster [MYMIC 2010b].
HMS	Healthcare Modeling Studio. A simulation modeling solution, is used to build custom analysis tools for a variety of healthcare facilities, including emergency departments, operating rooms, admissions, clinical labs and ancillary services. The tool can be tailored to each client's specific processes, organization, terminology and metrics, HMS helps healthcare professionals improve administrative and operational efficiency, reduce cost and maximize ROI, validate process change or facility expansion, and predict the impact of staffing changes or equipment upgrades [AAI 2007].
LES	Learning Environment Simulator (LES) developed at Los Alamos National Labs has been built as an interface to Critical Infrastructure Protection Decision Support System (CIPDSS). It is designed to engage decision makers at the grass-roots level (local/city/state), deepen their understanding of an evolving crisis, enhance intuition and let them test their own strategies. The initial version is based on a pandemic influenza outbreak and has been tested with a group of hospital administrators and first responders. LES is a simulated environment allowing the user to experience the complexities of a crisis before it happens, including impacts to critical infrastructures with their interdependencies and estimating human health & safety and economic impacts [LeClaire 2009].
MEDMODEL	MedModel is a simulation tool designed specifically for the healthcare industry for evaluation, planning and redesign of hospitals, clinics, and other healthcare systems. MedModel models can be used to identify inefficiencies in an existing process and test a variety of scenarios. Typical applications include: department specific productivity improvement, facilities design (labs, clinics, radiology, emergency rooms, etc.), planning for future changes, staff planning, analyzing patient capacity, equipment planning and logistical analysis, emergency preparedness, and bed capacity management [ProModel 2010b].
MUSTER	MUSTER is a simulation tool for Multi-user Emergency Response training. MUSTER supports training of doctors, nurses, Paramedics, EMT's, rescue workers, disaster medicine rescue teams and others in disaster medicine and management. The core of the training simulator is the patient model. The model has been developed by Danish doctors, and is able to simulate a patient's condition dynamically based on the

	injuries and the treatment he receives. Patients in a scenario can be defined individually [IFAD 2011].
Optima Predict	Optima predict is an interactive strategic planning solution for emergency services that provides a platform for effective planning and simulation of requirements of resources such as ambulances. Optima Predict takes into account key performance indicators such as response times, vehicle types and coverage, shift rosters, post locations and hospital ramp times to enable users to quickly build scenarios that make logistical and business sense [Optima 2011].
PLAN C	Planning with Large Agent-Networks against Catastrophes (PLAN C) is an agent based simulation tool for emergency managers, urban planners and public health officials to prepare and evaluate Pareto-optimal plans to respond to urban catastrophic situations. PLAN C has been used to simulate emergency responses in different urban catastrophic scenarios (e.g., chemical agent, bomb explosion, food poisoning, small pox). It can devise plans that optimize multiple objective functions (e.g., number of casualties, economic impact, time to recovery, etc.) in terms of their Pareto frontier in a high-dimensional space; for this purpose, it uses an evolutionary genetic search algorithm [NYU-CCPR 2009].
RIPS	Real-time Incident Preparedness Simulation developed by the SimGroup at the Center for the Integration of Medicine and Innovative Technology (CIMIT) is a training tool for emergency response personnel. It is an incident simulator with game like qualities and it provides a platform for creating disaster scenarios, sharing them, and then training on them with other professionals. It is based on the NIMS hierarchy [CIMIT 2002].
SimCare	SimCare Process Simulator 9.0 is a process simulation software for the healthcare industry. SimCare pro healthcare simulation includes support for hospitals, clinics, and blood centers. It allows for importing CAD files for the facilities such as emergency departments, and historical data for rapid model development of the model [CreateASoft 2011].

6.3. Relevant Standards and Guidelines

This section identifies standards and guidelines that are potentially relevant to the development of M&S applications for healthcare systems. The standards and guidelines may include mechanisms and formats for the interchange of data, data storage, generation of information displays, integration of systems, and/or conceptualization and design of healthcare M&S applications. Subsection 1 includes the standards that are specific to healthcare domain. The following subsections list standards that are common across the homeland security applications of M&S and focus on conceptual modeling, distributed simulation, geographical information system (GIS), and communications respectively.

6.3.1. Domain Specific Standards

Standard Title	Overview
After a Terrorist Bombing: Health and Safety Information for the General Public	**Description:** A document contains "Immediately after the event" and "Hours or days after the event" for helping people who have been affected by the blast and will provide updated information as soon as they learn more [CDC 2010a]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Bioterrorism Readiness Plan: A Template for Healthcare Facilities	**Description:** A Bioterrorism Readiness Plan to serve as a reference document and initial template to facilitate preparation of bioterrorism readiness plans for individual institutions [CDC 2010b]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC), The Association for Professionals in Infection Control and Epidemiology (APIC) Bioterrorism Task Force **Classification:** Operational guidelines
Business Continuity/Disaster Recovery Plan	**Description:** The business continuity/disaster recovery plan is to identify the most critical information needs for patient care, treatment, and services and business processes, and the impact on the hospital if these information systems were severely interrupted. The plan identifies alternative means for processing data, providing for recovery of data, and returning to normal operations as soon as possible [JCAHOSTD 2010]. **Standard Type:** IM.2.30 (2008) **Organization:** The Joint Commission **Classification:** Operational guidelines
Common Biometric Exchange Formats Framework (CBEFF)	**Description**: The standard specifies a common set of data elements necessary to support multiple biometric technologies and to promote interoperability of biometric-based application programs and systems by allowing for biometric data exchange. These common data elements can be placed in a single file, re-cord, or data object used to exchange biometric information between different system components and applications. This standard specifies the biometric data elements [ANSI 2010]. **Standard Type:** ANSI INCITS 398-2008 **Organization:** American National Standards Institute (ANSI) **Classification:** Document Format
Communicating in the First Hours for Anthrax: Short and Extended Messages	**Description:** These messages can be used by public health officials during the first hours after a suspected anthrax emergency. The short messages include essential information to help minimize the immediate risk to the public from an attack. The extended messages also include general information that

	can be used as a resource for officials in developing messages tailored to a specific situation [CDC 2010c]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Community-Based Mass Prophylaxis: A Planning Guide for Public Health Preparedness	**Description:** Planning guide to help state, county, and local officials meet federal requirements to prepare for public health emergencies [AHRQ 2010a]. Outlines five components of mass prophylaxis response to epidemic outbreaks. Addresses dispensing operations using a comprehensive operational structure for Dispensing/Vaccination Centers (DVCs) based on the National Incident Management System (NIMS). **Standard Type:** N/A **Organization:** The Agency of Healthcare Research & Quality (AHRQ) **Classification:** Operational guidelines
Digital Imaging and Communications in Medicine (DICOM)	**Description:** A specification for exchange of radiology images and other medical information between computers. It enables digital communication between diagnostic and therapeutic equipment and systems from various manufacturers. DICOM is a global Information-Technology that is used in virtually all hospitals worldwide. Its current structure is designed to ensure the interoperability of systems to produce, store, display, process, send, retrieve, query or print medical images and derived structured documents as well as to manage related workflow [NEMA 2010]. **Standard Type:** DICOM 3.0 **Organization:** American College of Radiology (ACR), and National Electrical Manufacturers Association (NEMA) **Classification:** General purpose integration interfaces
Disaster Privileges	**Description:** A plan that identifies the option to grant privileges during disaster situations to doctors and other licensed practitioners [JCAHOSTD 2010]. **Standard Type:** MS.4.110; HR.4.35 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Drawing Interchange File (DXF) Formats	**Description:** The DXF format is a tagged data representation of all the information contained in an AutoCAD drawing file. Tagged data means that each data element in the file is preceded by an integer number that is called a group code. A group code's value indicates what type of data element follows. This value also indicates the meaning of a data element for a given object (or record) type. Virtually all user-specified information in a drawing file can be represented in DXF format [AUTODESK 2010]. DXF can be used for exchange of radiology images and

