S&T Stakeholders Conference

Modeling and Simulation (M&S) Guidelines

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PARTNERING FOR A SAFER NATION

Abstract

M&S is an important tool for operations analysis, experimentation, system acquisition, and training. This tutorial outlines guidance for **program managers, M&S developers, and decision makers** on the judicious use of M&S, which incorporates guidelines from reference material and standards, policies, processes, and “best practice” developed in Federal departments, agencies, and entities. Focus areas include **examples of departmental M&S capabilities** and **approaches to M&S development, management, and evaluation.**

Draft M&S Course Outline

What is a "Model", "Simulation", etc.?

How is M&S used for homeland security?

- **National Infrastructure Simulation and Analysis Center (NISAC)**
- **National Atmospheric Release Advisory Center (NARAC)/Inter-Agency Modeling and Atmospheric Analysis Center (IMAAC)**
- **Emerging Capabilities in DHS S&T Directorate**

Who in DHS should consider using M&S?

When and where in DHS is M&S useful?

What are some considerations in acquiring M&S capabilities?

- **Economics**
- **Development**
- **Data**
- **Evaluation**

Why are M&S guidelines, standards, and "best practice" important for DHS?

How do other Federal agencies/organizations approach M&S?

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Homeland Security

Definitions

Model

(1) An **approximation**, **representation**, or **idealization of selected aspects** of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system. Note: Models may have other models as components.

(2) To serve as a model as (1).

(3) To develop or use as a model as in (1).

Simulation

(1) A model that **behaves or operates like a given system** when provided a set of controlled in-puts.

(Synonymous with: Simulation model)

(2) The process of developing or using a model as in (1).

Source: IEEE Standard Glossary of Modeling and Simulation Terminology (IEEE STD 610.3 - 1989)

Lists 33 different types of models (e.g., computational, descriptive, discrete, iconic, mathematical) and 20 different types of simulations (e.g., continuous, discrete, event-oriented, Monte Carlo, process-oriented).

Definitions from DoD and EPA

Model

DoD: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

EPA: A representation of the behavior of an object or process, often in mathematical or statistical terms. Models can also be physical or conceptual.

Simulation

DoD: A method for implementing a model over time. Also, a technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model.

EPA: One complete execution of the computer program, including input and output.

Sources: M&S Management. DoD Directive 5000.59.

Guidance for Quality Assurance Project Plans for Modeling. EPA QA/G-5M

Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models. EPA Council for Regulatory Environmental Modeling

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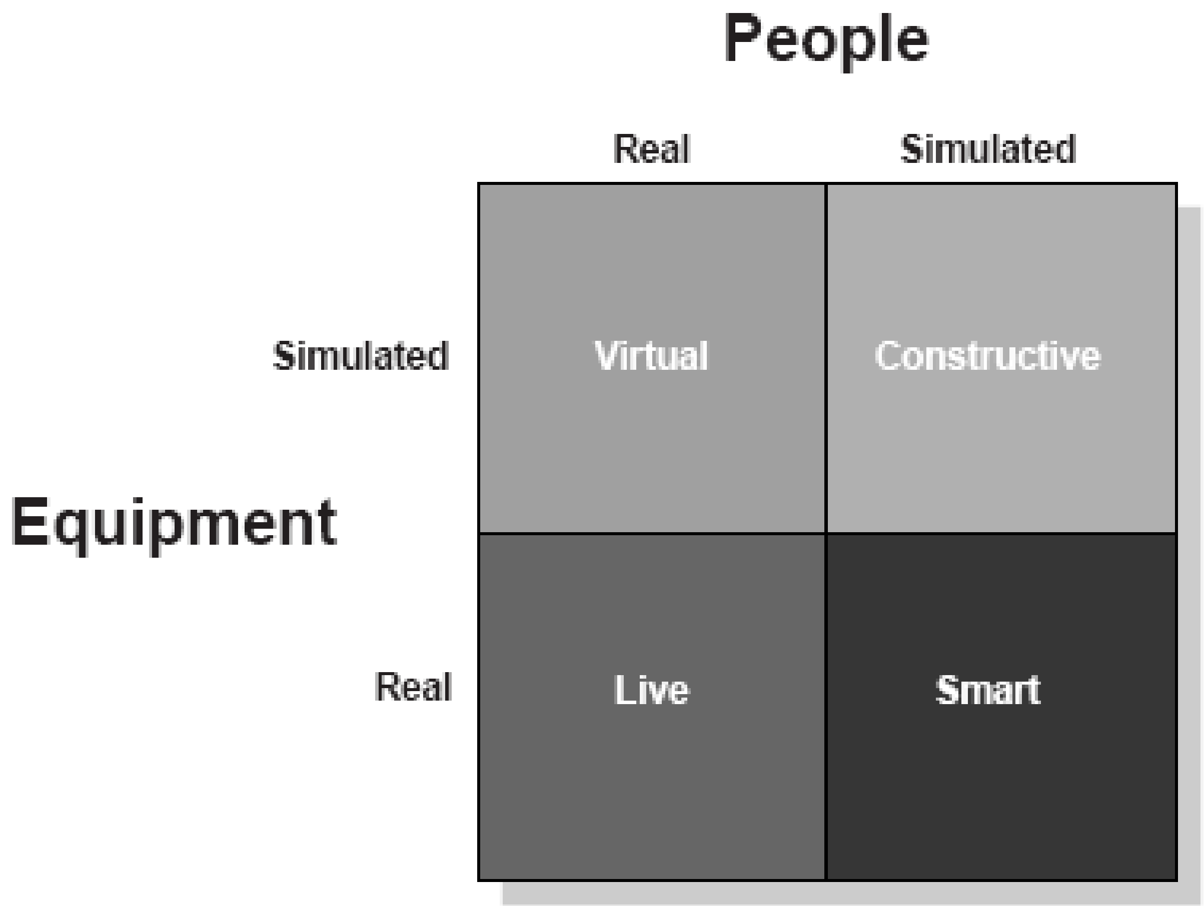
DoD/Live, Virtual, Constructive (LVC)

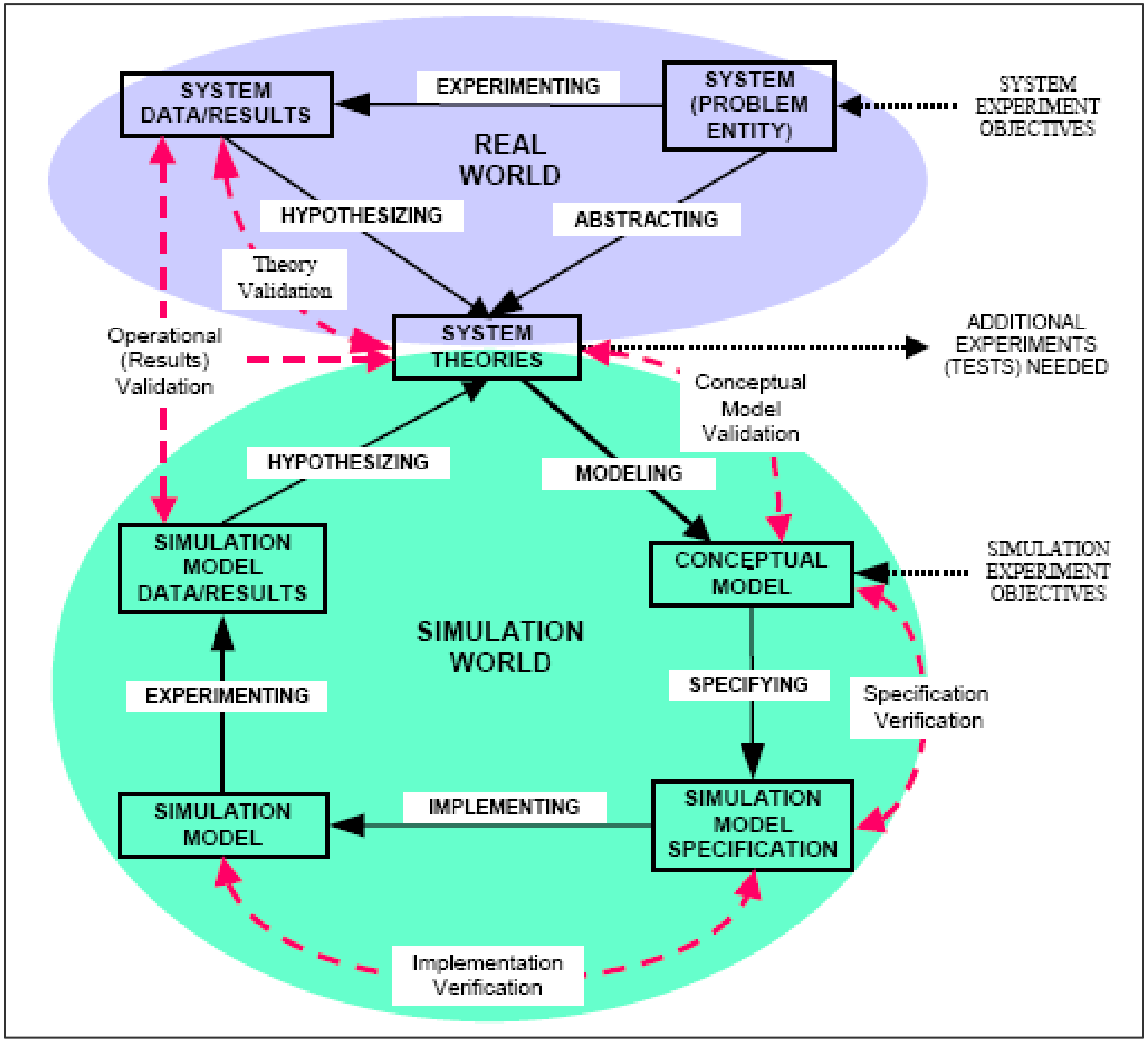
Live simulations are simulated operations of real systems using real people in realistic situations.

Virtual simulations put the human-in-the-loop (HITL)

Constructive Simulations are computer simulations that are strictly mathematical representations of systems and do not employ any actual hardware



A “Model” for M&S



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Source: R. G. Sargent, “Validation and Verification of Simulation Models”, Proceedings of the 2004 Winter Simulation Conference, 2004

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Modeling, Simulation and Analysis and The National Infrastructure Simulation and Analysis Center (NISAC)

S&T Stakeholders Conference - 2 June 2008

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OUTLINE

- NISAC Mission & Mandate
- Where NISAC fits in DHS
- What is NISAC
  - Not a product
  - Not a model
  - Not the only MS&A capability
- Modeling and Simulation for Analysis
  - Examples
- Summary

NISAC Mission

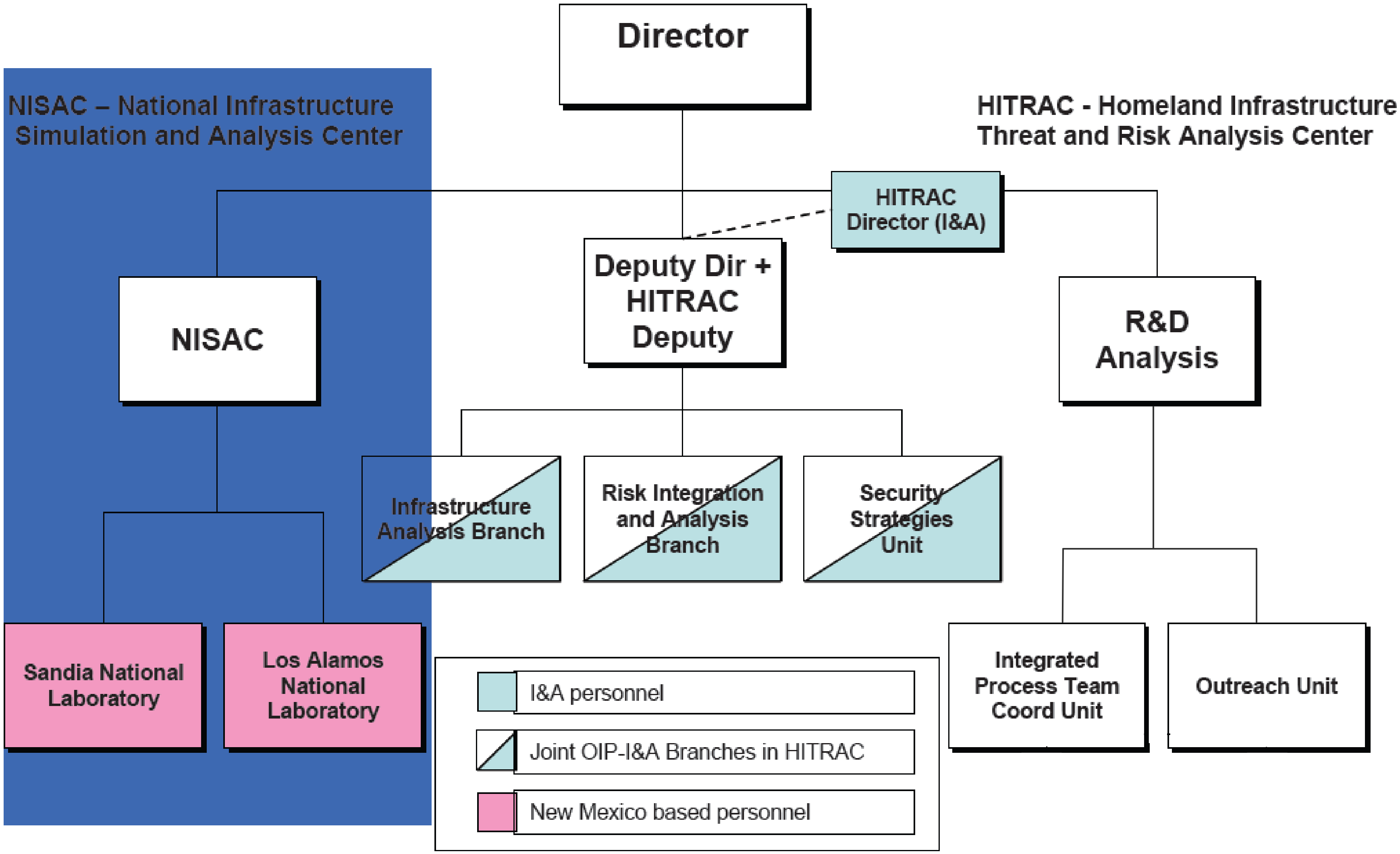
- **HSPD-7**
  - "[DHS] will utilize existing, and develop new capabilities as needed to model comprehensively the potential implications of ...vulnerabilities in critical infrastructure and key resources …"
- **Patriot Act, 2001**
  - NISAC will "serve as a source of *national competence* to address critical infrastructure protection and continuity through support for activities related to counterterrorism, threat assessment, and risk mitigation"
- **Homeland Security Appropriations Act of 2007**
  - Expanded NISAC's responsibilities and mission
  - NISAC … "shall serve as a source of *national expertise* to address critical infrastructure protection and continuity
- **National Infrastructure Protection Plan**
  - NISAC provides advanced modeling and simulation capabilities for the analysis of CIKR interdependencies, vulnerabilities, and other complex interactions

Where NISAC Fits in the Office of Infrastructure Protection

- ASIP
  DASIP
  - Chief of Staff
    Deputy COS
  - Chemical Security Compliance Division
  - Infrastructure Information Collection Division
  - Infrastructure Analysis & Strategy Division
  - CI/KR Protective Security Coordination Division
  - CI/KR Contingency Planning & Incident Management Division
  - CI/KR Partnerships & Outreach Division
  - Sector Specific Agency Executive Management Office

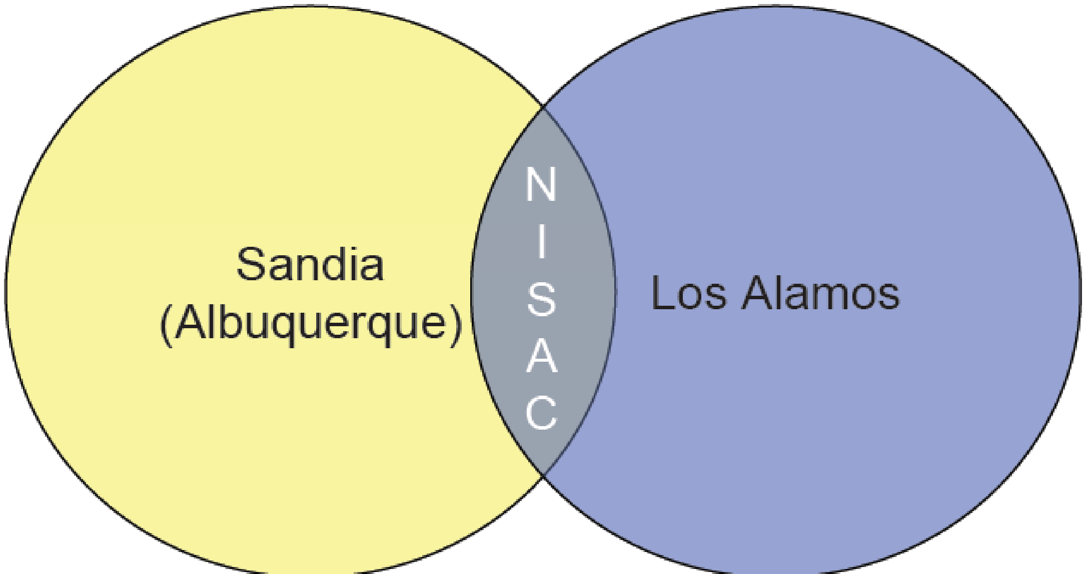
- *The only Congressionally mandated CIKR analysis activity responsive to the NIPP*
  - *Cross-Sector Expertise*
  - *Operational Perspective*

Infrastructure Analysis & Strategy Division



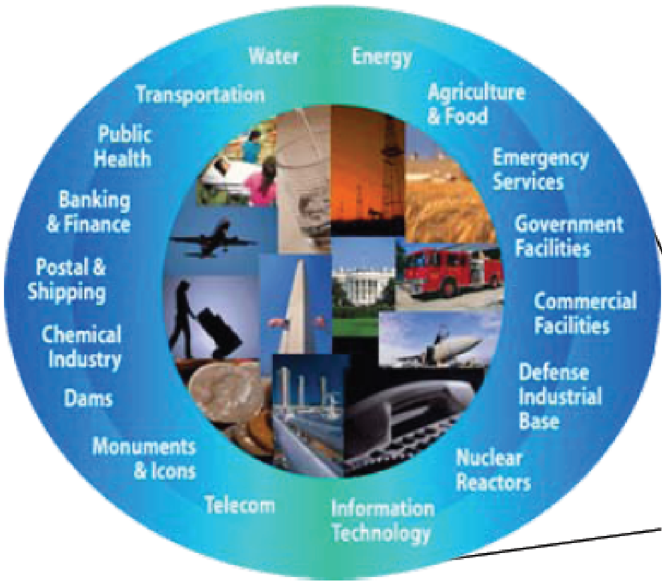
NISAC

- Two separate DOE National Laboratories
- Responsive to DHS / IP



- Approx 100 scientists & technicians
  - Multi-disciplinary
  - Innovative, and still evolving
  - Scientifically credible

NISAC Provides



MS&A

Sector & Cross Sector Knowledge

- Operations
- Locations
- Structure
- Services & Dependencies

Mission Space Understanding

- CIKR
- Population
- Topography
- Economics
- ***Critical Interdependencies***

Risk Mitigation

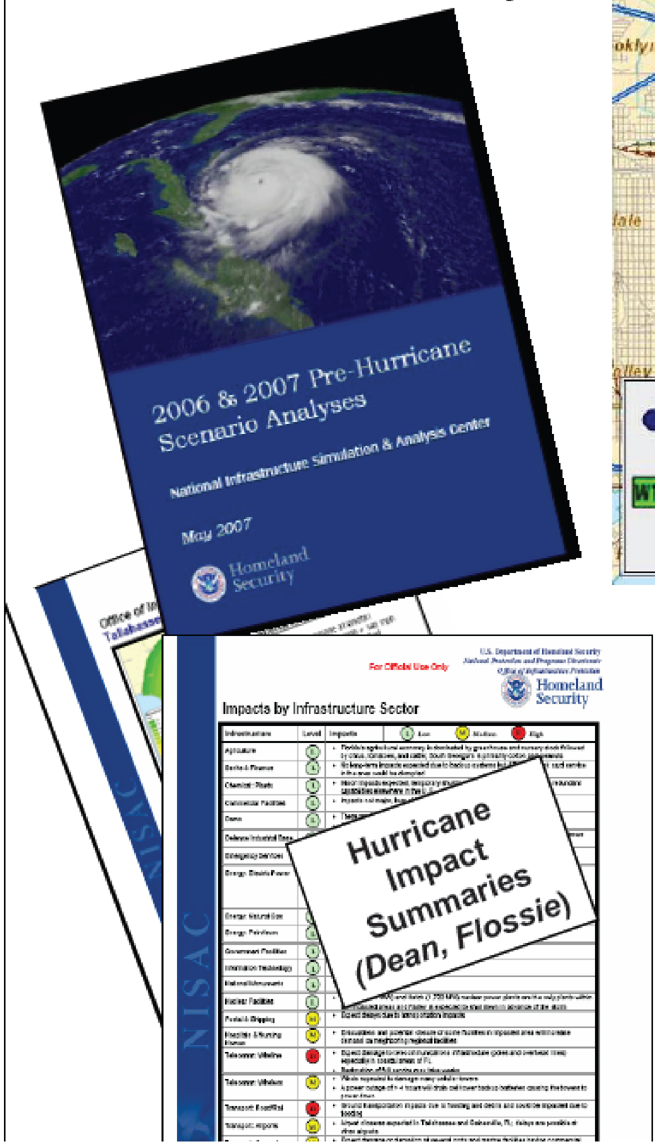
Incident Response

<u>MS&A Adds</u>

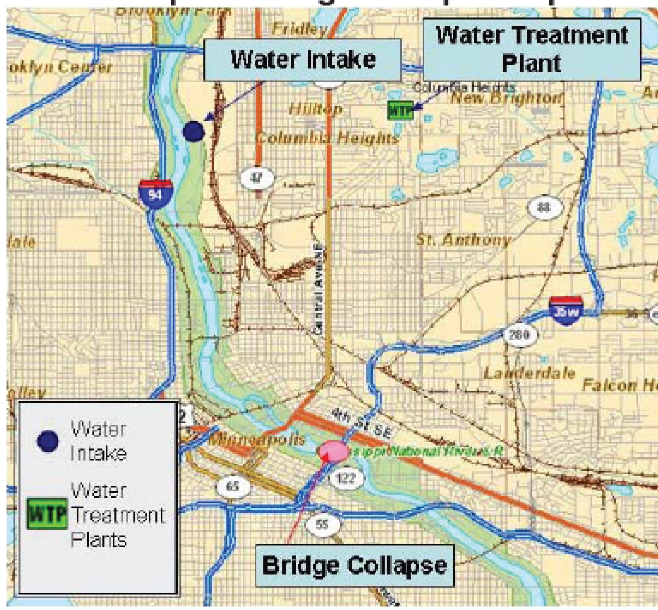
- Documented Methods
- Documented Results
- Reproducible Processes
- Qualified Multidiscipline Analysts
- FAST Analysis (when required)
- All-Sector Perspective

Recent NISAC Analytical Products

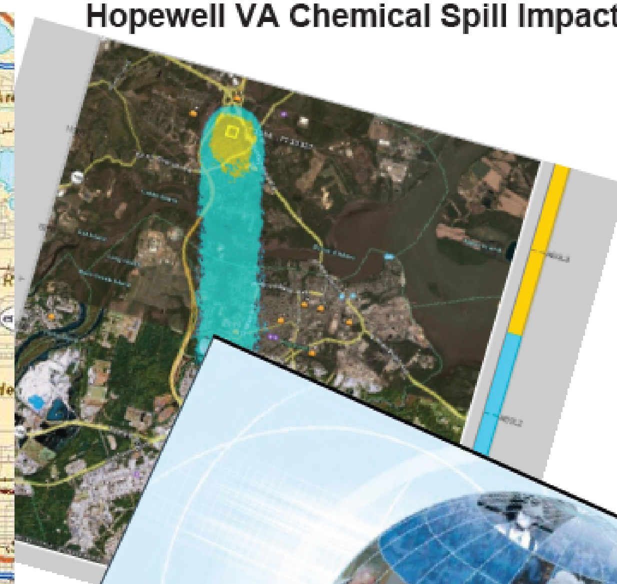
Pre-Hurricane Scenario Analyses

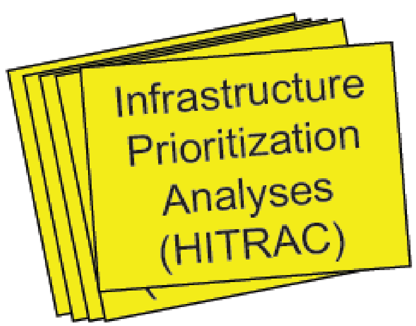


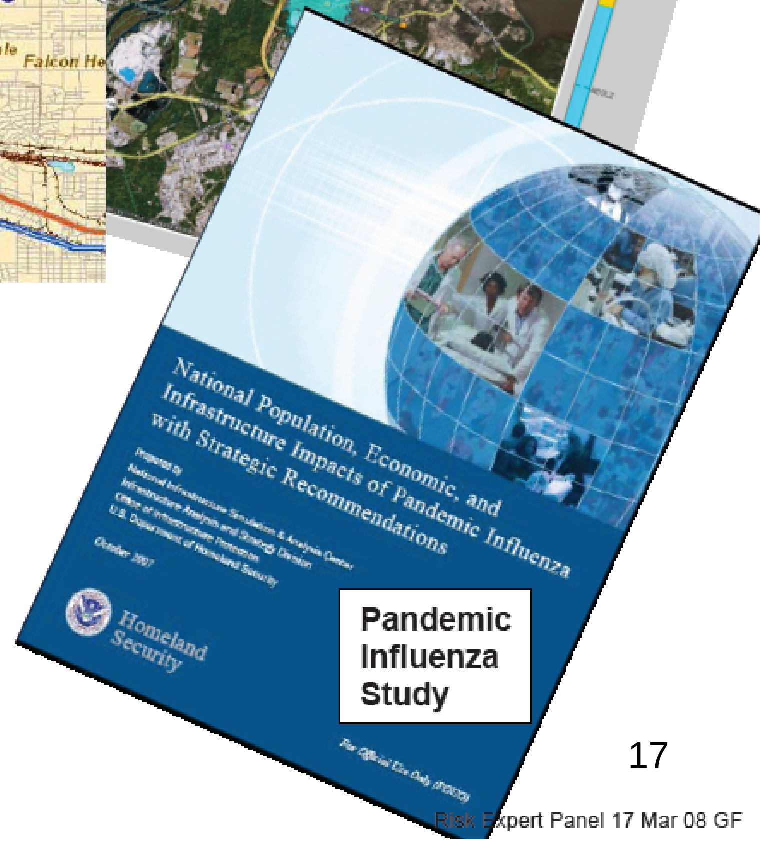
Minneapolis Bridge Collapse Report



Hopewell VA Chemical Spill Impact







NISAC Business Model

- **<u>Point of Entry:</u> IASD NISAC Branch**
- **ASIP is priority customer and defines priorities**
- **Joint Ventures encouraged**
  - Tasking exceeds resources
  - Unique capabilities for cross-sector and multi-sector analysis
- **<u>Outreach</u>** to CIKR Sectors, DHS Components, and Federal Interagency partners
  - HSIN
  - R&D Community via IASD Portal (Beta test in 2008)

Summary

- NISAC integrated into IP Mission through IASD
  - HITRAC
  - R&D Branch sector analyses & requirements
- Excels at Pre-incident analysis
  - Preparation, Prevention, Mitigation
  - Improving capability for Response
  - Data bases are not real-time
- NISAC performs cross-sector interdependency and cascading consequence analysis
  - Joint Ventures encouraged

IMAAC Provides Federal Dispersion Modeling During Events Requiring Federal Coordination

- Created by Homeland Security Council (April 2004)
- NARAC designated as the interim provider of IMAAC services
- Eight-agency Memorandum of Understanding and Interagency Working Group
- National deployment plan
  - Federal operations centers
  - Regional response assets (DHS/FEMA, DOE, EPA, NOAA)
  - States
- Local Integration of NARAC w/Cities pilot program
- Permanent site selection process underway

"The IMAAC provides a single point for the coordination and dissemination of Federal dispersion modeling and hazard prediction products that represent the Federal position during actual or potential incidents requiring federal coordination" - National Response Plan (NRP) Notice of Change May 2006

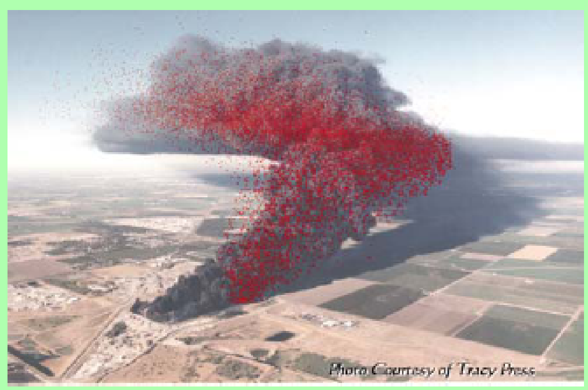
NARAC/IMAAC Provides Operational Services, Tools, Expertise for Preparedness and Response

Event Information

- Weather data
- Nuclear, radiological, chemical, and biological source information
- Terrain, land use, and population databases
- Measurement data and observations

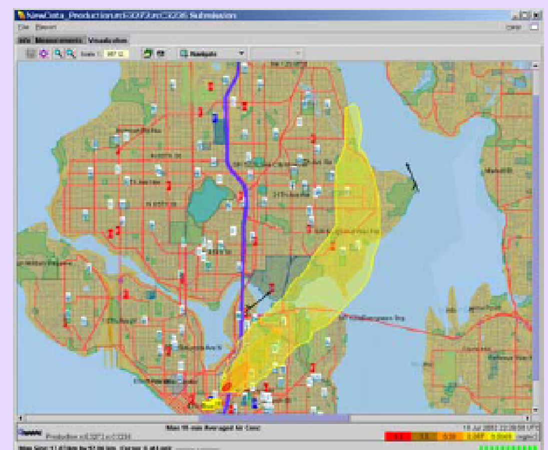
Operational Services and Expertise

- Suite of stand-alone to advanced WMD modeling tools (multi-scale models)
- 24/7/365 expert scientific staff (< 5 min. reachback)
- Detailed analysis, expert interpretation, quality assurance, and training
- Event reconstruction



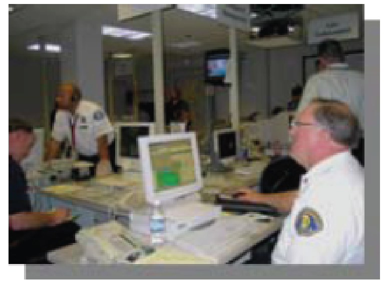
Actionable Information

- Hazard areas
- Health effects and exposed populations and facilities
- Casualty, fatality, and damage estimates
- Protective action recommendations and response strategies
- Threat assessments



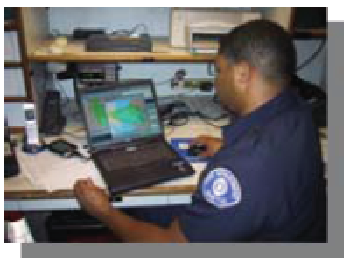
Internet- and Web-based Software Tools Provide Easy Access and Distribution of Predictions