	other medical information between computers. **Standard Type:** AutoCAD 2009, v.u.23.1.01 **Organization:** Autodesk, Inc. **Classification:** General purpose integration interfaces
Emergency Electrical Power Source	**Description:** A plan that describes the requirements of a hospital's emergency power system [JCAHOSTD 2010]. **Standard Type:** EC.7.20 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Emergency Management Drills	**Description:** A plan that describes a hospital's approach to conduct drills to test emergency management [JCAHOSTD 2010]. **Standard Type:** EC.4.20 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Emergency Management Planning	**Description:** An emergency management plan that comprehensively describes the approach to emergencies in the hospital or its community [JCAHOSTD 2010]. **Standard Type:** EC.4.10 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Environment of Care Crosswalk	**Description:** The Joint Commission Resources, a not-for-profit affiliate of The Joint Commission, released the Environment of Care Crosswalk. The 2009 Environment of Care Crosswalk helps hospitals to simplify their compliance activities and recognize when there is a duplication of requirements between the Joint Commission 2009 Environment of Care, Emergency Management, and Life Safety Standards, and the regulations of the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA) [JCR 2010]. **Standard Type:** 2009 Environment of Care **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Facts About the Laboratory Response Network	**Description:** Description of the network of labs that respond to biological & chemical terrorism. In 1999, the Centers for Disease Control and Prevention (CDC) established the Laboratory Response Network (LRN). The LRN's purpose is to run a network of labs that can respond to biological and chemical terrorism, and other public health emergencies. The LRN has grown since its inception. It now includes state and local public health, veterinary, military, and international labs. This fact sheet provides a brief description of the LRN, and how it works [CDC 2010d]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention

	(CDC) **Classification:** Operational guidelines
Guidance for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks	**Description:** This document identifies actions that a building owner or manager can implement without undue delay to enhance occupant protection from an airborne chemical, biological, or radiological attack [CDC 2010e]. **Standard Type:** N/A **Organization:** The National Institute for Occupational Safety & Health (NIOSH); The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Guidance for Public Health Departments and Clinicians Caring for Individuals Who May Have Been Recently Exposed to Polonium -210	**Description:** Clinical guidance recommendations for public health departments and clinicians to care people who may have been recently exposed to Polonium -210 (Po-210). Po-210 is considered to be one of the most hazardous radioactive materials known, but it must be inhaled or ingested to exert its toxic effects. It is found naturally in the environment, and the general population is internally contaminated with small but measurable amounts of it on a regular basis through food, water, and air [CDC 2010f]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Guidance on Initial Responses to a Suspicious Letter/Container With a Potential Biological Threat	**Description:** Guidelines for local responders, based on existing procedures, on the initial response to letters, packages, or containers containing suspicious powders, liquids, or other materials [DHS 2010b]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC), Federal Bureau of Investigation (FBI), Department of Homeland Security (DHS) **Classification:** Operational guidelines
Guidelines for Handling Decedents Contaminated with Radioactive Materials	**Description:** Detonation of a nuclear weapon or activation of a radiological dispersal device could cause radioactively contaminated decedents. These guidelines are designed to address both of these scenarios. They could also be applicable in other instances where decedents' bodies are contaminated with radioactive material (e.g., reactor accidents, transportation accidents involving radioactive material, or the discharge of a decedent from a hospital after injection or implantation of a radiopharmaceutical). These guidelines suggest ways for medical examiners, coroners, and morticians to deal with loose surface contamination, internal contamination, or shrapnel on or in decedents' bodies [CDC 2010g]. **Standard Type:** N/A

	Organization: The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Health Insurance Portability and Accountability Act (HIPAA)	**Description:** The Health Insurance Portability and Accountability Act (HIPAA) is a federal law that provides rights and protections for participants and beneficiaries in group health plans. HIPAA includes protections for coverage under group health plans that limit exclusions for preexisting conditions; prohibit discrimination against employees and dependents based on their health status; and allow a special opportunity to enroll in a new plan to individuals in certain circumstances [DOL 2010]. The Administrative Simplification provisions of the Health Insurance Portability and Accountability Act of 1996 (HIPAA, Title II) required the Department of Health and Human Services (HHS) to establish national standards for electronic health care transactions and national identifiers for providers, health plans, and employers. As the industry has implemented these standards, and increased the use of electronic data interchange, the nation's health care system will become increasingly effective and efficient [HHS 2010a]. **Standard Type:** HIPAA of 1996 (P.L.104 – 191) **Organization:** Department of Health and Human Services (HHS) **Classification:** Operational guidelines
Health Insurance Portability and Accountability Act (HIPAA) Security Rule	**Description:** The HIPAA Security Rule establishes national standards to protect individuals' electronic personal health information that is created, received, used, or maintained by a covered entity. The Security Rule requires appropriate administrative, physical and technical safeguards to ensure the confidentiality, integrity, and security of electronic protected health information [HHS 2010b]. **Standard Type:** HIPAA Security Rule 164.308 (a)(7)(i) **Organization:** National Institute of Standards and Technology (NIST) **Classification:** Operational guidelines
Health Level Seven (HL7) Standards	**Description:** Health Level Seven is one of several American National Standards Institute (ANSI) –accredited Standards Developing Organizations (SDOs) operating in the healthcare arena. Health Level Seven's domain is clinical and administrative data [HL7 2010]. HL7 standards are used for the exchange, management, and integration of electronic healthcare information. **Standard Type:** ANSI/HL7 V2 XML-2003; ANSI/HL7 V2.5-2003; ANSI/HL7 V3 DSR, R1-2005, ... ANSI/HL7 V3 PM, R1-2005; ANSI/HL7 V3 CR, R3-2005; ANSI/HL7 V3 MFRI, R1-2006 **Organization:** Health Level Seven (HL7); American National Standards Institute (ANSI)

	Classification: Domain-specific integration interfaces
Infection Control	**Description:** A plan that is used by the hospital to respond to an influx, or the risk of an influx, of infectious patients [JACHOSTD 2010]. **Standard Type:** IC.6.10 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident	**Description:** The guidance focuses on six key areas: (1) notification and communication, which emphasizes the importance of hospitals working with their communities and public health agencies on developing emergency communication plans; (2) triage; (3) patient management, including decontamination, treatment, care of special populations, discharge and follow up, and patient mental health concerns; (4) healthcare provider protection, including staff training and practitioner mental health concerns; (5) surveillance, and (6) community planning [CDC 2010h]. **Standard Type:** N/A **Organization:** the Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Interim Life Safety Measures (ILSM)	**Description:** Guidelines for Design and Construction of Hospital and Health Care Facilities to minimize the possibility of injury or damage due to fire, smoke & fumes, or other threat. ILSM are health and safety measures that are put in place to protect the safety of patients, visitors, and staff who work in the hospital [BMET 2010]. **Standard Type:** ILSM **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Interim Recommendations for Firefighters & Other First Responders for the Selection & Use of Protective Clothing & Respirators Against Biological Agents	**Description:** This interim statement of selection and use of protective clothing and respirators against biological agents is based on current understanding of the potential threats and existing recommendations issued for biological aerosols. The approach to any potentially hazardous atmosphere, including biological hazards, must be made with a plan that includes an assessment of hazard and exposure potential, respiratory protection needs, entry conditions, exit routes, and decontamination strategies [CDC 2010i]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) 6.3.2.　**Classification:** Operational guidelines
International Classification of Diseases	**Description:** The International Classification of Diseases (ICD) is designed to promote international comparability in the collection, processing, classification, and presentation of

	mortality statistics. This includes providing a format for reporting causes of death on the death certificate. The reported conditions are then translated into medical codes through use of the classification structure and the selection and modification rules contained in the applicable revision of the ICD, published by the World Health Organization. These coding rules improve the usefulness of mortality statistics by giving preference to certain categories, by consolidating conditions, and by systematically selecting a single cause of death from a reported sequence of conditions. The single selected cause for tabulation is called the underlying cause of death, and the other reported causes are the non-underlying causes of death. The combination of underlying and non-underlying causes is the multiple causes of death. The ICD has been revised periodically to incorporate changes in the medical field. To date, there have been 10 revisions of the ICD. [CDC 2010j]. **Standard Type:** ICD-10; ICD-10-CM (ICD-10 Clinical Modification) **Organization:** The National Center for Health Statistics (NCHS); Centers for Medicare and Medicaid Services **Classification:** Operational guidelines
Introductory Resource Guide for Implementing the Health Insurance Portability and Accountability Act (HIPAA) Security Rule	**Description:** A publication discusses security considerations and resources on security terms and concepts used and presented in the HIPAA security rule [NIST 2010a]. **Standard Type:** N/A **Organization:** National Institute of Standards and Technology (NIST) **Classification:** Operational guidelines
Maintenance, Testing, and Inspection Requirements for Hospital Emergency Power System	**Description:** A plan that identifies how a hospital maintains, tests, and inspects its emergency power system [JCAHOSTD 2010]. **Standard Type:** EC.7.40 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Managing Hazardous Material Incidents (MHMI)	**Description:** The MHMI series is a three volume set (with a video) comprised of recommendations for on-scene (pre-hospital), and hospital medical management of patients exposed during a hazardous materials incident [CDC 2010k]. **Standard Type:** N/A **Organization:** The Agency for Toxic Substances and Disease Registry (ATSDR) **Classification:** Operational guidelines
Mass Casualty Event Preparedness and Response	**Description:** This document provides information of preparedness and response for preparing for a terrorist bombing, after a terrorist bombing, coping with a traumatic event, emergency wound care, injuries, brain injuries, and burns, etc.