Local/State Emergency Operations Center



Information distribution & decision making

Local, Regional, State Responders



- Fast-running local models
- Access to advanced models
- *iClient* software

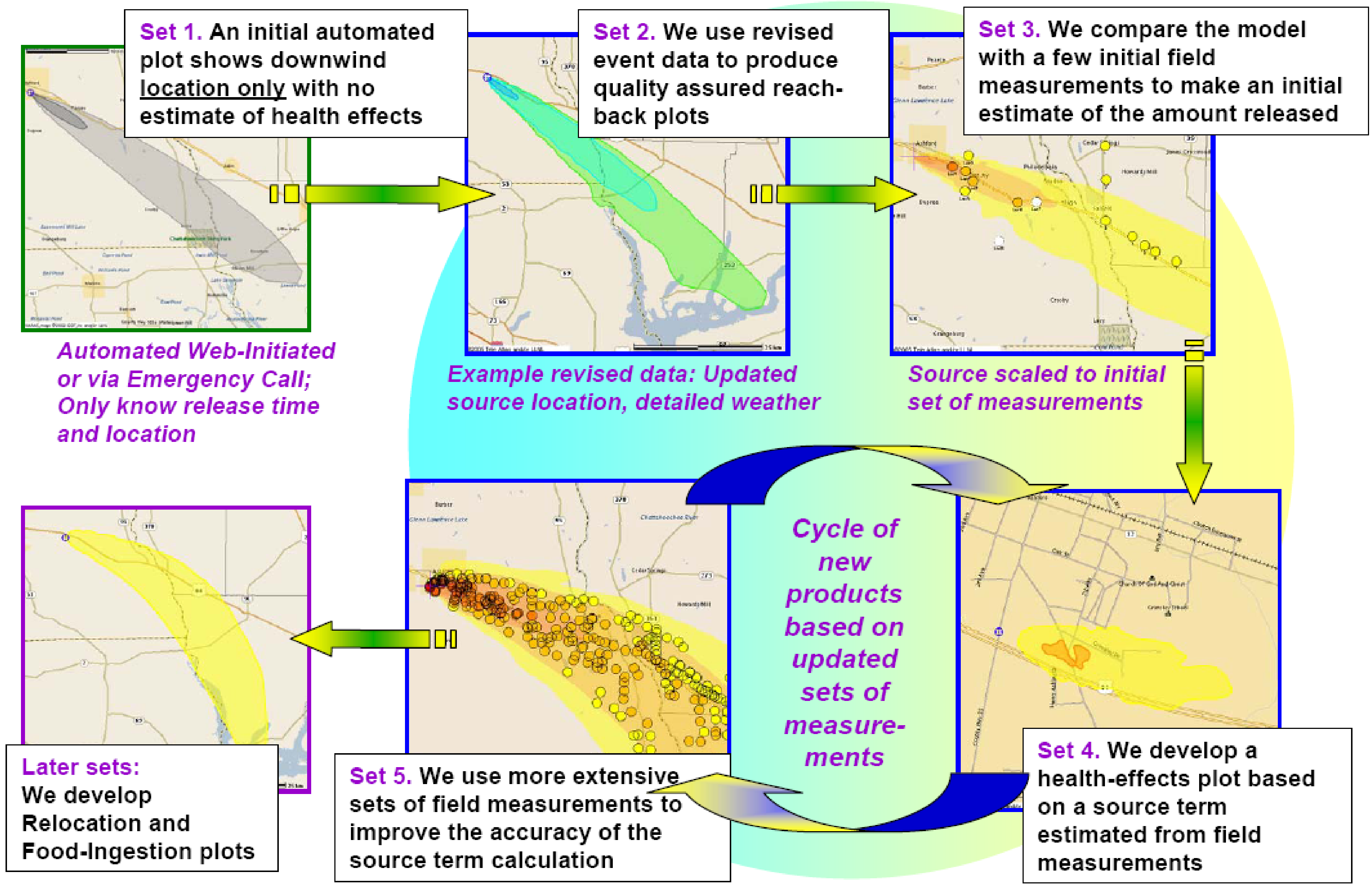
Internet, dial-up, satellite or wireless communication

IMAAC Web

- Advanced modeling tools
- Scientific support and analyses

Collaborating City, County, State & Federal Agencies

Standard Operational Procedures Couple Modeling and Monitoring in a Cyclical Process



Integrated Modeling Capabilities Include In-House and Externally Built Models

Model	Source	Description
ADAPT	**LLNL**	**Diagnostic meteorological model**
BLAST	**SNL**	**Pressure effects model for high explosives and RDDs**
COAMPS	**NRL/LLNL**	**Mesoscale forecast model**
WRF	**NCAR**	**Community weather research forecast model**
EPICODE	**Commercial**	**Gaussian plume model with hazardous chemical databases**
GridGen	**LLNL**	**Grid generation software for ADAPT/LODI using terrain data**
Hotspot	**LLNL**	**Gaussian plume model for radioactive and nuclear material**
KDFOC	**LLNL**	**Gross fission products fallout effects model**
LODI	**LLNL**	**Lagrangian stochastic particle dispersion model**
NUKE	**SNL**	**Prompt dose, thermal, and overpressure effects model for nuclear weapon**
WRF	**NCAR**	**Community numerical weather prediction model (in-house versions)**

UDM	**DSTL**	**Empirical urban model (prototype integration completed)**
FEM3MP	**LLNL**	**Multiprocessor computational fluid dynamics (CFD) building-resolving model**

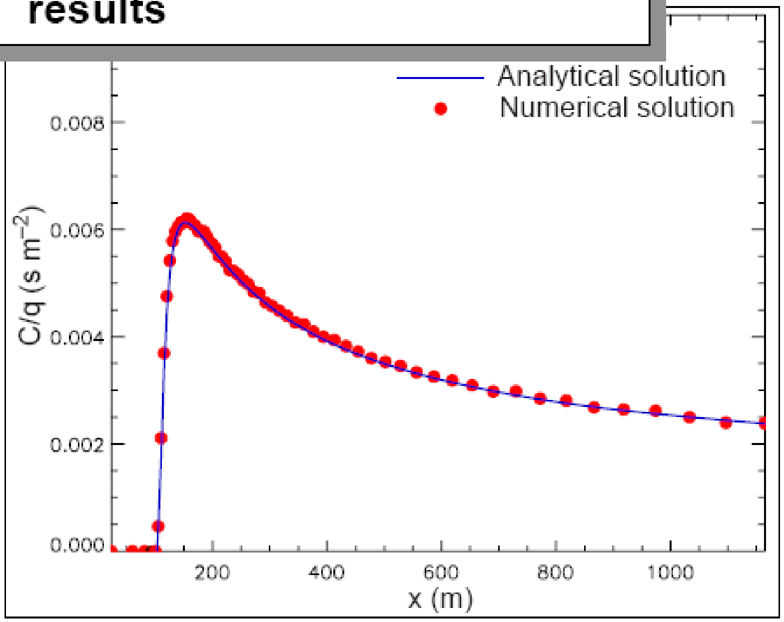
Collaborations Provide Additional Models & Data

Stand-Alone Models from Collaborations		
Model	**Source**	**Description**
CAMEO/ ALOHA	NOAA/EPA	Gaussian plume model with toxic industrial chemical databases
HPAC	DTRA	Plume modeling system with SCIPUFF
RASCAL	NRC	Radiological source terms and Gaussian plume/puff model for nuclear power plant releases
Turbo FRMAC	SNL	Radiological dose calculations from air and ground contamination

Forecast Model Results from External Sources		
Agency	**Model**	**Resolution/Coverage**
Air Force Weather Agency (AFWA)	MM5	45 and 15 km resolution, special regional forecasts
Fleet Numerical Meteorology and Oceanography Center (FNMOC)	NOGAPS 4.0	1° resolution, global
	COAMPS	Special regional forecasts
National Weather Service (NWS)	WRF	40 km and 12 km resolution, US
	GFS (AVN)	0.5° and 1° resolution, global
	RUC	20 km resolution, US

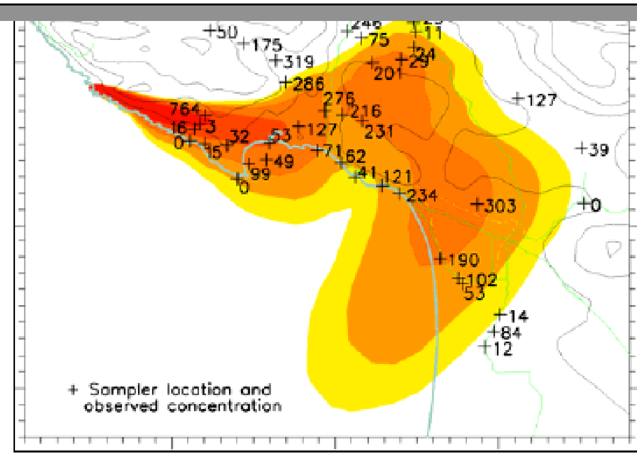
NARAC/IMAAC Models and Operations are Extensively Tested and Evaluated

- **Analytic solutions test models versus known, exact results**



•Field experiments test models in real-world cases

Examples: Roller Coaster, Project Prairie Grass, Savannah River Musicale Atmospheric Tracer Studies, Diablo Canyon Tracer Study, ETEX, URBAN



- **Operational testing** evaluates the usability, efficiency, consistency and robustness of models for operational conditions

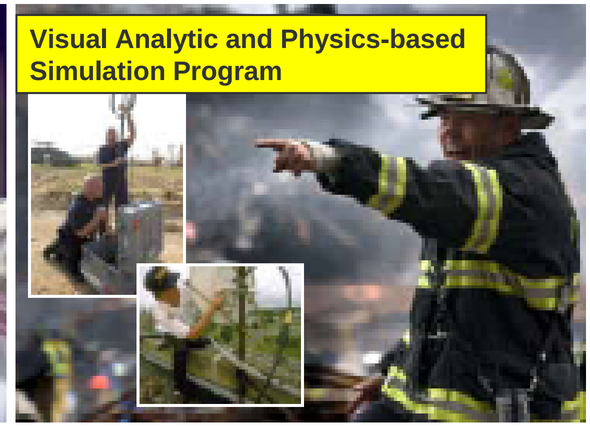
Examples: Chernobyl, Kuwait oil fires, tire fires, industrial accidents, Algeciras Spain Cesium release, Tokaimura criticality accident, Cerro Grande (Los Alamos) fire

Emerging M&S Capabilities in DHS S&T Directorate

Explosives

Chemical/Biological

Command, Control, & Interoperability



Borders/Maritime

Human Factors

Infrastructure/Geophysical

M&S is integral to analysis and supports decision making at many levels

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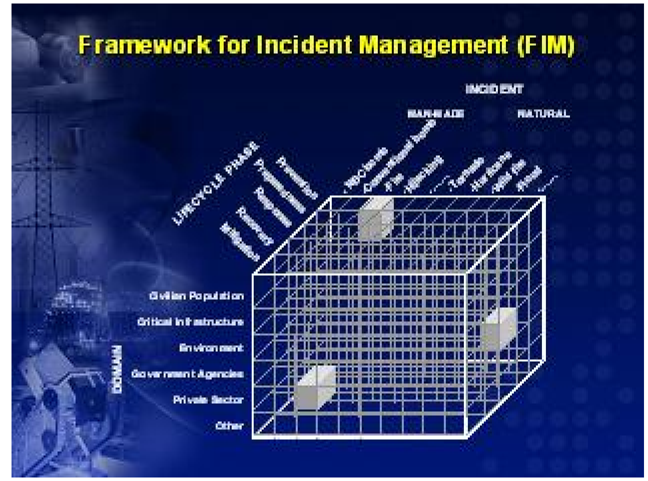
M&S in Perspective

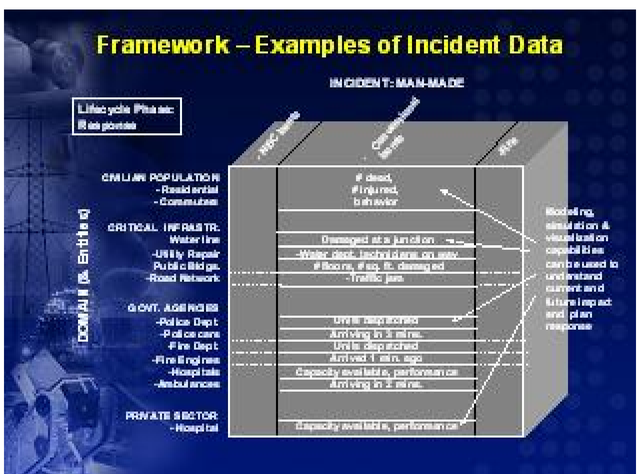


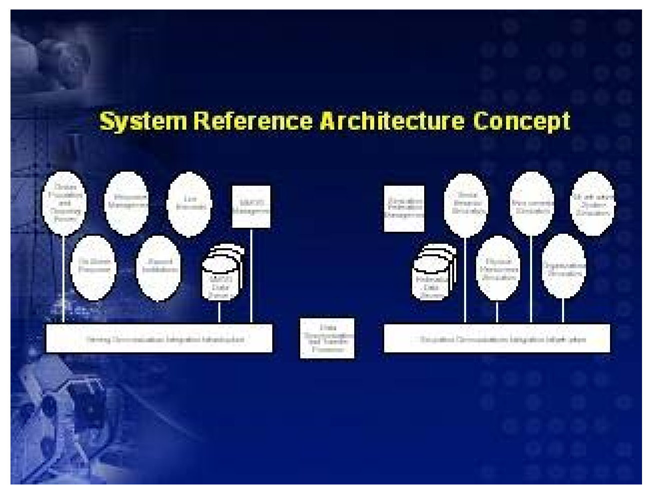
Decision Analysis

Skilled analysts match the right M&S and data to answer the question at hand

Data

M&S





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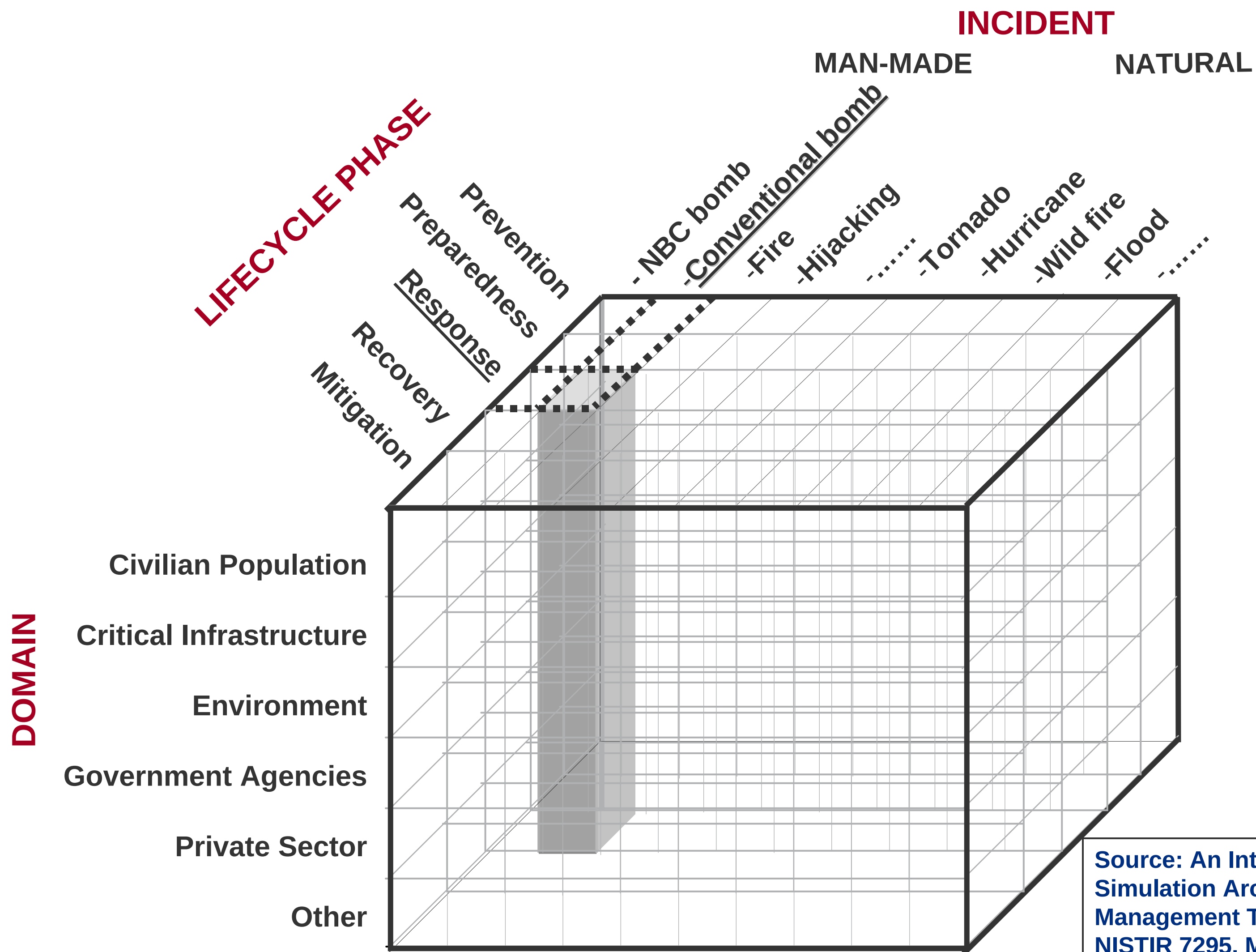
Framework For Incident Management (FIM)



Source: An Integrated Gaming and Simulation Architecture for Incident Management Training, NISTIR 7295, March 2006

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Cells Represent Potential M&S Applications: Many potential uses for Incident Management!