	[CDC 2010l]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Medical Management Guidelines for Unidentified Chemicals	**Description:** Basic victim management recommendations to follow when the chemical is not known [CDC 2010n]. **Standard Type:** N/A **Organization:** The Agency for Toxic Substances and Disease Registry (ATSDR) **Classification:** Operational guidelines
NIOSH Pocket Guide to Chemical Hazards (NPG)	**Description:** The NIOSH Pocket Guide to Chemical Hazards (NPG) is intended as a source of general industrial hygiene information on several hundred chemicals/classes for workers, employers, and occupational health professionals. The NPG does not contain an analysis of all pertinent data, rather it presents key information and data in abbreviated or tabular form for chemicals or substance groupings (e.g., cyanides, fluorides, manganese compounds) that are found in the work environment. The information found in the NPG should help users recognize and control occupational chemical hazards [CDC 2010m]. **Standard Type:** N/A **Organization:** The National Institute for Occupational Safety & Health (NIOSH) **Classification:** Operational guidelines
Patient Flow Management	**Description:** Plans that identify and mitigate impediments to efficient patient flow throughout the hospital [JCAHOSTD 2010]. **Standard Type:** LD.3.15 **Organization:** The Joint Commission Resources **Classification:** Operational guidelines
Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners	**Description:** This planners' guide presents an introduction to population monitoring in radiation emergencies for public health officials and emergency preparedness planners at the state and local levels. It describes how to plan for population monitoring and provides practical suggestions to address the many challenges it presents when a large population is potentially impacted. Population monitoring is the process of identifying, screening, and monitoring people for exposure to radiation or contamination from radioactive materials [CDC 2010o]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Preparing for a Terrorist Bombing:	**Description:** This document focuses on common sense

A Common Sense Approach	principles that will be useful in a bombing event [CDC 2010p]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Public Health Response to Biological & Chemical Terrorism: Interim Planning Guidance for State Public Health Officials	**Description:** This Planning Guidance is designed to help state public health officials determine the roles of their departments in response to biological and chemical terrorism and to understand the emergency response roles of local health departments and the emergency management system. The Planning Guidance also can be used to help state health departments coordinate their efforts with the many agencies and organizations at all levels of government that ultimately would respond to a biological or chemical terrorism event [CDC 2010q]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Recognition of Illness Associated with the Intentional Release of a Biologic Agent	**Description:** The guidance provides healthcare providers & public health personnel for recognizing illnesses or patterns of illness that might be associated with intentional release of biologic agents [CDC 2010r]. **Standard Type:** MMWR 2001 **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Roundtable on Population Monitoring Following a Nuclear/Radiological Incident	**Description:** Recommendations & comments from participants in CDC's roundtable (Jan. 11-12, 2005) on challenges associated with monitoring people affected by a nuclear or radiological incident [CDC 2010s]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Sheltering in Place during a Radiation Emergency	**Description:** A fact sheet, prepared by the Centers for Disease Control and Prevention, used during a radiation emergency to help protect individuals and family and to help prepare a safe and well-stocked shelter from exposure to radiation [CDC 2010t]. **Standard Type:** N/A **Organization:** The Centers for Disease Control and Prevention (CDC) **Classification:** Operational guidelines
Standard for Competence of	**Description:** The standard identifies the minimum levels of

Responders to Hazardous Materials/Weapons of Mass Destruction Incidents	competence required by responders to emergencies involving hazardous materials/weapons of mass destruction (WMD). It is based on the operational philosophies that emergency responders should be trained to perform their expected tasks, and that a responder cannot safely and effectively respond to a terrorism or criminal scenario involving hazmats/WMD if they don't first understand basic hazardous materials response [NFPA 2010]. **Standard Type:** NFPA 472-2008 **Organization:** The National Fire Protection Association (NFPA) **Classification:** Operational guidelines
Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents	**Description:** The standard includes qualifications for EMS responders to terrorism incidents that involve hazardous materials. It identifies the levels of competence required of emergency medical services (EMS) personnel who respond to hazardous materials incidents. It specifically covers the requirements for Basic Life Support (BLS) and Advanced Life Support (ALS) personnel in the pre-hospital setting [NFPA 2010]. **Standard Type:** NFPA 473-2008 **Organization:** The National Fire Protection Association (NFPA) **Classification:** Operational guidelines
Standard Guide for Assessing the Health Hazard of Pesticides to Applicators and Others with Potential Exposure	**Description:** This guide covers a stepwise process for using information concerning biological, chemical, physical, and toxicological properties of a pesticide or other chemical(s), or of a formulation to identify adverse effects that may occur to pesticide applicators or others with potential exposure [ASTM 2011]. **Standard Type:** E1429 – 91(2004) **Organization:** ASTM International **Classification:** Operational Guideline
Standard Guide for Hospital Preparedness and Response	**Description:** A guide intended to assist the leaders of hospitals in the design, planning, and response to be undertaken by hospitals and health care organizations to an event that necessitates the activation of an emergency operations plan [ASTM 2011]. **Standard Type:** ASTM E2413 – 04 (2009) **Organization:** ASTM International **Classification:** Operational guidelines
Standard Practice for Radiological Emergency Response	**Description:** This practice provides decision-making considerations for response to incidents that involve radioactive materials. It provides information and guidance for what to include in response planning, and what activities to conduct during a response. It should be used in emergency services

	response such as law enforcement, fire department, and emergency medical response actions. This practice assumes that implementation begins with the recognition of a radiological incident and ends when emergency response actions cease or the response is assumed by specialized regional, state, or federal response teams [ASTM 2011]. **Standard Type:** ASTM E2601-08 **Organization:** ASTM International **Classification:** Operational guidelines

6.3.3. Conceptual Modeling Standards

Standard Title	Overview
Discrete Event System Specification (DEVS)	**Description:** DEVS is a systems-theoretic approach to modeling. More specifically, it is state-centered formalism. A system consists of interconnected subsystems. A subsystem is a system. Leaf systems (atomic DEVSes) are state machines. DEVS can be viewed as a framework unifying a number of other formalisms in a consistent, systems theoretic, state centered fashion [DEVS 2011]. **Standard Type:** Specification **Organization:** Simulation Interoperability Standards Organization (SISO); Society for Modeling and Computer Simulation International (SCS) **Classification:** Domain-specific integration interface
Systems Modeling Language (SysML)	**Description:** SysML is a general purpose modeling language for systems engineering applications. It is a dialect of UML, the industry standard for modeling software-intensive systems. It supports the specification, analysis, design, verification and validation of a broad range of systems and systems-of-systems. These systems may include hardware, software, information, processes, personnel, and facilities [OMG 2011]. **Standard Type:** SysML 1.2 **Organization:** Object Management Group, Inc. (OMG) **Classification:** Document format
Unified Modeling Language (UML)	**Description:** A graphical language for visualizing, specifying, constructing and documenting the artifacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual things such as business processes and system functions, as well as concrete things such as programming language statements, database schemas, and reusable software components [ANSI 2011c]. **Standard Type:** UML 2.0, UML 2.1.1; UML 2.1.2; UML 2.2; UML 2.3; ISO/IEC 19501:2004 **Organization:** ISO; ANSI; Object Management Group, Inc. (OMG)

	Classification: Document format

6.3.4. Distributed Simulation Standards

Standard Title	Overview
Distributed Interactive Simulation	**Description:** Distributed Interactive Simulation (DIS) is a government/industry initiative to define an infrastructure for linking simulations of various types at multiple locations to create realistic, complex, virtual worlds for the simulation of highly interactive activities. A series of IEEE standards to support information exchange between simulation applications participating in the DIS environment are defined. IEEE Std 1278.1 defines the format and semantics of data messages, also known as Protocol Data Units (PDUs), that are exchanged between simulation applications and simulation management. IEEE Std 1278.2 defines the communication services required to support the message exchange described in IEEE Std 1278.1. IEEE 1278-3 provides guidelines for establishing a DIS exercise, managing the exercise, and providing proper feedback. IEEE 1278-4 establishes guidelines for the verification, validation, and accreditation (VV&A) of Distributed Interactive Simulation (DIS) exercises [IHS 2011a]. **Standard Type:** IEEE 1278-1993, IEEE 1278.1-1995, IEEE 1278.1A-1998, IEEE-1278.2-1995, IEEE 1278.3-1996, IEEE 1278.4-1997 **Organization:** IEEE; IHS, Inc. **Classification:** Domain-specific integration interface
Extensible Modeling and Simulation Framework (XMSF)	**Description:** The Extensible Modeling and Simulation Framework (XMSF) is defined as a set of Web-based technologies and services, applied within an extensible framework, that enables a new generation of modeling & simulation (M&S) applications to emerge, develop and interoperate [DODCCRP 2011]. XMSF provides a framework which allows both Department of Defense (DoD) and non-DoD Modeling and Simulation (M&S) projects to take advantage of Web-based technologies. **Standard Type:** XMSF 1.0 **Organization:** Naval Postgraduate School MOVES Institute; George Mason University NetLab; Science Applications International Corporation; Old Dominion University **Classification:** Domain-specific integration interface
High Level Architecture (HLA)	**Description:** This standard defines the HLA, its components, and the rules that outline the responsibilities of HLA federates and federations to ensure a consistent implementation [IEEE 2011c]. **Standard Type:** IEEE 1516-2000, IEEE 1516.1-2000, 1516.2-

| | 2000, ANSI/IEEE 1516.3-2003; IEEE 1516.4-2007
Organization: IEEE/Simulation Interoperability Standards Organization (SISO); ANSI
Classification: Domain-specific integration interface |

6.3.5. Selected Geographic Information System (GIS) Standards

Standard Title	Overview
CityGML – Exchange and Storage of Virtual 3D City Models	**Description:** A standard for the representation, storage, and exchange of virtual 3D city and landscape models. CityGML is implemented as an application schema of the Geography Markup Language version 3.1.1. It is based on a rich, general purpose information model in additional to geometry and appearance information. For specific domain areas, CityGML also provides an extension mechanism to enrich the data with identifiable features under preservation of semantic interoperability [OGC 2011a]. **Standard Type:** OGC 06-057r1; ISO TC211 **Organization:** Open Geospatial Consortium, Inc. (OGC) **Classification:** Domain-specific integration interface
American National Standard for Information Technology – Geographical Information Systems – Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE)	**Description:** This standard provides a means to model and categorize real-world geographic phenomena of interest to the Facilities, Infrastructure, and Environment (FIE) Domain(s) into a set of geographic data that can be represented in a spatial database and presented to a user in digital form. This SDSFIE standard is intended to provide the enterprise spatial database schema to support multiple FIE applications. This National Standard is applicable to the federal, state, county, and city agencies; private companies; and any other organizations that perform AM & FM functions for facilities and other types of infrastructure (such as roads, waterways, utility systems, etc,) and/or perform environmental compliance, restoration, and/or pollution prevention activities [ANSI 2011a]. **Standard Type:** ANSI INCITS 353-2006 **Organization:** American National Standards Institute (ANSI); International Committee for Information Technology Standards (INCITS) **Classification:** Domain-specific integration interface
Content Standard for Digital Geospatial Metadata (CSDGM)	**Description:** The standard is often referred to as the FGDC Metadata Standard. The objectives of the standard are to provide a common set of terminology and definitions for the documentation of digital geospatial data. The standard establishes the names of data elements and compound elements (groups of data elements) to be used for these purposes, the definitions of these compound elements and data elements, and information about the values that are to be provided for the data

	elements [FGDC 2011a]. **Standard Type:** FGDC-STD-001-1998; FGDC-STD-001.1-1999; FGDC-STD-001.2-2001 **Organization:** Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific integration interface
Content Standard for Digital Geospatial Metadata (CSDGM) – Extensions for Remote Sensing Metadata	**Description:** The standard of Extensions for Remote Sensing Metadata standard provides a common terminology and set of definitions for documenting geospatial data obtained from remote sensing, within the framework of the FGDC Content Standard for Digital Geospatial Metadata (CSDGM) standard. The extensions provide a means to use standard FGDC content to describe geospatial data derived from remote sensing measurements. This standard is intended to support the collection and processing of geospatial metadata for data derived from remote sensing. It is intended to be used by all levels of government and the private sector [FGDC 2011b]. **Standard Type:** FGDC-STD-012-2002 **Organization:** The Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific integration interface
GeoAPI SWG Standard	**Description:** The GeoAPI Standard Working Group (SWG) aims to create the GeoAPI 3.0 Standard, which will define a set of Java language interfaces along with an associated test suite, to provide a standardized, programming language level realization of some core Open Geospatial Consortium (OGC) specifications. These interfaces will facilitate the creation of accurate, coherent, interoperable, and verifiable implementations of those OGC standards [GEOAPI 2011]. **Standard Type:** OGC GeoAPI 3.0 SWG **Organization:** OGC **Classification:** Domain-specific integration interface
Geographic Information – Encoding	**Description:** The standard specifies the requirements for defining encoding rules to be used for interchange of geographic data within the ISO 19100 series of International Standards [ISO 2011b]. **Standard Type:** ISO 19118:2005 **Organization:** ISO **Classification:** Domain-specific integration interface
Geographic Information – Location-Based services – Multimodal Routing and Navigation	**Description:** The standard specifies the data types and their associated operations for the implementation of multimodal location-based services for routing and navigation. It is designed to specify web services that may be made available to wireless devices through web-resident proxy applications, but is not limited to that environment [ISO 2011b]. **Standard Type:** ISO 19134:2007 **Organization:** ISO

	Classification: Domain-specific integration interface
Geographic Information – Location-based Services – Tracking and Navigation	**Description:** ISO 19133:2005 describes the data types, and operations associated with those types, for the implementation of tracking and navigation services. It is designed to specify web services that can be made available to wireless devices through web-resident proxy applications, but is not restricted to that environment [ISO 2011b]. **Standard Type:** ISO 19133:2005 **Organization:** ISO **Classification:** Domain-specific integration interface
Geographic Information – Portrayal	**Description:** The standard defines a schema describing the portrayal of geographic information in a form understandable by humans. It includes the methodology for describing symbols and mapping of the schema to an application schema. It does not include standardization of cartographic symbols, and their geometric and functional description [ISO 2011b]. **Standard Type:** ISO 19117:2005 **Organization:** ISO **Classification:** Domain-specific integration interface
Geographic Information – Procedures for Item Registration	**Description:** ISO 19135:2005 specifies procedures to be followed in establishing, maintaining and publishing registers of unique, unambiguous and permanent identifiers, and meanings that are assigned to items of geographic information. In order to accomplish this purpose, ISO 19135:2005 specifies elements of information that are necessary to provide identification and meaning to the registered items and to manage the registration of these items [ISO 2011b]. **Standard Type:** INCITS/ISO/IEC 19135-2005 **Organization:** ISO; International Committee for Information Technology Standards (INCITS); International Electrotechnical Commission (IEC) **Classification:** Domain-specific integration interface
Geographic Information – Schema for Moving Features	**Description:** The standard defines a method to describe the geometry of a feature that moves as a rigid body [ISO 2011b]. **Standard Type:** ISO 19141:2008 **Organization:** ISO **Classification:** Domain-specific integration interface
Geographic Information – Services	**Description:** ISO 19119:2005 identifies and defines the architecture patterns for service interfaces used for geographic information, defines its relationship to the Open Systems Environment model, presents a geographic services taxonomy and a list of example geographic services placed in the services taxonomy. It also prescribes how to create a platform-neutral service specification, how to derive conformant platform-specific service specifications, and provides guidelines for the