Framework – Examples of Incident Data

For LIFECYCLE PHASE: Response

INCIDENT: MAN-MADE

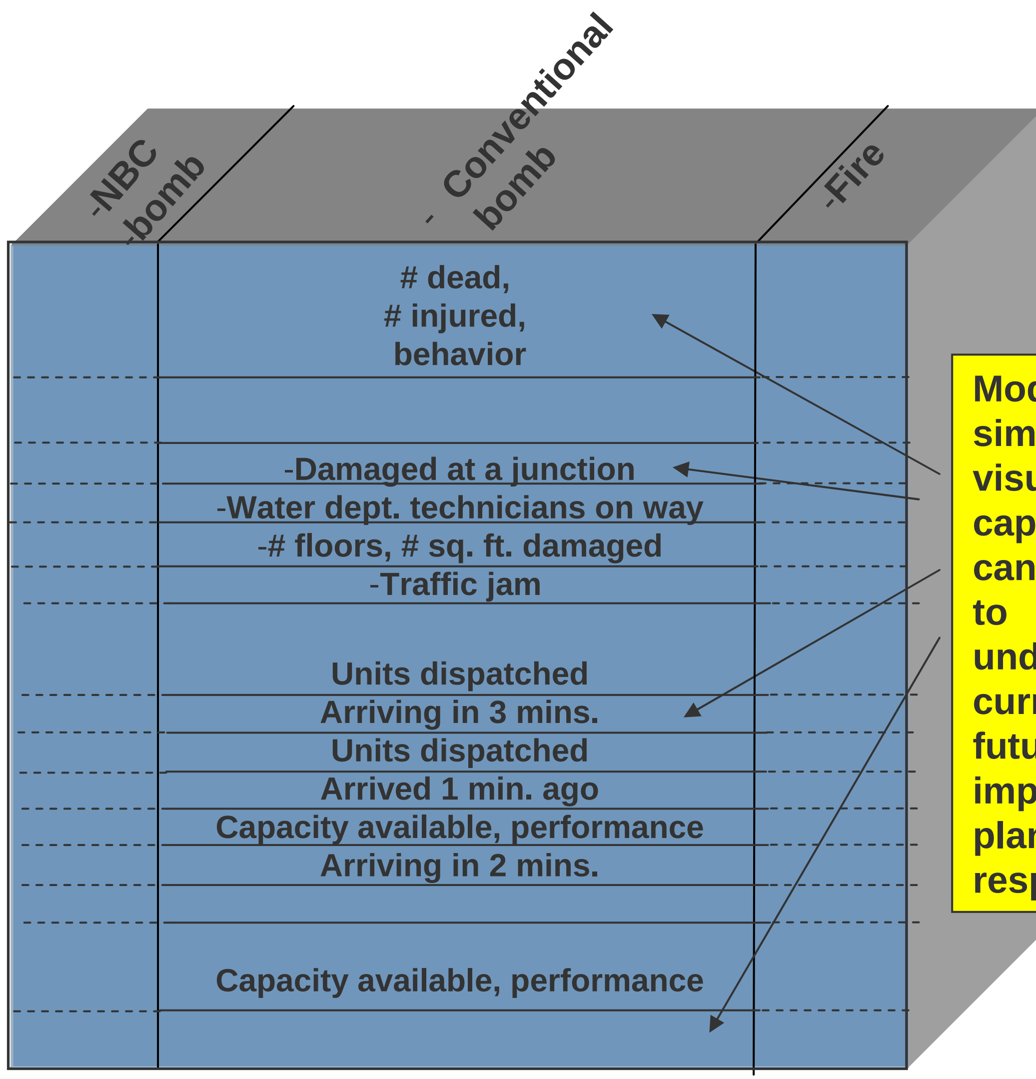
DOMAIN (& Entities)

CIVILIAN POPULATION
- Residential
- Commuters

CRITICAL INFRASTR.
-Water line
-Utility Repair
-Public Bldgs.
-Road Network

GOVT. AGENCIES
-Police Dept.
-Police cars
-Fire Dept.
-Fire Engines
-Hospitals
-Ambulances

PRIVATE SECTOR
- Hospital



Modeling, simulation & visualization capabilities can be used to understand current and future impact and plan response

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System Reference Architecture Concept

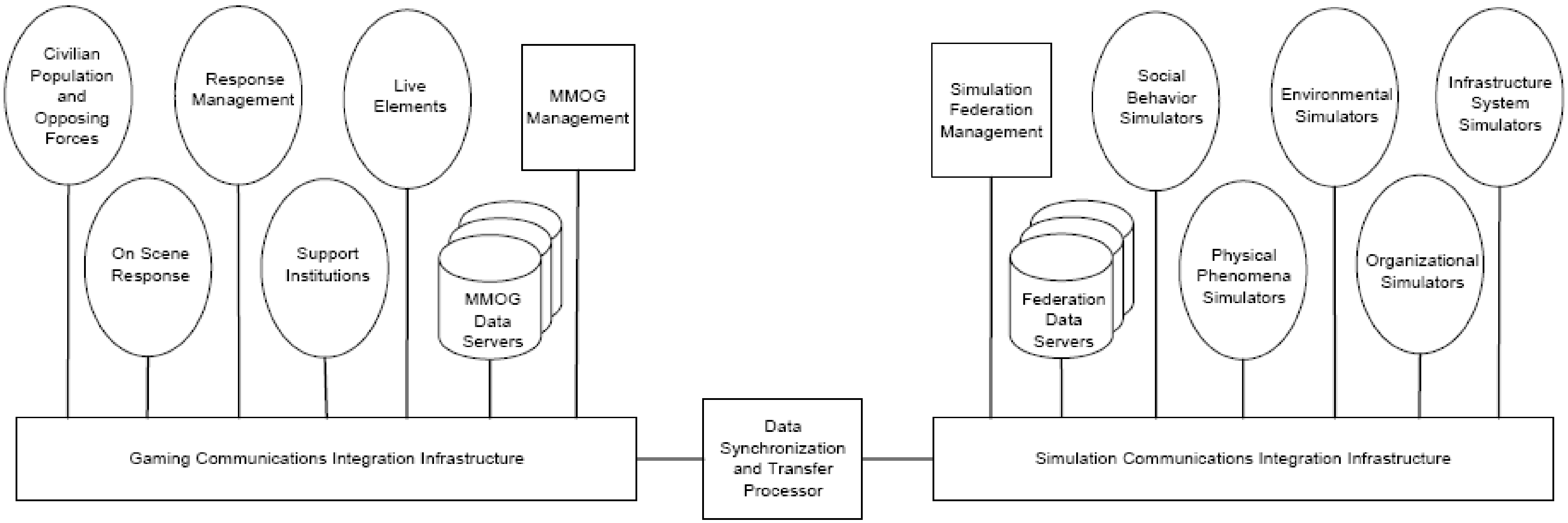

Figure 2. Architecture concept for Simulation and Gaming Incident management Training System

Source: An Integrated Gaming and Simulation Architecture for Incident Management Training, NISTIR 7295, March 2006

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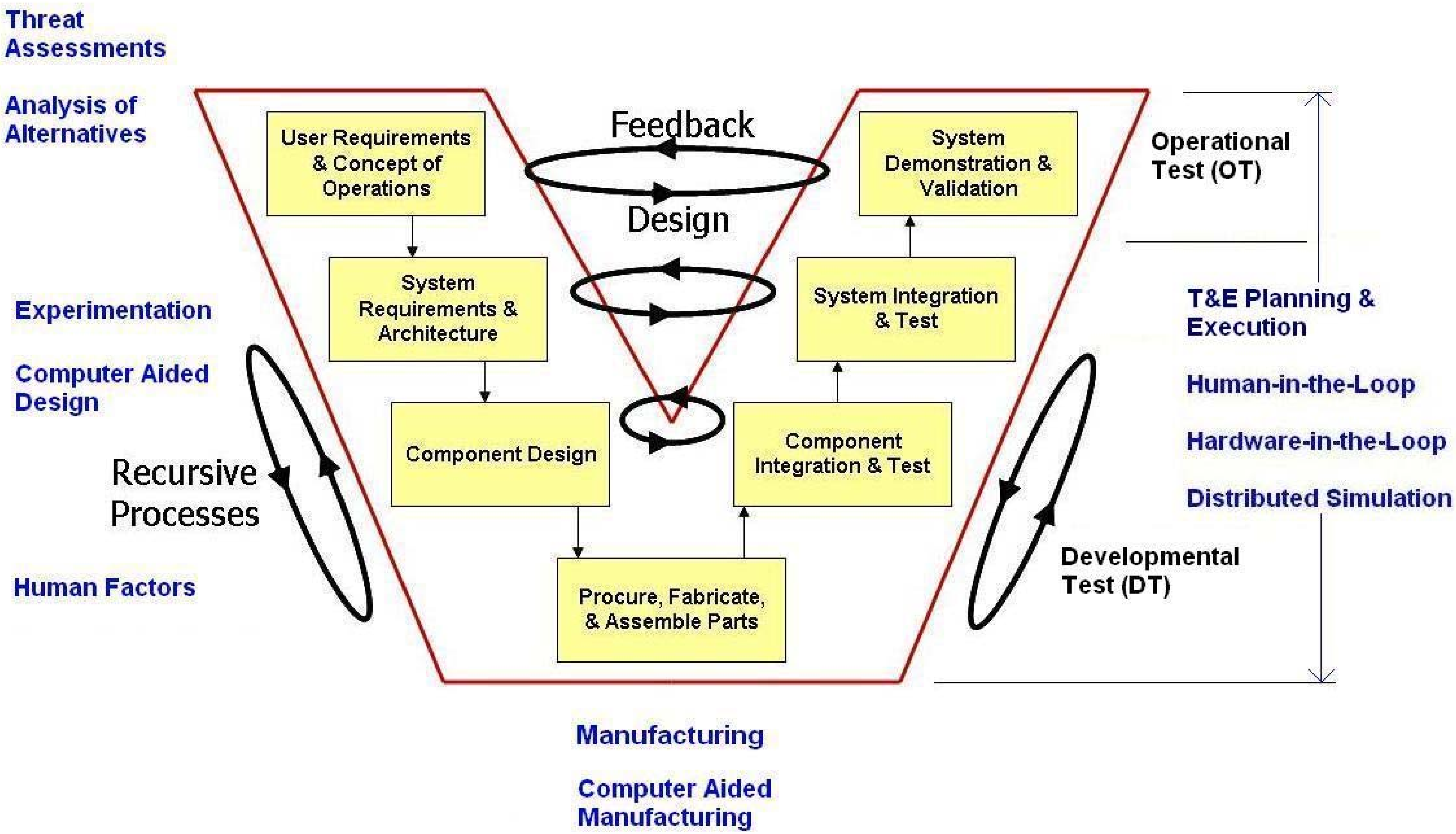
M&S in Systems Engineering



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M&S in Systems Engineering (continued)

The HW/SWIL simulations are often described as engineering level simulations. They typically consist of multiple classes of simulations. The HW/SWIL includes actual hardware and software, mathematical models, and external stimuli used together to demonstrate the capability of a system or subsystem to operate within an environment simulating actual conditions. A HW/SWIL simulation has proven to be an important tool in system development, test and operational support.

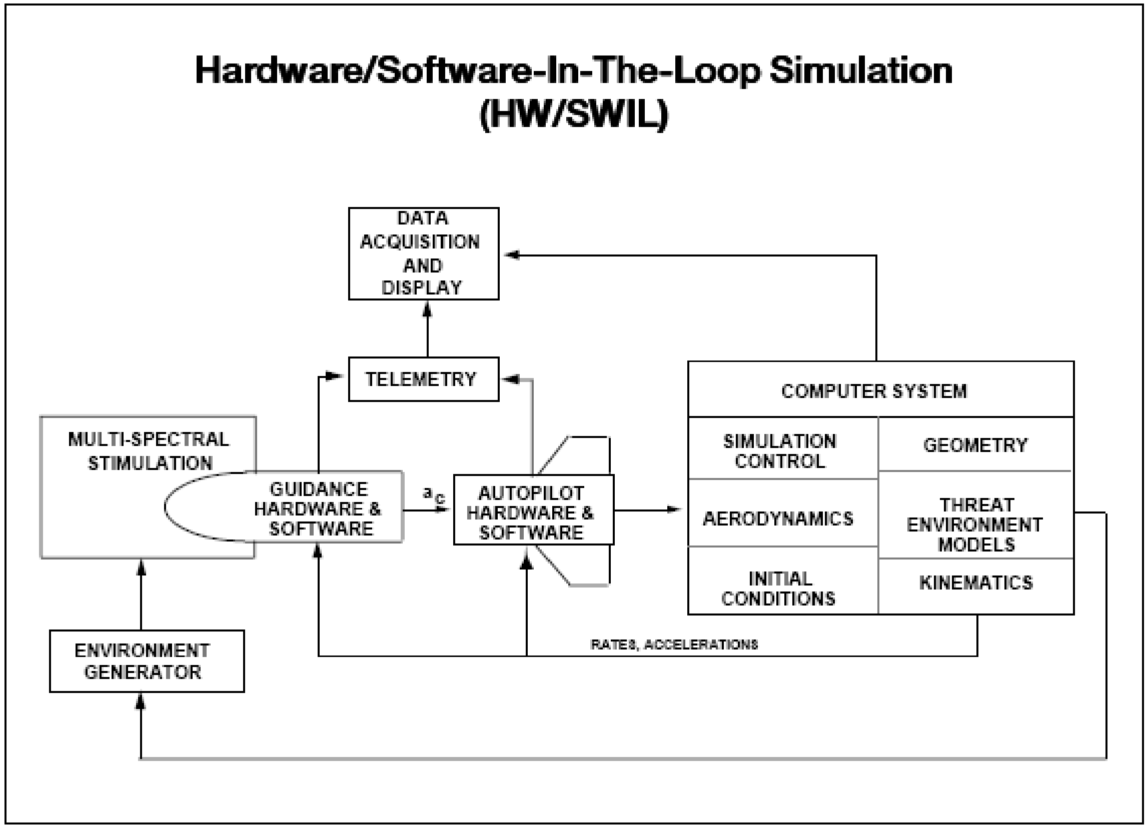

Figure 4-4. Hardware/Software-In-The-Loop Simulation (HW/SWIL)

Source: "System Acquisition Manager's Guide for the use of Models and Simulations", Defense Systems Management College Press, Fort Belvoir, VA, 1994

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M&S in Systems Engineering (continued)

Source: "Guidelines: Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E)", U. S. Army T&E Management Agency, Washington, DC, 2000

Table 1. Overview of M&S Application in Support of T&E.

1. Support pretest planning.
2. Identify key test parameters earlier.
3. Bound, in a gross manner, the problem and propose solutions based on the intended environment, force structure, threat, tactics, strategy, and doctrine.
4. Identify oversights and flawed logic.
5. Determine sensitivity of a system to various input parameters.
6. Allow non-destructive testing of high cost items.
7. Provide better understanding when full-scale testing is not possible.
8. Augment, extend, and enhance test results, as appropriate.
9. Provide multiple "environments" for examining test objectives.
10. Provide advantages of test compression, control expenditures, enable replication, and reduction of variables under study.
11. Assess impact of known parameters of unavailable threat systems.
12. Accomplish human factors supportability or soldier-machine interface analyses in part-task or limited fidelity "mock-ups."
13. Provide estimates of potential test outcomes.
14. Extrapolate, with caution, test results into other scenarios and levels of force aggregation.
15. Address issues which cannot be physically tested.
16. Address "what if" questions during post-test analyses.
17. Develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.
18. Develop new tactics for the employment of new weapon systems under test.
19. Provide overall system, scenario, or environment representation.
20. Represent the input, process, and output of non-available systems, subsystems, or components (friendly or threat).
21. Represent the whole integrated system when all components are not available.
22. Allow an assessment of test events that would otherwise be exposed to threat intelligence exploitation.
23. Act as a system driver or stimulator in order to stress a system beyond available test scenarios.
24. Determine adequacy of the planned operational, maintenance, and supportability concepts.
25. Estimate mature system mission reliability, availability, and logistics support frequency.