	selection and specification of geographic services from both platform-neutral and platform-specific perspectives [ISO 2011b]. **Standard Type:** INCITS/ISO 19119-2005 **Organization:** ISO; International Committee for Information Technology Standards (INCITS) **Classification:** Domain-specific integration interface
Geographic Information – Simple Feature Access	**Description:** ISO 19125-1:2004 establishes a common architecture for geographic information and defines terms to use within the architecture. It also standardizes names and geometric definitions for Types for Geometry. INCITS/ISO 19125-2-2004 specifies an Structured Query Language (SQL) schema that supports storage, retrieval, query and update of simple geospatial feature collections via the SQL Call Level Interface (SQL/CLI) and establishes an architecture for the implementation of feature tables. INCITS/ISO 19125-2-2004 defines terms to use within the architecture of geographic information and defines a simple feature profile of ISO 19107. In addition, this part of ISO 19125:2004 describes a set of SQL Geometry Types together with SQL functions on those types. The Geometry Types and Functions described represent a profile of ISO 13249-3. INCITS/ISO 19125-2-2004 standardizes the names and geometric definitions of the SQL Types for Geometry and the names, signatures and geometric definitions of the SQL Functions for Geometry [ISO 2011b]. **Standard Type :** INCITS/ISO 19125-1-2004 ; INCITS/ISO 19125-2-2004 **Organization:** ISO; International Committee for Information Technology Standards (INCITS) **Classification:** Domain-specific integration interface
Geographic Information Framework Data Standard	**Description:** The standard establishes common data requirements for the exchange of National Spatial Data Infrastructure (NSDI) framework data [FGDC 2011c]. **Standard Type:** FGDC-STD-014.0-2008; FGDC-STD-014.1-2008; FGDC-STD-014.2-2008; FGDC-STD-014.3-2008; FGDC-STD-014.4-2008; FGDC-STD-014.5-2008; FGDC-STD-014.6-2008; FGDC-STD-014.7-2008; FGDC-STD-014.7b-2008; FGDC-STD-014.7c-2008; FGDC-STD-014.7d-2008; FGDC-STD-014.7e-2008 **Organization:** Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific integration interface
GeoTIFF	**Description:** GeoTIFF is a metadata format, which provides geographic information to associate with the image data. GeoTIFF implements the geographic metadata formally, using compliant Tagged Image File (TIFF 6.0) tags and structures. "GeoTIFF" refers to TIFF files, which have geographic (or cartographic) data embedded as tags within the TIFF file. The geographic data can then be used to position the image in the

	correct location and geometry on the screen of a geographic information display [GEOTIFF 2011]. **Standard Type:** GeoTIFF/Revision 1.0 **Organization:** geotiff.osgeo.org **Classification :** Document format
Governmental Unit and Other Geographic Area Boundaries	**Description:** A specification for establishing of content requirements for the collection and interchange of Government units and legal entity boundary data and for facilitating the maintenance and use of that information [FGDC 2010]. **Standard Type:** FGDC-STD-014.5-2008 **Organization:** Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific Integration Interfaces
GRIdded Binary (GRIB)	**Description:** Format specifications for representing meteorological, gridded-point data [WMO 2010a]. **Standard Type:** FM 92-IX Ext. GRIB; FM 92-VIII EXT. GRIB **Organization:** World Meteorological Organization (WMO) **Classification:** Domain-specific Integration Interfaces
Homeland Security Mapping Standard – Point Symbology for Emergency Management	**Description:** The primary purpose of this standard is to establish a common set of symbols for use by mapmakers in support of emergency managers and first responders. It will allow users to rapidly interpret map data and to be able to disseminate consistent, usable information. This American National Standard is applicable to all organizations that create maps or otherwise display features for the Emergency Management or First Responder communities. It is limited at this time to support portrayal of point features that relate to the emergency management and hazard mapping disciplines [ANSI 2011b]. **Standard Type:** ANSI INCITS 415-2006 **Organization:** American National Standards Institute (ANSI); International Committee for Information Technology Standards (INCITS) **Classification:** Domain-specific integration interface
OpenGIS Implementation Specification for Geographic Information – Simple Feature Access	**Description:** The OpenGIS Simple Features Interface Standard (SFS) provides a well-defined and common way for applications to store and access feature data in relational or object-relational databases, so that the data can be used to support other applications through a common feature model, data store, and information access interface. OpenGIS Simple Features are geospatial features described using vector data elements such as points, lines, and polygons [OGC 2011c]. **Standard Type:** OGC 06-103r4 Version 1.2.1, OGC 05-126 **Organization:** Open Geospatial Consortium, Inc (OGC) **Classification:** Domain-specific integration interface
Spatial Data Transfer Standard	**Description:** The Spatial Data Transfer Standard (SDTS) base

Standard Title	Overview
(SDTS)	specification (Parts 1, 2, and 3) describes the underlying conceptual model and the detailed specifications for the content, structure, and format for exchange of spatial data. Additional parts (4, 5, 6, and potentially others) are added as profiles, each of which defines specific rules and formats for applying SDTS for the exchange of particular types of data [FGDC 2011d] **Standard Type:** FGDC-STD-002.1; FGDC-STD-002.5; FGDC-STD-002.6; FGDC-STD-002.7-2000 **Organization:** Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific integration interface
Standard for a U.S. National Grid (USNG)	**Description:** A standard is used to define the U.S. National Grid and supports Universal Transverse Mercator (UTM) coordinates, Military Grid Reference System (MGRS) grids, and the specific grid presentation requirements. It is used for acquisition/production of printed map and acquisition of location service appliances with printed map products [FGDC 2011e] **Standard Type:** FGDC-STD-011-2001 **Organization:** Federal Geographic Data Committee (FGDC) **Classification:** Domain-specific integration interface

6.3.6.   Selected Communication Standards

Standard Title	Overview
Common Alerting Protocol (CAP)	**Description:** The Common Alerting Protocol (CAP) is a simple, flexible data interchange format for collecting and distributing "all-hazard" safety notifications and emergency warnings over information networks and public alerting systems. In Web-services applications, CAP provides a lightweight standard for exchanging urgent notifications. CAP can also be used in data-broadcast applications and over legacy data networks. CAP is fully compatible with the existing national broadcast Emergency Alert System (EAS) [OASIS 2011a]. It is an XML-related data interchange standard for alerting and event notification applications. The standard supports two functions: a standalone protocol and a payload for Emergency Data Exchange Language (EDXL) messages. **Standard Type:** CAP-V1.1 **Organization:** Organization for the Advancement of Structured Information Standards (OASIS) **Classification:** Domain-specific integration interface
Common Incident Management Message Sets for use by Emergency Management Centers	**Description:** This standard is the Base Standard for a family of related standards that address the intercommunication needs of emergency management centers and other types of centers engaged in transportation incident management [IEEE 2010]. **Standard Type:** IEEE 1512-2000, IEEE 1512.1, IEEE 1512.2,

	IEEE 1512.3 **Organization:** Institute of Electrical and Electronics Engineers (IEEE) **Classification:** Document Format
Emergency Data Exchange Language (EDXL)	**Description:** Several organizations are collaborating on the design and development of a suite of specifications under the name "Emergency Data Exchange Language (EDXL)" [OASIS 2011b]. EDXL is an integrated framework for a wide range of emergency data exchange standards to support operations, logistics, planning, and finance. **Standard Type:** EXDL Distribution Element, V. 1.0 (EDXL-DE-V1.0); EDXL Resource Message Specification 1.0 Working Draft Version 26 (EDXL-RM 1.0 v0026); EDXL Hospital Availability Exchange v1.0 Public Review Draft 02 (EDXL-HAVE-1.0-spec-pr02) **Organization:** Organization for the Advancement of Structured Information Standards (OASIS); Department of Homeland Security (DHS); Emergency Interoperability Consortium (EIC) **Classification:** Domain-specific integration interface
National Information Exchange Model (NIEM)	**Description:** NIEM is designed to develop, disseminate, and support enterprise-wide information exchange standards and processes that can enable jurisdictions to effectively share critical information in emergency situations, as well as support the day-to-day operations of agencies throughout the nation [NIEM 2011]. **Organization:** A partnership of the U.S. Department of Justice, the U.S. Department of Homeland Security, and the U.S. Department of Health and Human Services. **Classification:** Domain-specific integration interface

6.4. Data Sources

This section identifies databases and other sources of data that may be used to develop or run healthcare models and simulations. The name of data source, a brief description of its contents, its access location, responsible organization, data formats used, as well as classification of the type of data is given below.