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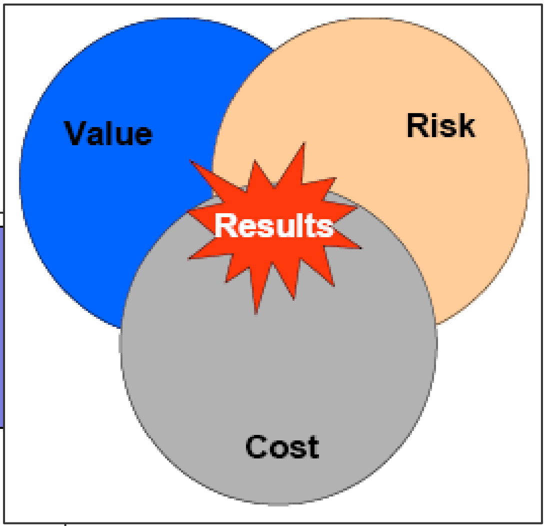
Economics of M&S

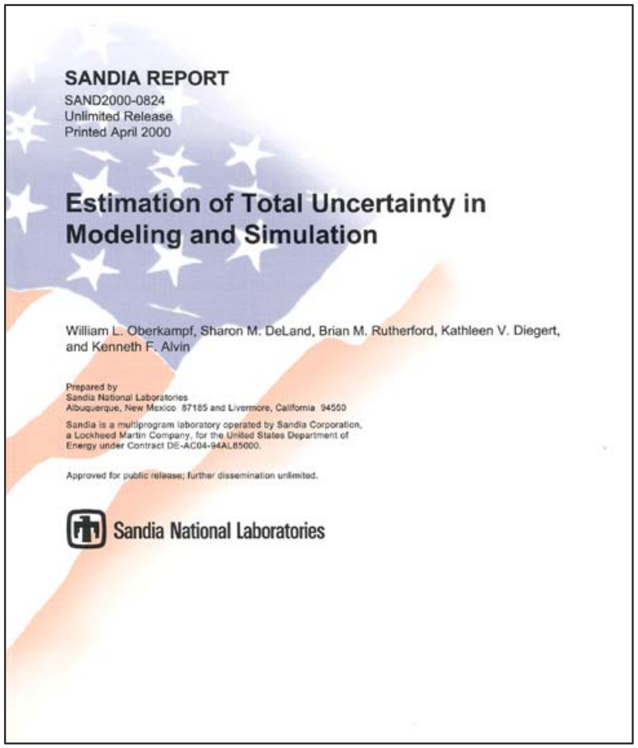
Step 1: Develop a Decision Framework	Step 2: Alternatives Analysis	Step 3: Pull the Information Together	Step 4: Communicate and Document
<u>TASKS</u> 1) Identify and define value structure 2) Identify and define risk structure 3) Identify and define cost structure 4) Begin documentation	<u>TASKS</u> 1) Identify and define alternatives 2) Estimate value and cost 3) Conduct risk analysis 4) Ongoing documentation	<u>TASKS</u> 1) Aggregate the cost estimate 2) Calculate the return on investment 3) Calculate the value score 4) Calculate the risk score 5) Compare value, cost, and risk	<u>TASKS</u> 1) Communicate value to customers and stakeholders 2) Prepare budget justification document 3) Satisfy ad hoc reporting requirement 4) Use lessons learned to improve processes



Source: Value Measuring Methodology: A How-to-Guide, Federal CIO Council, Best Practices Committee, 2004

Homeland Security

Development


SANDIA REPORT
SAND2000-0824
Unlimited Release
Printed April 2000

Estimation of Total Uncertainty in Modeling and Simulation

William L. Oberkampf, Sharon M. DeLand, Brian M. Rutherford, Kathleen V. Diegert, and Kenneth F. Alvin

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Sandia National Laboratories

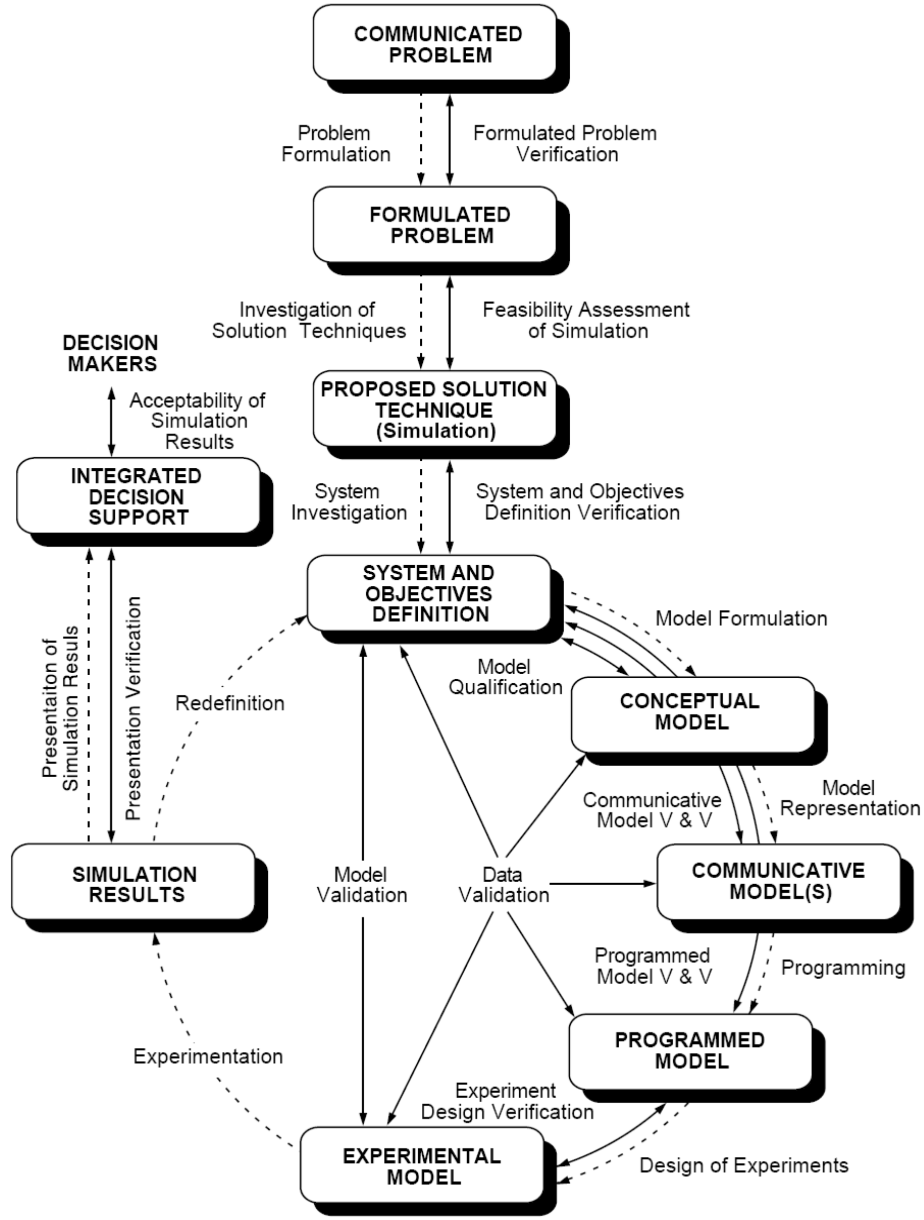
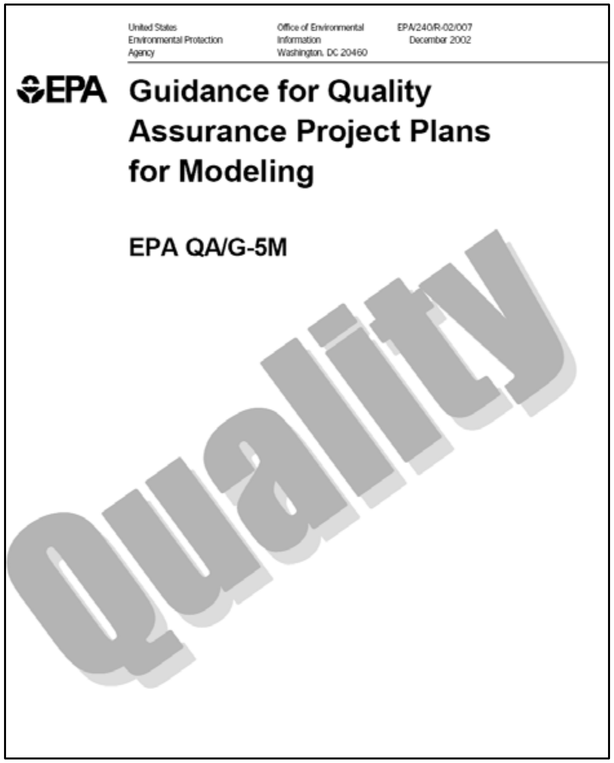


Figure 3
Life Cycle of a Simulation Study[39, 40]

Homeland Security

Development


United States Environmental Protection Agency
Office of Environmental Information Washington, DC 20460
EPA/240/R-02/007 December 2002

EPA

Guidance for Quality Assurance Project Plans for Modeling

EPA QA/G-5M

Quality

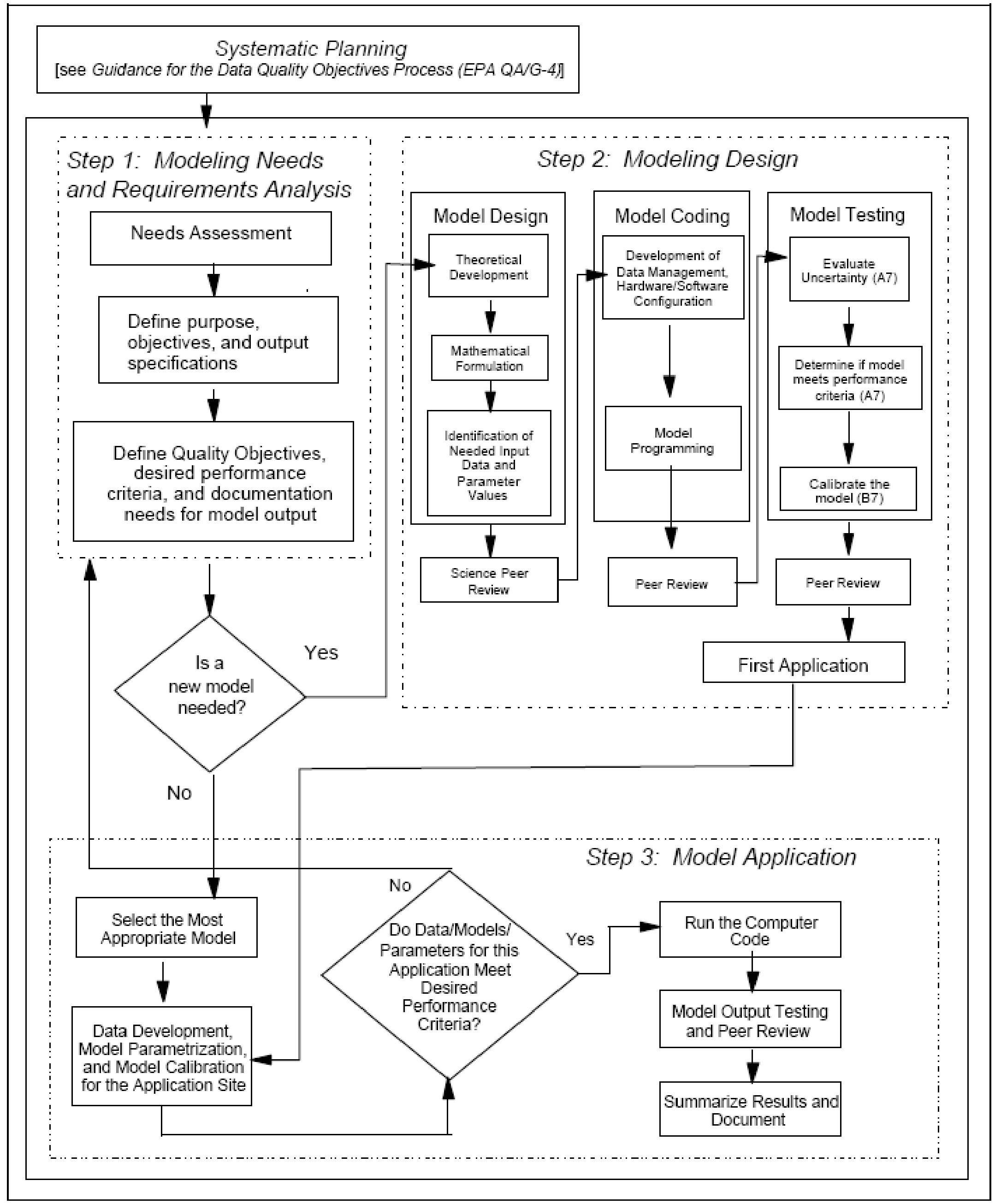


Figure 2. Typical Life-Cycle of a Three Step Modeling Project

Homeland Security

Data

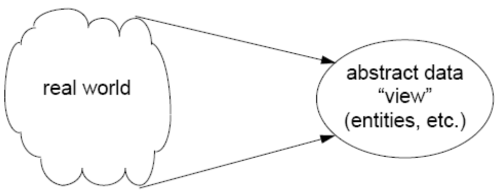


Figure 1: Data as model

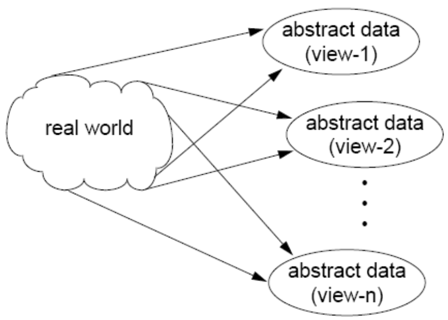


Figure 2: Alternate data "views" of reality

Source: A Discussion of Data Quality for Verification, Validation, and Certification, Jeff Rothenberg, Rand Corp., 1997

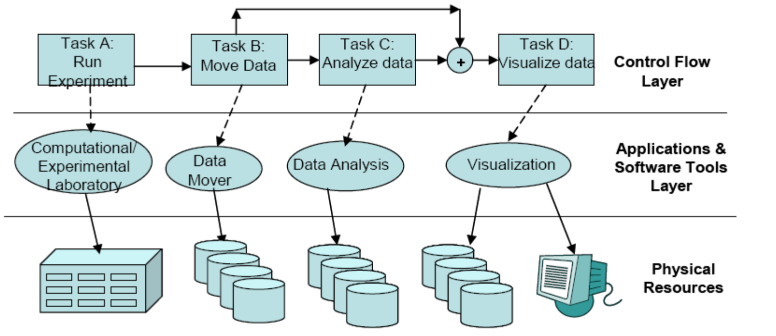
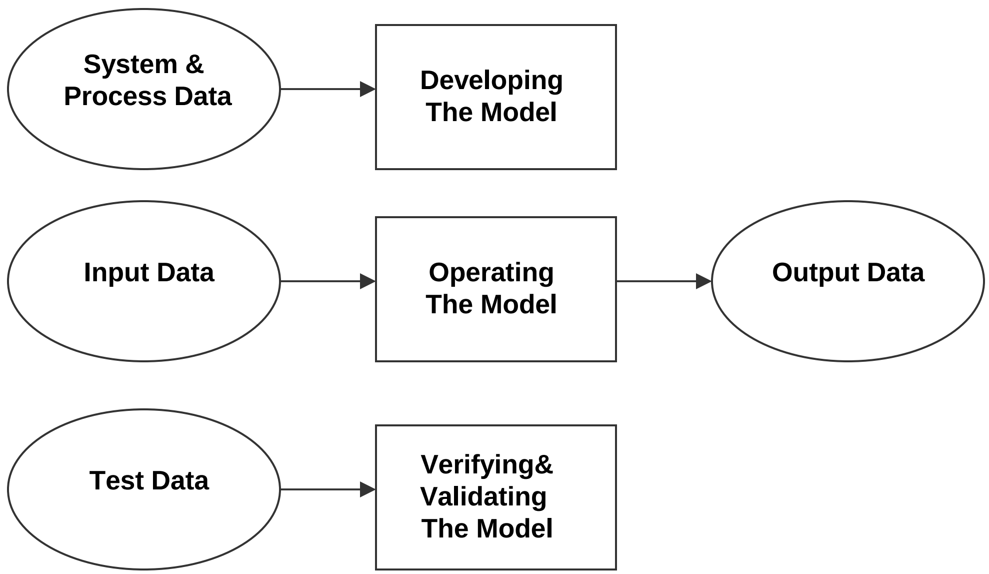


Figure I-2.2: Example of a workflow created in the scientific investigation process, showing the three layers: control flow, applications and software tools, and physical computer hardware.