Data Source Title	Overview
Ambulatory Health Care Data	**Description:** The National Ambulatory Medical Care Survey (NAMCS) is a national survey designed to meet the need for objective, reliable information about the provision and use of ambulatory medical care services in the United States. Findings are based on a sample of visits to non-federal employed office-based physicians who are primarily engaged in direct patient care. The National Hospital Ambulatory Medical Care Survey (NHAMCS) is designed to collect data on the utilization and provision of ambulatory care services in hospital emergency and

	outpatient departments. Findings are based on a national sample of visits to the emergency departments and outpatient departments of non-institutional general and short-stay hospitals [CDC 2010y]. **Data Source:** NAMCS/NHAMCS **Organization:** National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) **Format:** Report **Classification:** Demographic and Behavior, Resources
American Hospital Association (AHA) Database	**Description:** American Hospital Association (AHA) Database contains data for every hospital in the U.S. The data is collected from AHA annually survey. Non-responding hospital data are estimated using advanced methods to approximate specific data elements. Multiple data sets power this database, including the latest edition of the AHA Annual Survey of Hospitals, primary research into the organizational structures of Systems and Networks conducted by Health Forum, and information from Health Forum subscriber lists [AHADATA 2010a]. **Data Source:** American Hospital Association (AHA) Database. Five tools are provided: Hospital Statistics Wizard; Hospital Market Analysis Wizard; Health Care Systems and Networks Wizard; Hospital Detail Report Wizard; Mailing List Wizard **Organization:** American Hospital Association (AHA) **Format Used:** PDF, Excel table, Chart **Classification:** Resources, Demographic and Behavior
American Housing Survey (AHS)	**Description:** The American Housing Survey (AHS) collects data on the Nation's housing, including apartments, single-family homes, mobile homes, vacant housing units, household characteristics, income, housing and neighborhood quality, housing costs, equipment and fuels, size of housing unit, and recent movers. National data are collected in odd numbered years, and data for each of 47 selected Metropolitan Areas are collected currently about every six years. The national sample covers an average 55,000 housing units. Each metropolitan area sample covers 4,100 or more housing units. The Data Access includes three categories: National Data, Metropolitan Data, and Dates metropolitan Areas are Survey [CENSUS 2010]. **Data Source:** AHS Data Access **Organization:** U.S. Census Bureau (USCS) **Format Used:** Excel; PDF **Classification:** Demographic and Behavioral
Behavioral Risk Factor Surveillance System (BRFSS)	**Description:** The Behavioral Risk Factor Surveillance System (BRFSS) is a state-based system of health surveys that collects information on health risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury. For many states, the BRFSS is the only available source of timely, accurate data on health-related behaviors [CDC 2010u]. **Data Source:** BRFSS Maps, BRFSS GIS Data, BRFSS Datasets

	Organization: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion/Division of Adult and Community Health **Format:** SHP, RTF, SAS, XPT, PDF, TXT, CSV, SAS7BCAT, SAS7BDAT, ZIP **Classification:** Demographic and Behavior, Controlling Documents, Incidents
CDC Wide-ranging Online Data for Epidemiologic Research (WONDER)	**Description:** The Centers for Disease Control and Prevention (CDC) WONDER – Wide-ranging Online Data for Epidemiologic Research – is an integrated information and communication system for public health. It speeds and simplifies access to public health information for state and local health departments, the public health service, and the academic public health community. CDC WONDER allows accessing statistical research data and reports published by CDC and querying numeric data sets on CDC's computers [CDC 2010w]. **Data Source:** WONDER Online Databases **Organization:** The Centers for Disease Control and Prevention (CDC) **Format:** HTML, chart and map images (bitmaps), ASCII, spreadsheet **Classification:** Resources, Controlling Documents, Demographic and Behavioral
CDC.gov Widgets and Gadgets	**Description:** CDC.gov provides content in several useful ways, via our e-mail updates, podcasts and RSS feeds. Our newest features are the Flu Updates, Emergency Text Messages and the CDC Data and Statistics Widget. Widgets are online applications built by one Web site that can be displayed onto another Web site. A widget is a CDC.gov application that displays the featured content directly on your web page. You can embed content in personalized home pages, blogs, and other sites. Once you've added the widget, there's no technical maintenance. CDC.gov will update the content automatically. Available widgets include Adult BMI Calculator, H1N1 (Swine Flu), Fraudulent H1N1 Products, H1N1 School Guidance, Pet Health and Safety, Public Health Image Library Image of the Day, Five Minutes or Less for Health, Smoking and Tobacco Use, Flu IQ, Seasonal Flu Updates, National Environmental Public Health Tracking Program, CDC Text Messages, etc. [CDC 2010v]. **Data Source:** CDC.gov **Organization:** Centers for Disease Control and Prevention **Format:** TXT, RSS **Classification:** Incidents, Demographic and Behavior, Environment, Controlling Document
Clinical Data Repository (CDR)	**Description:** The Clinical Center installed a hospital-wide, real-time computerized medical information system (MIS) in 1976. This system supports the Clinical Center's dual responsibilities of providing quality patient care and collecting research data. The

	Clinical Data Repository (CDR) is a new facility that will house all electronic data collected at the clinical center from the time MIS was installed (1975) until today. The CDR will be continually updated with current data and will be the single place to find information for clinical, research, and administrative use [NIH 2010a]. **Data Source:** CDR Version 1.4, CCMIS (Mac/MIS, Web/MIS 3.0) **Organization:** National Institute of health (NIH) **Format:** Clinical Data Repository (CDR) **Classification:** Demographic and Behavior
Directory of Information Resources Online (DIRLINE)	**Description:** DIRLINE (Directory of Information Resources Online) is the National Library of Medicine's online database containing location and descriptive information about a wide variety of information resources including organizations, research resources, projects, and databases concerned with health and biomedicine. DIRLINE contains over 8,500 records and focuses primarily on health and biomedicine, although it also provides limited coverage of some other special interests. These information resources fall into many categories including federal, state, and local government agencies; information and referral centers; professional societies; self-help groups and voluntary associations; academic and research institutions and their programs; information systems and research facilities. Topics include HIV/AIDS, maternal and child health, most diseases and conditions including genetic and other rare diseases, health services research and technology assessment. Each record may contain information on the publications, holdings, and services provided [NIH 2010b]. **Data Source:** DIRLINE **Organization:** The National Library of Medicine (NLM) **Format:** Report **Classification:** Resources, Controlling Documents
Drug Information Portal	**Description:** The Drug Information Portal, a free web resource, provides an informative, user–friendly portal to current drug information for over 15,000 drugs. Links to sources span the breadth of the National Library of Medicine (NLM), the National Institutes of Health (NIH) and other government agencies. Current information regarding consumer health, clinical trials, AIDS–related drug information, MeSH pharmacological actions, PubMed biomedical literature, and physical properties and structure can be retrieved by searching on a drug name. A varied selection of focused topics in medicine and drug–related information is also available from displayed subject headings [NIH 2010c]. **Data Source:** Drug Information Portal **Organization:** The National Library of Medicine (NLM) **Format:** Report **Classification:** Resources, Controlling Document