Source: The Office of Science Data-Management Challenge, Report from DOE Workshop, March – May 2004

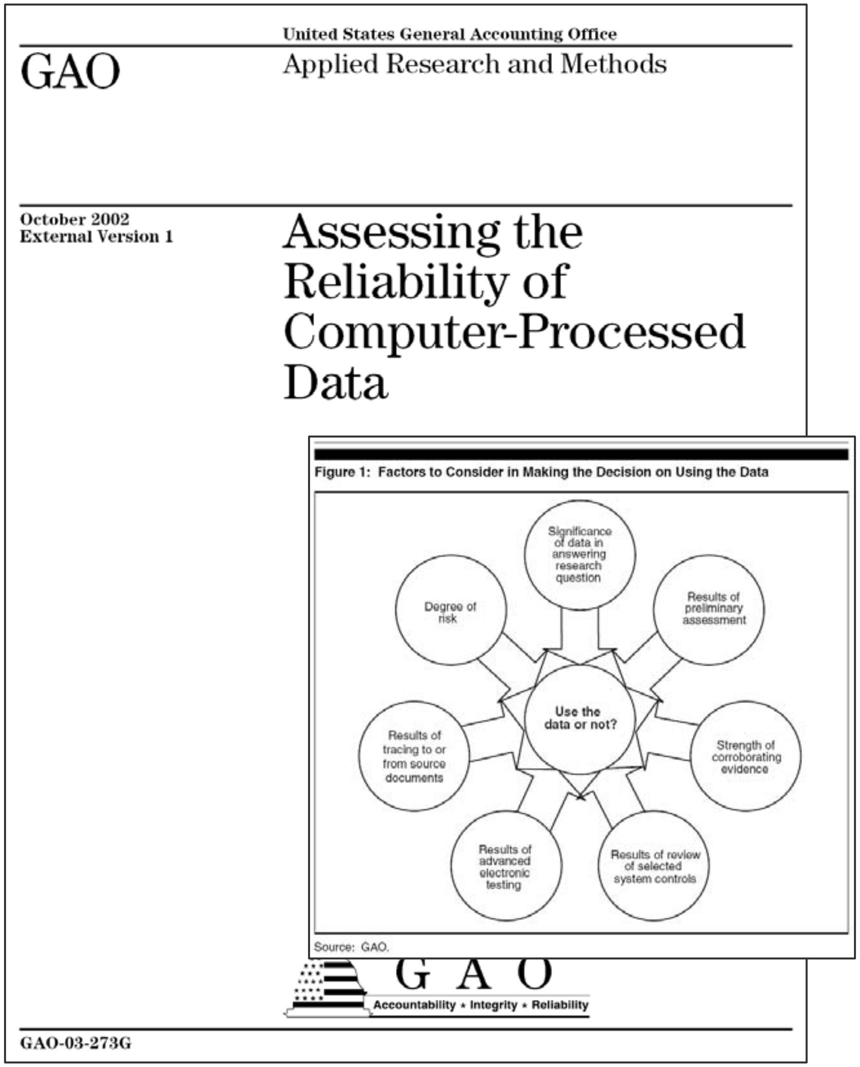


How Data Affects Modeling

Source: Applied Modeling and Simulation: An Integrated Approach to Development and Operation, David J. Cloud, Larry B. Rainy (editors), McGraw Hill, 1998

Homeland Security

Data (continued)


United States General Accounting Office

GAO

Applied Research and Methods

October 2002
External Version 1

Assessing the Reliability of Computer-Processed Data

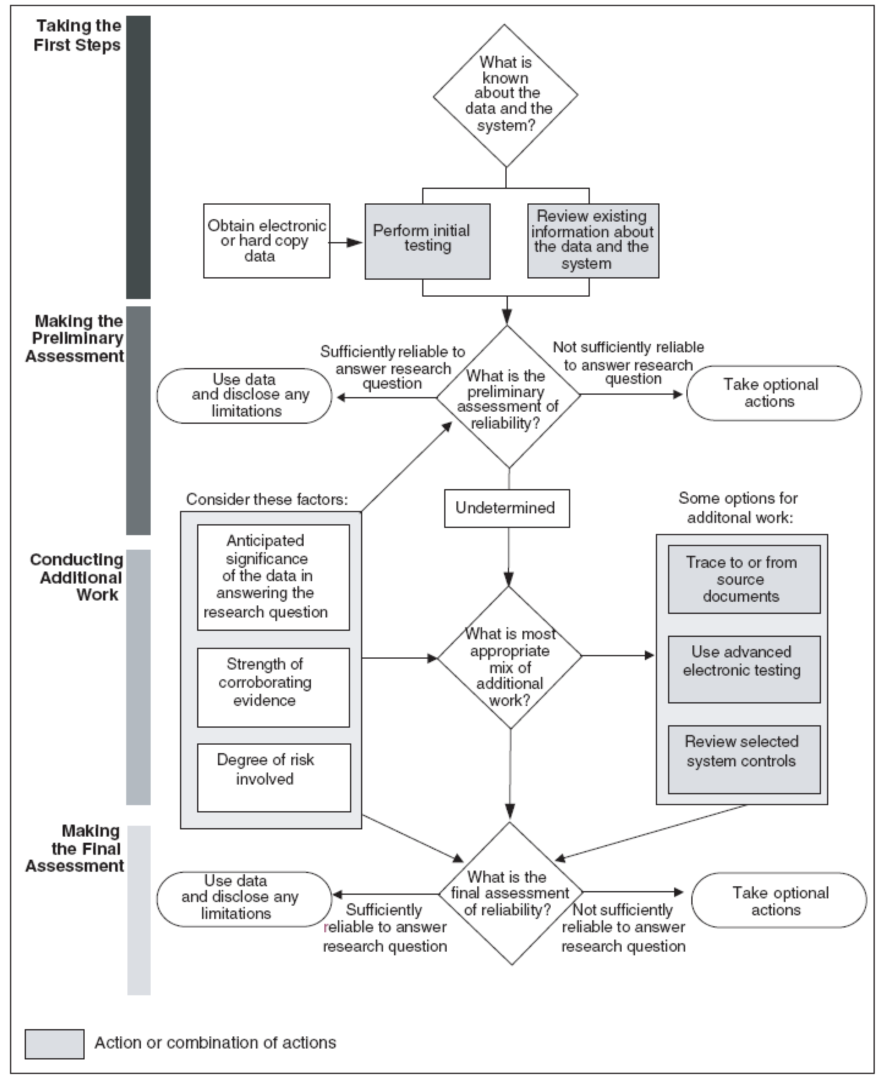
Figure 1: Factors to Consider in Making the Decision on Using the Data

Source: GAO.

G A O
Accountability * Integrity * Reliability

GAO-03-273G

Figure 3: Data Reliability Assessment Process



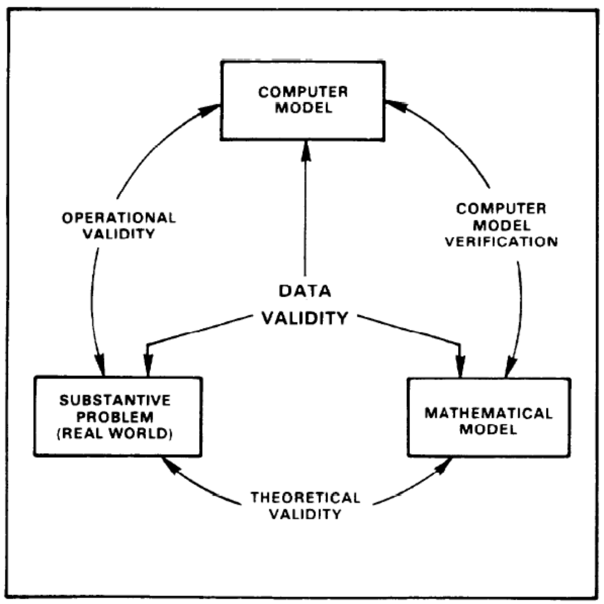
Source: GAO.

Evaluation

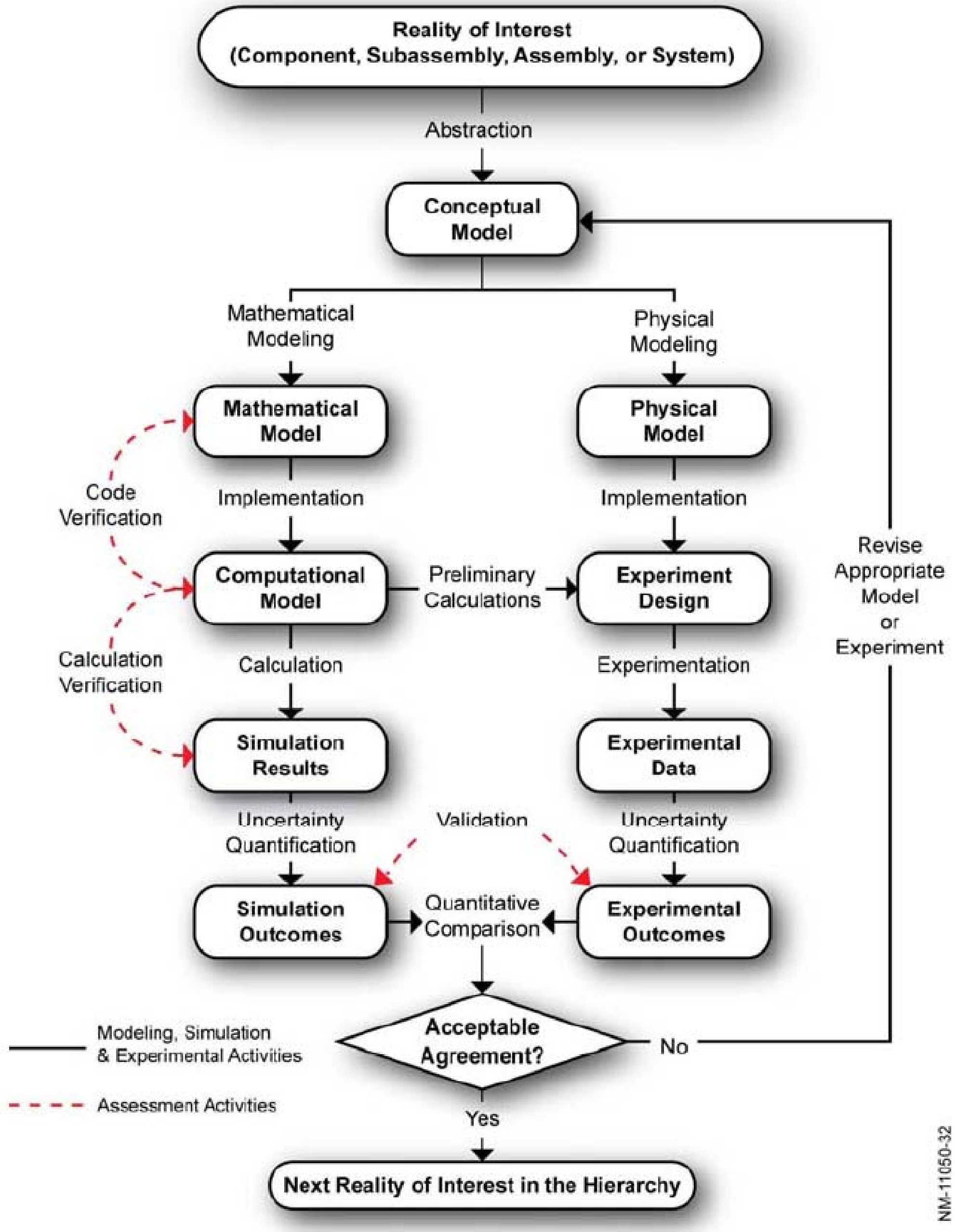
'All models are wrong, but some are useful.'

Source: Box, G.E.P., Robustness in the strategy of Scientific Model Building, in Robustness in Statistics, R.L. Launer and G.N. Wilkinson, Editors. 1979, Academic Press: New York

RELATIONSHIPS AMONG VALIDATION, VERIFICATION, AND MODELING PHASES



Source: Guidelines for Model Evaluation, GAO PAD-79-17, 1979



Source: Guide for Verification and Validation in Computational Solid Mechanics, ASME V&V 10-2006

Draft M&S Course Outline

What is a "Model", "Simulation", etc.?

How is M&S used for homeland security?

- National Infrastructure Simulation and Analysis Center (NISAC)
- National Atmospheric Release Advisory Center (NARAC)/ Inter-Agency Modeling and Atmospheric Analysis Center (IMAAC)
- Emerging Capabilities in DHS S&T Directorate

Who in DHS should consider using M&S?

When and where in DHS is M&S useful?

What are some considerations in acquiring M&S capabilities?

- Economics
- Development
- Data
- Evaluation

Why are M&S guidelines, standards, and "best practice" important for DHS?

How do other Federal agencies/organizations approach M&S?

Importance of Guidelines

UNITED STATES GENERAL ACCOUNTING OFFICE 0982

REPORT TO THE CONGRESS

AUG 25 1976

LIBRARY SYSTEM

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Ways To Improve Management Of Federally Funded Computerized Models

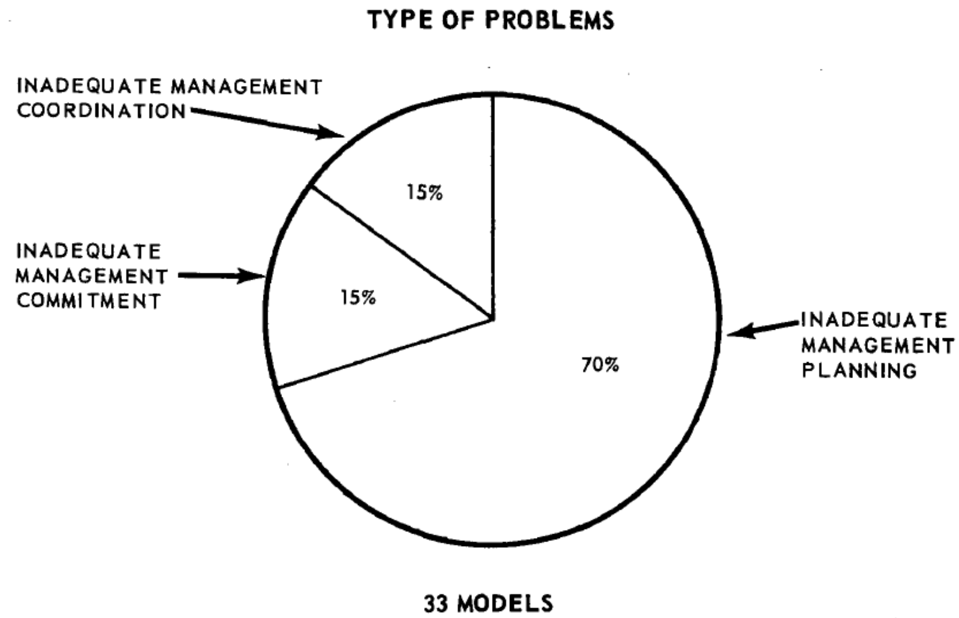
National Bureau of Standards
Department of Commerce
General Services Administration

The Department of Commerce needs to formulate standards for, and the General Services Administration should provide guidance to, Federal agencies for improving management of computerized models.

Because of the need for and absence of standards and guidance, GAO developed a phased approach which identified major activities necessary for planning, managing, and controlling computerized model development projects. Experienced model developers and users indicated considerable need for this type of general management guidance. The guidance should help to

--reduce wasted expenditures for models not used,
--reduce cost overruns, and
--initiate model development efforts that will better satisfy demands placed upon them.

LCD-75-111 703512 098203 AUG.23.1976



Five Phases Model Development

1. Problem definition
2. Preliminary Design
3. Detail Design
4. Evaluation
5. Maintenance

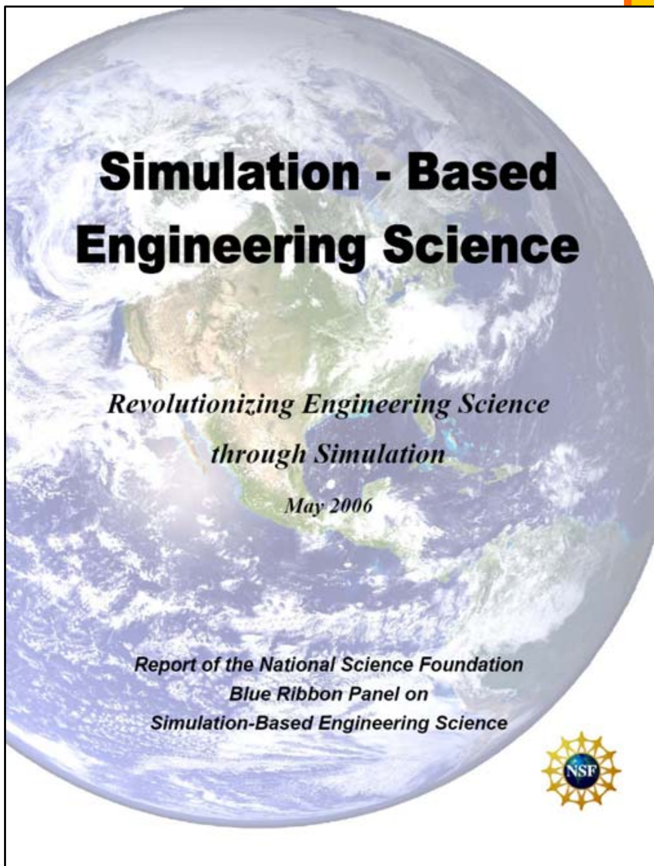
Homeland Security

Importance of Guidelines (continued)

M&S is an integral tool to support the DHS mission. Guidelines should:

- **Enhance Decision Maker confidence in M&S results**
- **Ensure M&S results meet requirements**
- **Promote integration and interoperability of tools**
- **Enable private sector and commercial involvement in developing homeland security tools**
- **Promulgate "best practice" from government and private sector experience**
- **Advance the maturity of M&S as a field of technology**

Importance of Guidelines (continued)



Major Findings

1. SBES is a discipline indispensable to the nation's continued leadership in science and engineering. It is central to advances in biomedicine, nanomanufacturing, homeland security, microelectronics, energy and environmental sciences, advanced materials, and product development. There is ample evidence that developments in these new disciplines could significantly impact virtually every aspect of human experience.

2. Formidable challenges stand in the way of progress in SBES research. These challenges involve resolving open problems associated with multiscale and multi-physics modeling, real-time integration of simulation methods with measurement systems, model validation and verification, handling large data, and visualization. Significantly, one of those challenges is education of the next generation of engineers and scientists in the theory and practices of SBES.

3. There is strong evidence that our nation's leadership in computational engineering and science, particularly in areas key to Simulation-Based Engineering Science, is rapidly eroding. Because competing nations worldwide have increased their investments in research, the U.S. has seen a steady reduction in its proportion of scientific advances relative to that of Europe and Asia. Any reversal of those trends will require changes in our educational system as well as changes in how basic research is funded in the U.S.

Draft M&S Course Outline

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- Evaluation

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How do other Federal agencies/organizations approach M&S?

Homeland Security

Some Federal Guidelines for M&S

Federal Activity	M&S Guideline or Policy		
	Development	Evaluation	Use
DoD	X	X	X
DOE/NNSA	X	X	X
EPA	X	X	X
FDA	X		
Federal Highway Administration	X	X	X
GAO	X	X	X
NASA	X	X	X
NOAA	X		X
NRC	X	X	X
USGS		X	X

Homeland Security

DoD

Acquisition Modeling and Simulation Master Plan

Department of Defense
Acquisition
Modeling and Simulation
Master Plan

April 17, 2006
Issued Under the Authority
of the
Systems Engineering Forum
Office of the Under Secretary of Defense (Acquisition, Technology and Logistics)
Defense Systems

Objectives

- Provide necessary policy and guidance
- Enhance the technical framework for M&S
- Improve model and simulation capabilities
- Improve model and simulation use
- Shape the workforce

Objective 1

Actions
1-1 M&S management
1-2 Model-based systems engineering & collaborative engineering environments
1-3 M&S in testing
1-4 M&S planning documentation
1-5 RFP & contract language
1-6 Security certification

Objective 2

Actions
2-1 Product development metamodel
2-2 Commercial SE standards
2-3 Distributed simulation standards
2-4 DoDAF utility
2-4(a) DoDAF 2.0 Acq'n Overlay
2-4(b) Standards for interchange
2-5 Metadata template for reusable resources

Objective 3

Actions
3-1 Acquisition inputs to DoD M&S priorities
3-2 Best practices for model/sim development
3-3 Distrib. LVC environments
3-3(a) Standards
3-3(b) Compliance
3-3(c) Event services
3-4 Central funding of broadly-needed M&S
3-4(a) Prioritized needs
3-4(b) Pilot projects
3-4(c) Expansion as warranted

Objective 4

Actions
4-1 Define M&S strategy
4-2 M&S best practices: planning & employment
4-3 Foster reuse
4-3(a) Business model
4-3(b) Responsibilities
4-3(c) Discovery
4-4 Info availability
4-4(a) Scenarios
4-4(b) Systems
4-4(c) Threats
4-4(d) Environments
4-5 VV&A
4-5(a) Documentation
4-5(b) Risk-basis
4-5(c) Examination
4-6 COTS SE tools
4-7 M&S metrics

Objective 5

Actions
5-1 Required M&S competencies
5-2 Commercial M&S lessons
5-3 Body of Knowledge for Acqn M&S
5-4 M&S education & training
5-4(a) DAU, DAG & on-line CLMs
5-4(b) Conferences, workshops & assist visits
5-5 MSIAC utility

Lead Responsibility for Actions

OUSD (AT&L):	1-1, 2-3, 2-5, 3-1, 3-2, 3-3(a), 3-4(a), 3-4(b), 3-4(c), 4-1, 4-3(a), 4-3(b) [co-lead], 4-3(c), 4-4(a), 4-5(a), 4-5(b), 4-7 [co-lead], 5-3, 5-5		
USD(AT&L)/DS:	1-2, 1-3 & 1-4 [co-lead], 1-5, 2-1, 2-2, 2-4.a, 4-2, 4-4(b), 4-5(c), 4-6, 5-1 [co-lead], 5-2, 5-4(b)		
ASD(NII):	1-6, 2-4(b), 4-3(b) [co-lead]		
DOT&E:	1-3 & 1-4 [co-lead]		
DIA:	4-4(c)	**DoD(CIO):** 2-2 [co-lead]	**DAU:** 5-1 [co-lead], 5-4(a) **USD(I):** 4-3(b) [co-lead]
Components:	3-3(b), 3-3(c)	**Dept of the Navy:** 4-7 [co-lead]	**DoD Modeling & Simulation Executive Agents (MSEAs) Terrain:** 4-4(d)

Figure 1: Acquisition M&S Objectives and Actions

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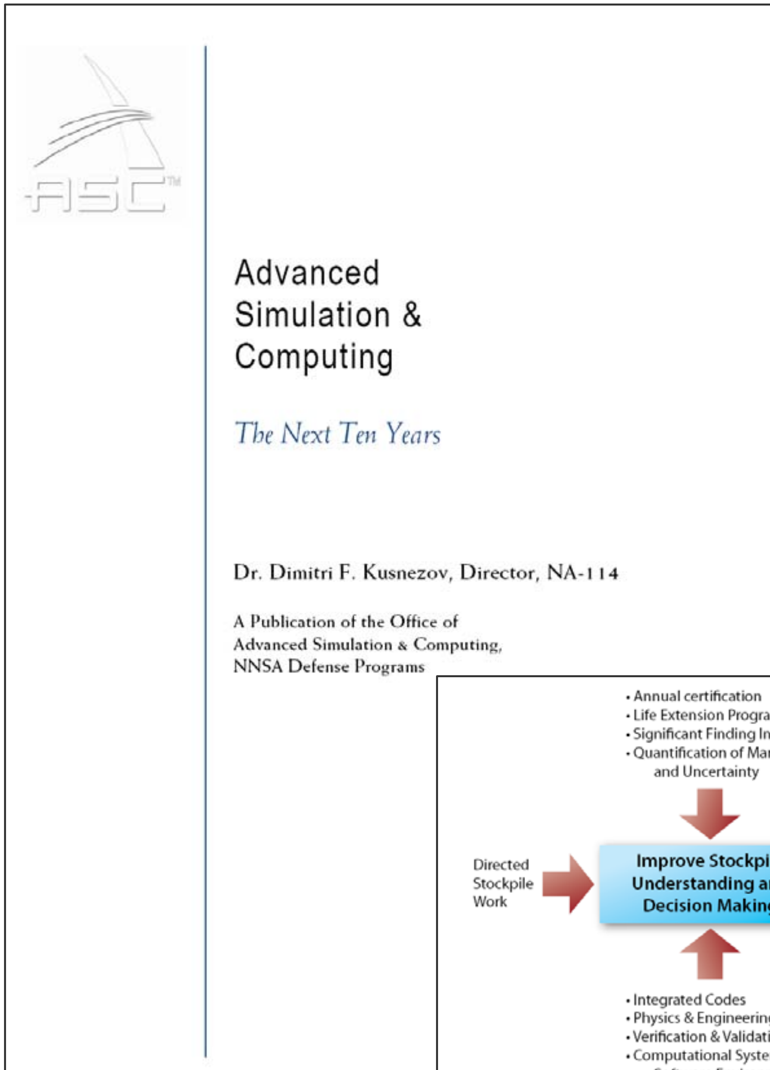
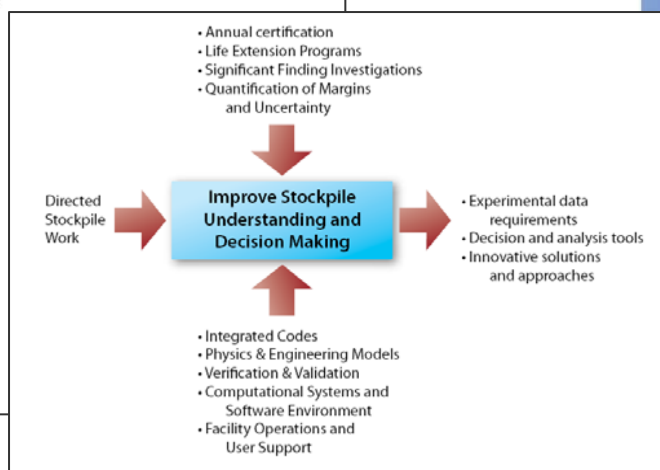
DOE/NNSA

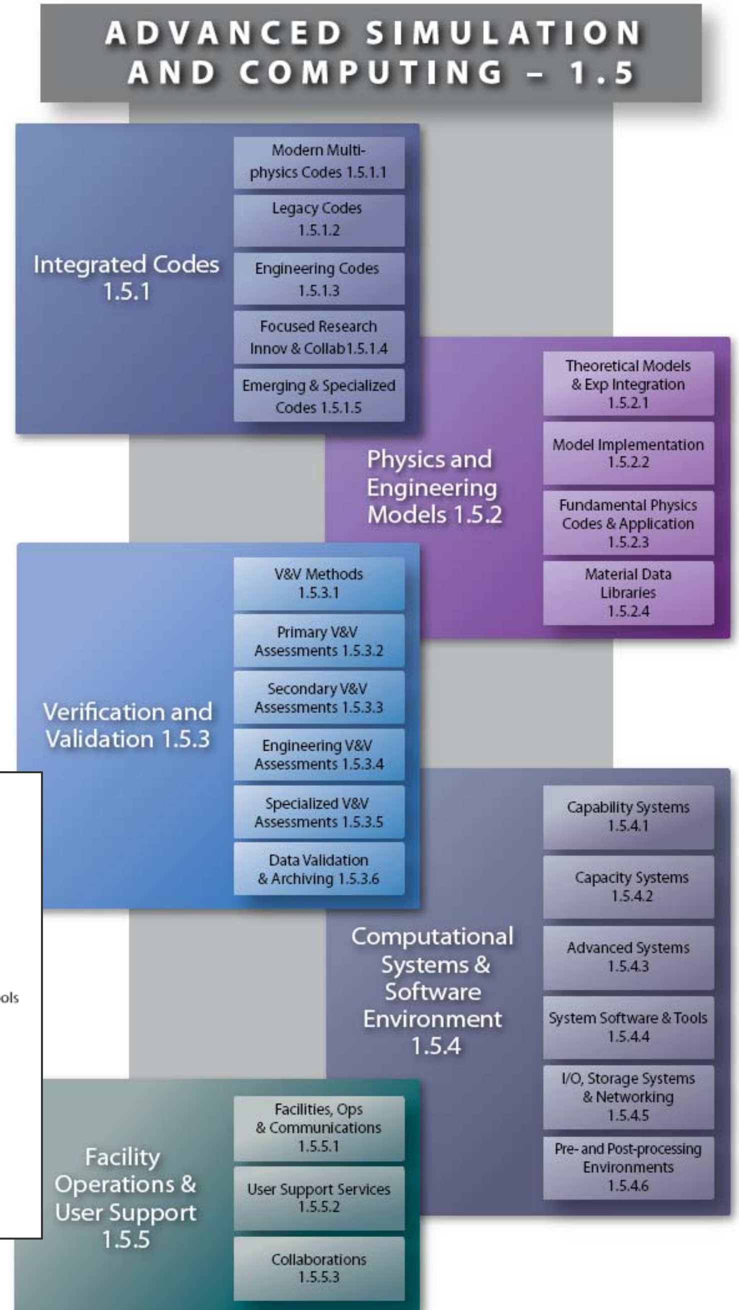

Advanced Simulation & Computing

The Next Ten Years

Dr. Dimitri F. Kusnezov, Director, NA-114

A Publication of the Office of Advanced Simulation & Computing, NNSA Defense Programs





Homeland Security

EPA

Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models

Prepared by:

The Council for Regulatory Environmental Modeling

Principal Authors:

Pasky Pascual   Neil Stiber   Elsie Sunderland

Office of Science Policy,
Office of Research and Development
Washington, D.C. 20460

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Jason West, OAR
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Joe Williams, ORD
Richard Winfield, R2
Tim Wool, R4
James Yarborough, R6
John Yearsley, R10
Larry Zaragoza, OSWER

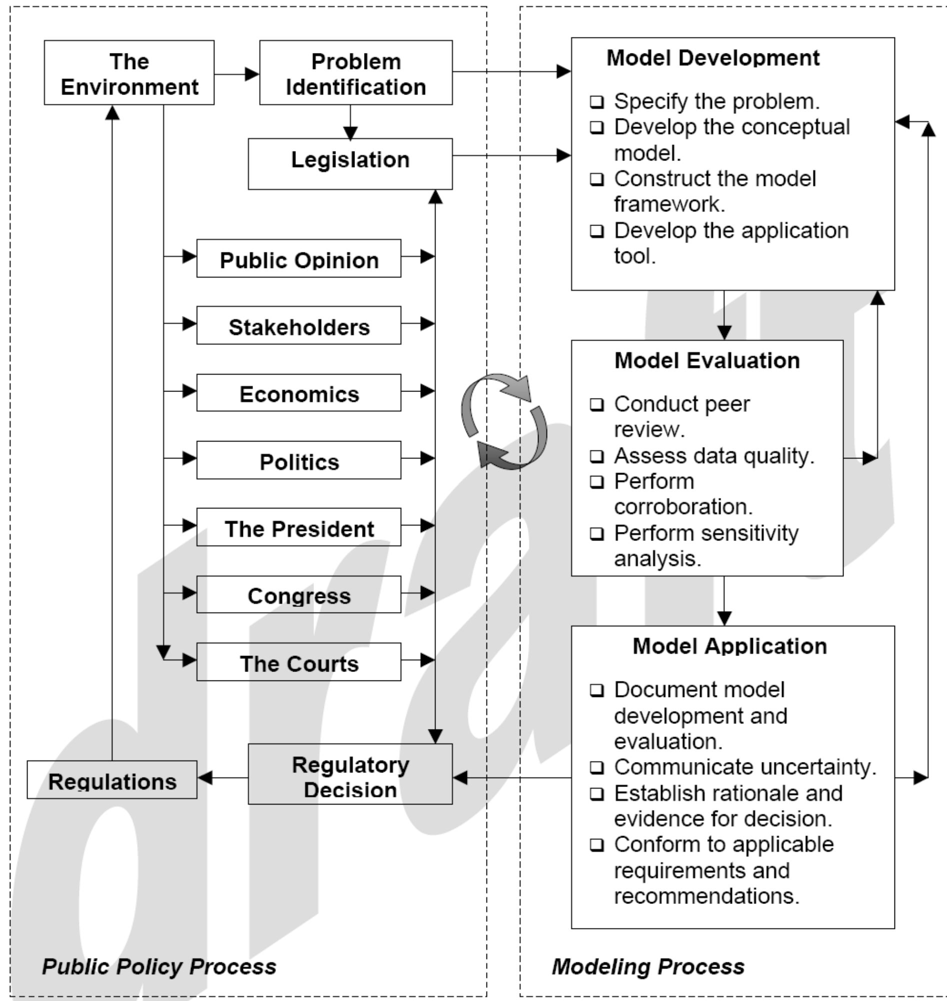

Figure 1. The Role of Modeling in the Public Policy Process. This guidance recommends best practices to develop, evaluate, and apply models that are to be used in the public policy process.