FedStats	**Description:** FedStats provides access to the full range of official statistical information produced by the Federal Government without having to know in advance which Federal agency produces which particular statistic. With convenient searching and linking capabilities to more than 100 agencies that provide data and trend information on such topics as economic and population trends, crime, education, health care, aviation safety, energy use, and farm production [FEDSTATS 2010]. **Data Source:** www.fedstats.gov **Organization:** The Federal Interagency Council on Statistical Policy **Format:** HTML, spreadsheets **Classification:** Resources, Demographic and Behavior, Environment, Controlling Documents
Haz-Map	**Description:** Haz-Map is an occupational health database designed for health and safety professionals and for consumers seeking information about the health effects of exposure to chemicals and biological agents at work. Haz-Map links jobs and hazardous tasks with occupational diseases and their symptoms. It is one of the products and services made available by the National Library of Medicine's (NLM) Toxicology and Environmental Health Information Program. Haz-Map includes three categories: hazardous agents, occupational diseases, and high risk jobs [NIH 2010d]. **Data Source:** Haz-Map **Organization:** The National Library of Medicine (NLM) **Format:** Report **Classification:** Demographic and Behavior, Environment, Controlling Documents
Healthcare Cost and Utilization Project (HCUP) Databases	**Description:** Healthcare Cost and Utilization Project (HCUP) databases bring together the data collection efforts of State data organizations, hospital associations, private data organizations, and the Federal government to create a national information resource of patient-level health care data (HCUP Partners). HCUP includes the largest collection of longitudinal hospital care data in the United States, with all-payer, encounter-level information beginning in 1988. These databases enable research on a broad range of health policy issues, including cost and quality of health services, medical practice patterns, access to health care programs, and outcomes of treatments at the national, State, and local market levels [AHRQ 2010b]. **Data Source:** Nationwide Inpatient Sample (NIS), Kids' Inpatient Database (KID) , Nationwide Emergency Department Sample (NEDS), State Inpatient Databases (SID), State Ambulatory Surgery Databases (SASD), and State Emergency Department Databases (SEDD) **Organization:** The Agency for Healthcare Research and Quality (AHRQ)

	Format: PDF, HTML **Classification:** Demographic and Behavior, Resources, Controlling Documents
Healthy People 2010 Database	**Description:** DATA2010 is an information system developed by staff of the division of Health Promotion Statistics of the National Center for Health Statistics, CDC, and contains the most recent monitoring data for tracking Healthy People 2010. With this system, world-wide users have the ability to view the data collected to track Healthy People 2010 objectives, with national baseline and monitoring data for each Healthy People 2010 objective. Users can select data options to create and browse real-time tables and graphs of the baseline and tracking year data for all 28 health focus areas, as well as the leading health indicators. This interactive system allows users to query an updated database and construct tables. Tables can be constructed for specific objectives, or objectives identified by focus areas, data source, or by select population [CDC 2010x]. **Data Source:** DATA2010 **Organization:** National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) **Format:** Table and Graph **Classification:** Controlling Documents, Demographic and Behavior
Hospital Compare	**Description:** Hospital Compare is used to find information on how well hospitals care for patients with certain medical conditions or surgical procedures, and results from a survey of patients about the quality of care they receives during a recent hospital stay. The data provided includes process of care, mortality, and readmission quality measures. The collection period for the measures is generally 12 months. However, some measures may be based upon fewer than 12 months. Generally, the Hospital Compare quality measures are refreshed the third month of each quarter [CMS 2010]. **Data Source:** Medicare Hospital Compare **Organization:** Centers for Medicare and Medicaid Services (CMS) of Department of Health and Human Services, Hospital Quality Alliance **Format:** CSV, dbf **Classification:** Resources, Controlling Documents
Hospital Electronic Health Records (HER) Adoption Database	**Description:** The Hospital HER Adoption Database 2010 is based on a survey of U.S. hospitals tracking the adoption of electronic health records (HER), also known as electronic medical records (EMR). The data included are hospital specific. The database is used to determine where hospitals are along the technology adoption curve regarding electronic clinical documentation, results viewing, computerized provider order entry, decision support, and bar coding; find out where these functions are implemented in the hospital: emergency

	department, ICU, general medical/surgical, specialty, onsite ambulatory practices, and offsite ambulatory practices; and understand the capabilities of hospital's electronic systems [AHADATA 2010b]. **Data Source:** Database **Organization:** American Hospital Association (AHA) **Format:** PDF, Microsoft Excel file **Classification:** Demographic and Behavior, Resources, Controlling Documents
National Emergency Medical Services (EMS) Information System (NEMSIS)	**Description:** The Hazardous Substances Emergency Events Surveillance (HSEES) system was established to collect and analyze information about acute releases of hazardous substances and threatened releases that result in a public health action such as an evacuation. The goal of HSEES is to reduce the morbidity (injury) and mortality (death) that result from hazardous substances events, which are experienced by first responders, employees, and the general public. The HSEES system data and prevention outreach are critical for identifying, preventing, and mitigating the consequences of terrorist threats against our chemical infrastructure. Fourteen state health departments currently have cooperative agreements with ATSDR to participate in HSEES: Colorado, Florida, Iowa, Louisiana, Michigan, Minnesota, New Jersey, New York, North Carolina, Oregon, Texas, Utah, Washington, and Wisconsin [NEMSIS 2010]. **Data Source:** NEMSIS NHTSA Dataset Version 3 **Organization:** National Highway Traffic Safety Administration (NHTSA); Health Resources and Services Administration (HRSA); CDC; University of Utah; University of North Carolina **Format Used:** XSD **Classification:** Demographic and Behavioral
National Incident Management System – Incident Resource Inventory System (NIMS-IRIS)	**Description:** National Incident Management System – Incident Resource Inventory System (NIMS-IRIS) is a database management tool that allows emergency responders to enter typed resources and select specific resources for mutual aid purposes based upon mission requirements, capability of resources, and response time. NIMS-IRIS tracks equipment, communications, contracts, facilities, responders, services, supplies, and teams [FEMA 2010]. **Data Source:** NIMS-IRIS Version 2.2 **Organization:** Federal Emergency Management Agency (FEMA) **Format:** EDXL **Classification:** Resources
Rand Public Health Preparedness Database	**Description:** The Rand Corporation database, funded by the U.S. Department of Health and Human Services, provides access to numerous public health preparedness exercises. It is primarily intended for state and local public health officials. The database

	provides a list of possible exercises performed along with criteria rating the success of each exercise. There are fourteen design criteria used to rate each exercise. These criteria are: 1) clearly stated goals; 2) clearly stated objectives; 3) the objectives are appropriate given the goals; 4) each objective is addressed during the exercise; 5) objectives are measurable; 6) the scenario is appropriate given the goals and objectives; 7) the scenario is internally consistent; 8) scenario is "a realistic depiction of the capabilities and resources likely to be available to a participating health jurisdiction;" 9) clear guidance about participants; 10) all participants are engaged; 11) exercise can be replicated; 12) results in action items; 13) feedback is solicited from participants; 14) can be completed within the given timeframe. The goal of this database is "to identify the best exercises to help local and state public health departments prepare for public health emergencies." [RAND 2010] **Data Source:** Rand Public Health Preparedness Exercise Database **Organization:** RAND Corporation, Department of Health and Human Services (HHS) **Format:** **Classification:** Training, Resources
Risk Group Database for Risk Group Classification for Infectious Agents	**Description:** In many countries, including the United States, infectious agents are categorized in risk groups based on their relative risk. Depending on the country and/or organization, this classification system might take the following factors into consideration: pathogenicity of the organism, mode of transmission and host range, availability of effective preventive measures (e.g., vaccines), availability of effective treatment (e.g., antibiotics), and other factors. The Risk group classifications used in the Risk Group Database are primarily used in the research environment as part of a comprehensive bio-safety risk assessment. The Risk Group database provides four search engines: search bacteria, search virus, search fungi, and search parasites [ABSA 2010]. **Data Source:** ABSA Risk Group Database **Organization:** American Biological Safety Association (ABSA) **Format:** **Classification:** Controlling Documents, Demographic and Behavior
The Emergency Response Safety and Health Database	**Description:** The Emergency Response Safety and Health Database is a rapidly accessible occupational safety and health database developed by NIOSH for the emergency response community. The ERSH-DB contains accurate and concise information on high-priority chemical, biological and radiological agents that could be encountered by personnel responding to a terrorist event. The information contained in the ERSH-DB represents a compilation of material from a diverse array of sources, and is intended to address the safety and health

	information needs of a wide range of emergency response personnel, including, but not limited to, the fields of fire and rescue, emergency medicine, law enforcement, emergency management, public health, safety and health, and mortuary and funeral. As a central source of information, the ERSH-DB allows diverse segments of the emergency response community to share a wealth of information that is not readily accessible and to avoid duplication of effort [CDC 2010aa]. **Data Source:** ERSH-DB **Organization:** The Centers for Disease Control and Prevention (CDC); The National Institute of Occupational Safety & Health (NIOSH) **Format Used:** text, table **Classification:** Controlling Documents
TheDataWeb Browser	**Description:** TheDataWeb is a network of online data libraries that the DataFerrett accesses the data through. DataFerrett is a unique data analysis and extraction tool—with recoding capabilities—to customize federal, state, and local data to suit the user's requirements. (FERRETT stands for Federated Electronic Research, Review, Extraction, and Tabulation Tool.) Data topics of TheDataWeb include census data, economic data, health data, income and unemployment data, population data, labor data, cancer data, crime and transportation data, family dynamics, vital statistics data, etc. [THEDATAWEB 2010] **Data Source:** BetaDataFerrett **Organization:** U.S. Census Bureau **Format:** XML/CAP 1.1, ATOM, RSS **Classification:** Controlling Documents, Demographic and Behavior, Resources
TOXicology Data NETwork (TOXNET)	**Description:** TOXNET (TOXicology Data NETwork) is a cluster of databases covering toxicology, hazardous chemicals, environmental health and related areas. It is managed by the Toxicology and Environmental Health Information Program (TEHIP) in the Division of Specialized Information Services (SIS) of the National Library of Medicine (NLM). Toxicology databases include Hazardous Substances Data Bank (HSDB), Integrated Risk Information System (IRIS), International Toxicity Estimates for Risk (ITER), Chemical Carcinogenesis Research Information System (CCRIS), Genetic Toxicology (GENE-TOX), Toxicology interactive guide (Tox Town), Household Products Database, Occupational Toxicology Database (Haz-Map), toxic chemicals released on map (TOXMAP), Drugs and Lactation (LacMed), and Carcinogenic Potency Database (CPDB) [NIH 2010e]. **Data Source:** TOXNET **Organization:** The National Library of Medicine (NLM) **Format:** Report, XML **Classification:** Controlling Documents, Demographic and Behavior, Environment

Weapons of Mass Destruction (WMD), Emergency Management and Medical Websites	**Description:** A comprehensive list of internet sites of use for emergency planning and in particular Weapons of Mass Destruction (WMD) and medical emergency planning [YNHHS 2010]. **Data Source:** Yale New Haven Center for Emergency Preparedness and Disaster Response Yale New Haven Health System **Organization:** Yale New Haven Health System **Format Used:** N/A **Classification:** Controlling Documents
Web-based Injury Statistics Query and Reporting System (WISQARS)	**Description:** The Web-based Injury Statistics Query and Reporting System (WISQARS) is an interactive database system that provides customized reports of injury-related data. The database includes fatal injury data (from the National Vital Statistics System), nonfatal injury data (from the National Electronic Injury Surveillance System), and violent deaths (from the National Violent Death Reporting System (NVDRS) [CDC 2010z]. **Data Source:** WISQARS **Organization:** Centers for Disease Control and Prevention (CDC) **Format:** CSV **Classification:** Incidents

7. Discussions and Recommendations

This section is intended to capture practices and issues relevant to program sponsors, project managers, researchers, developers, and implementers of M&S of healthcare systems for homeland security applications. The resources presented in section 6 and research, development and implementation experiences are used to identify the best practices to be followed for future efforts and to provide uncertainties, cautions and warnings for use of such applications. Further, the resources in section 6 are compared with the information in sections 4 and 5 to identify the unmet needs and requirements. These unmet needs and requirements are used to identify and prioritize the research, development, standards, and implementation issues that should be addressed going forward. This section hence provides a summary of discussion topics and recommendations that are divided into three major areas:

- Identification of best practices (Section 7.1)
- Uncertainties, cautions and warnings regarding expectations of these models and simulations (Section 7.2)
- Research, development, standards and implementation issues that may need to be addressed by the research community, program sponsors, and stakeholders to improve the quality and utility of incident management models and simulations (Section 7.3)

7.1.   Best Practices

Best practices are really only effective if a methodology is well defined for a given problem solving approach. For example, the LUMAS model shows how learning influences a documented methodology, and the link between L and M in the LUMAS model is where best practice is encountered by the user of a methodology. Computer models and simulations are tools in a variety of problem solving methodologies such as operations research, systems engineering, and management science, where methodology is defined as a collection of related processes, methods, and tools. Methodologies evolve as they are used by practitioners to address new problems and as new technologies and tools are developed to support them. Methodological advances are encouraged by documenting existing methods, processes and tools and by updating these periodically based on lessons learned and best practice from practical experience. This section will identify recommended approaches and best practices for solving different types of hazardous material release modeling problems.

A variety of M&S approaches, methodologies, and tools are currently available. Some are more suitable to solving certain classes of problems than others. This section will identify recommended approaches and best practices for solving different types of healthcare modeling problems.

- *Provide tools that can be used at the local level for healthcare systems analysis, evaluation, or training purposes*
- *Use various test and validation methods*
- *Provide tools that do not require sophisticated and expensive system support*
- *Provide distributed web-based tools that allow health care organizations to develop and run custom exercises.*

7.2.   Uncertainties, Cautions and Warnings

This sub-section is intended to highlight and document the limitations associated with M&S applications to minimize improper use and highlight potential areas for further development. M&S application requires significant effort and hence they should be utilized only when appropriate, i.e., they should be considered for complex problems that cannot be addressed using other analytical options. The level of detail and specificity achieved by using the most sophisticated models and simulations may not be practical or necessary for all assets, systems, or networks. In these circumstances, a simplified dependency and interdependency analysis based on expert judgment may provide sufficient insight to make informed risk management decisions in a timely manner [DHS 2009].

For applications that are identified as suitable for M&S applications, it should be recognized that models provide results with varying levels of error and uncertainty. Analysts should ensure that decision-makers understand the uncertainties in M&S results and other limitations such as the ones listed below. Models provide results with varying levels of error and uncertainty. This sub-section is intended to highlight and document the limitations associated with M&S applications to minimize improper use and highlight potential areas for further development.

- *Epidemic models are particularly susceptible to variations in predicted results due to difficulties in precisely modeling human behaviors and random occurrences of transmission of diseases.*
- *Training exercises may not create the stress conditions and state of mind in the healthcare systems personnel that would occur during a real incident or epidemic.*
- *Data inconsistencies between simulated exercises and real incidents may affect the results and perceptions.*
- *Communication difficulties and incompatibilities between systems may not be accurately reflected in training exercises.*

7.3.   Research, Development, Standards, and Implementation Issues

A number of research, development, standards, and implementation issues remain to be addressed. An initial straw man list follows:

- *Identification of appropriate models, simulations, tools, and databases to address healthcare system analysis and training needs*
- *Increasing reality in healthcare M&S training exercises and devices*
- *Identification of common models, simulations, tools, and databases that can be shared by the user community*
- *Identification of technical gaps and needs for models, simulations, tools, and databases*
- *Development of system requirements specifications for healthcare models, simulations, tools, and databases*
- *Development of systems dynamics models for addressing strategic issues for different healthcare systems and incident scenarios*
- *Development of mechanisms to enable access to and usage of healthcare M&S applications by the healthcare providers, partners, and emergency response personnel*
- *Development of simulation application architectures to enable module integration and standard data interfaces to import data from external databases*
- *Use of a system-of-systems engineering approach to the development of applications*
- *Use of UML/SysML in specification of healthcare systems and M&S applications*
- *Development of M&S applications as open systems*
- *Use of object-oriented models in healthcare M&S*
- *Integration of healthcare models and simulations*
- *Establishment of security and protection mechanisms for sensitive data*
- *Ownership and usage of publicly vs. privately developed models, simulations, tools, and databases*
- *Return on investment to stakeholders and sponsors for research projects*

8. Conclusion

This initial version of the document is the starting point of an effort to capture the current knowledge relevant to M&S of healthcare for homeland security applications. It identifies the needs, translates them into requirements and provides summary information on resources available to meet the needs and requirements. The information on needs, requirements, and resources is used together with research, development, and implementation experiences to distill practices and issues for future efforts.

This version will be used to facilitate input from domain experts in a workshop setting. It is hoped that the next version updated with such input will provide value as a reference for program managers, project managers, researchers, developers, and implementers of M&S for healthcare for homeland security applications. Use of the updated document as a common reference may help increase the awareness across the associated communities and help enhance collaborative efforts for homeland security applications of M&S for healthcare.

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