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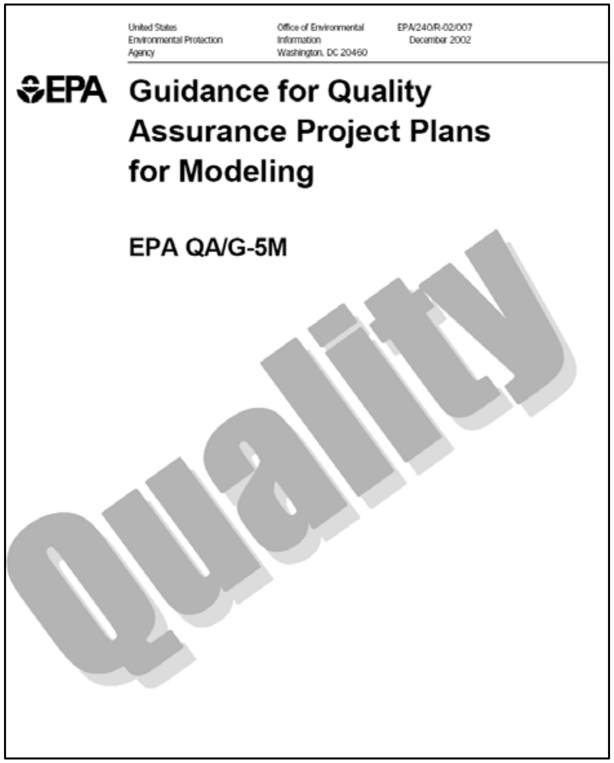
EPA


United States Environmental Protection Agency
Office of Environmental Information Washington, DC 20460
EPA/240/R-02/007 December 2002

EPA Guidance for Quality Assurance Project Plans for Modeling

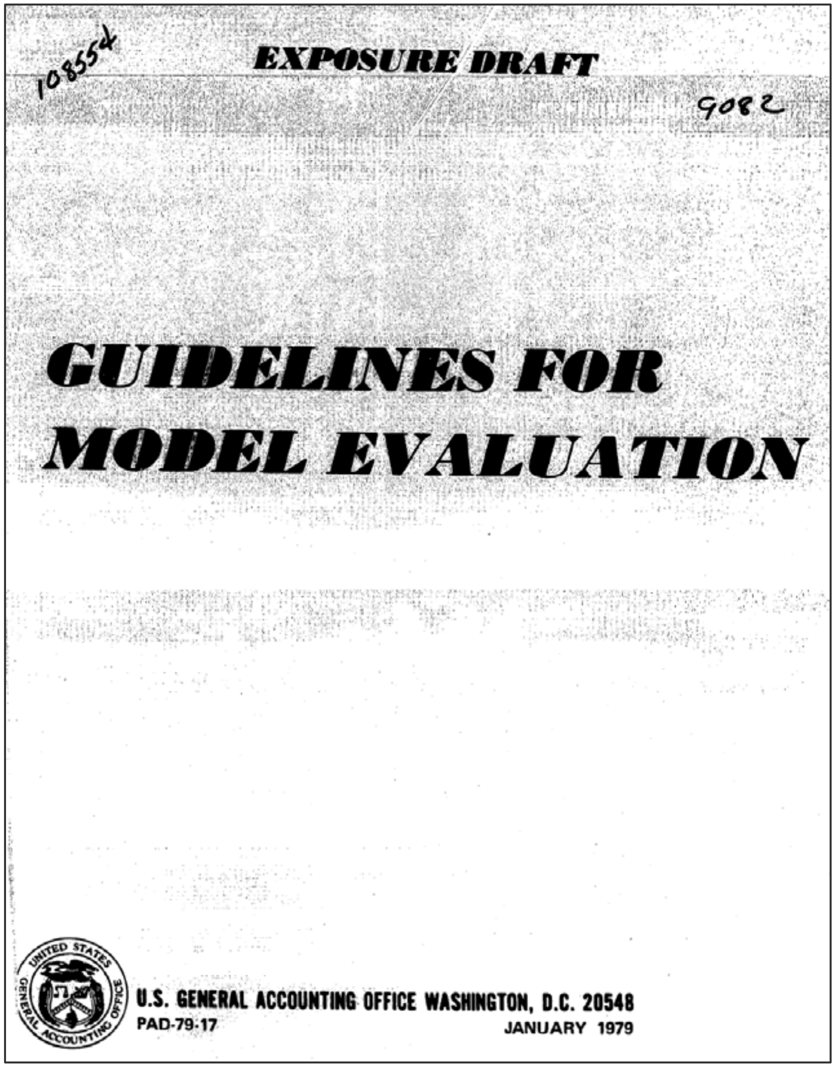
EPA QA/G-5M

Quality

Table 2. Examples of Modeling Projects with Differing Intended Uses

Purpose for Obtaining Model-Generated Information (Intended Use)	Typical Quality Assurance Issues	Level of QA
• Regulatory compliance • Litigation • Congressional testimony	• Legal defensibility of data sources • Compliance with laws and regulatory mandates applicable to data gathering	
•		
• Regulatory development • State Implementation Plan (SIP) attainment • Verification of Model	• Compliance with regulatory guidelines • Existing data obtained under suitable QA program • Audits and data reviews	
•		
• Trends monitoring (non-regulatory) • Technology development • “Proof of principle”	• Use of accepted data-gathering methods • Use of widely accepted models • Audits and data reviews	
•		
• Basic research • Bench-scale testing	• QA planning and documentation at the facility level • Peer review of novel theories and methodology	

GAO



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EXPOSURE DRAFT

9082

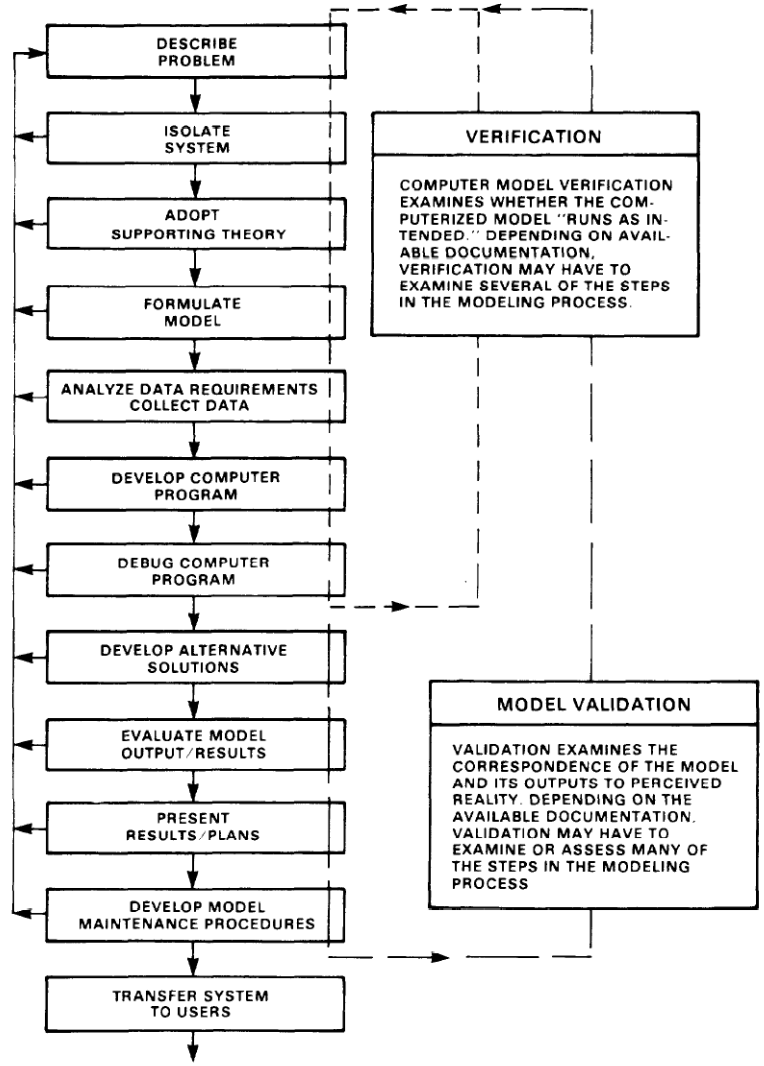
GUIDELINES FOR MODEL EVALUATION

U.S. GENERAL ACCOUNTING OFFICE WASHINGTON, D.C. 20548

PAD-79-17

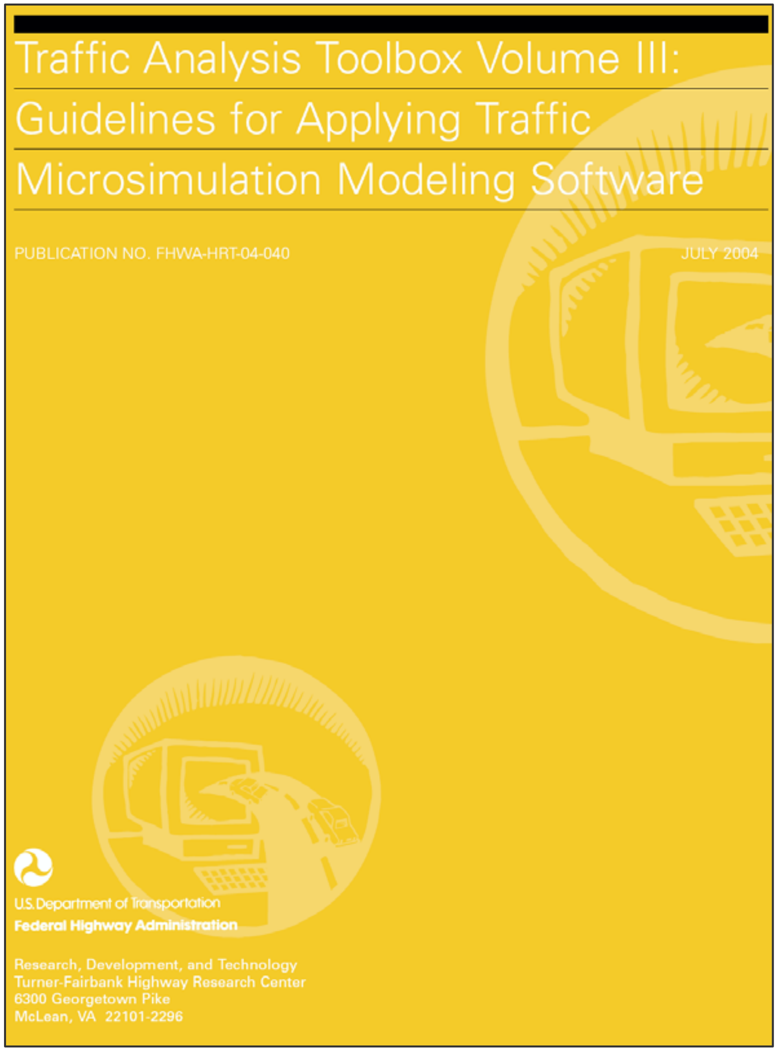
JANUARY 1979

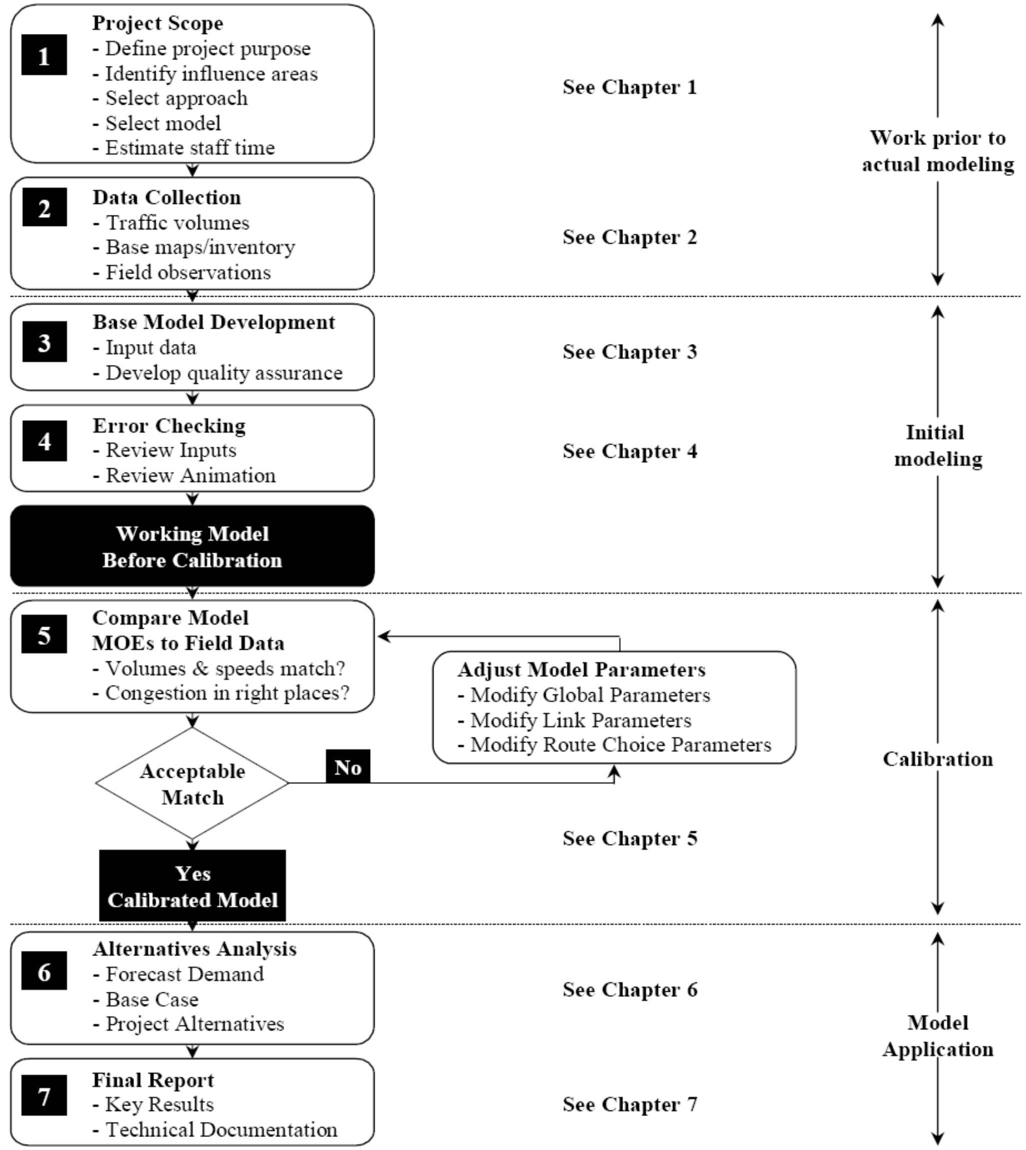
BASIC STEPS IN THE MODELING PROCESS



Homeland Security

FHWA





Developed by the FHWA Traffic Analysis Tools Team and later adapted from *Advanced Corsim Training Manual*, Short, Elliott, Hendrickson, Inc., Minnesota Department of Transportation, September 2003.

Figure 1. Microsimulation model development and application process.

Homeland Security

NASA

INTERIM NASA TECHNICAL STANDARD

National Aeronautics and Space Administration
Washington, DC 20546-0001

NASA-STD-(I)-7009

Approved: 12-01-2006

Expiration Date: 11-30-2011

STANDARD FOR MODELS AND SIMULATIONS

MEASUREMENT SYSTEM IDENTIFICATION:
NOT MEASUREMENT SENSITIVE

APPROVED FOR PUBLIC RELEASE – DISTRIBUTION IS UNLIMITED

This document represents the technical consensus of the developing group but does not yet have final NASA approval.

Table 1—Uses of M&S for Which the Standard is Required

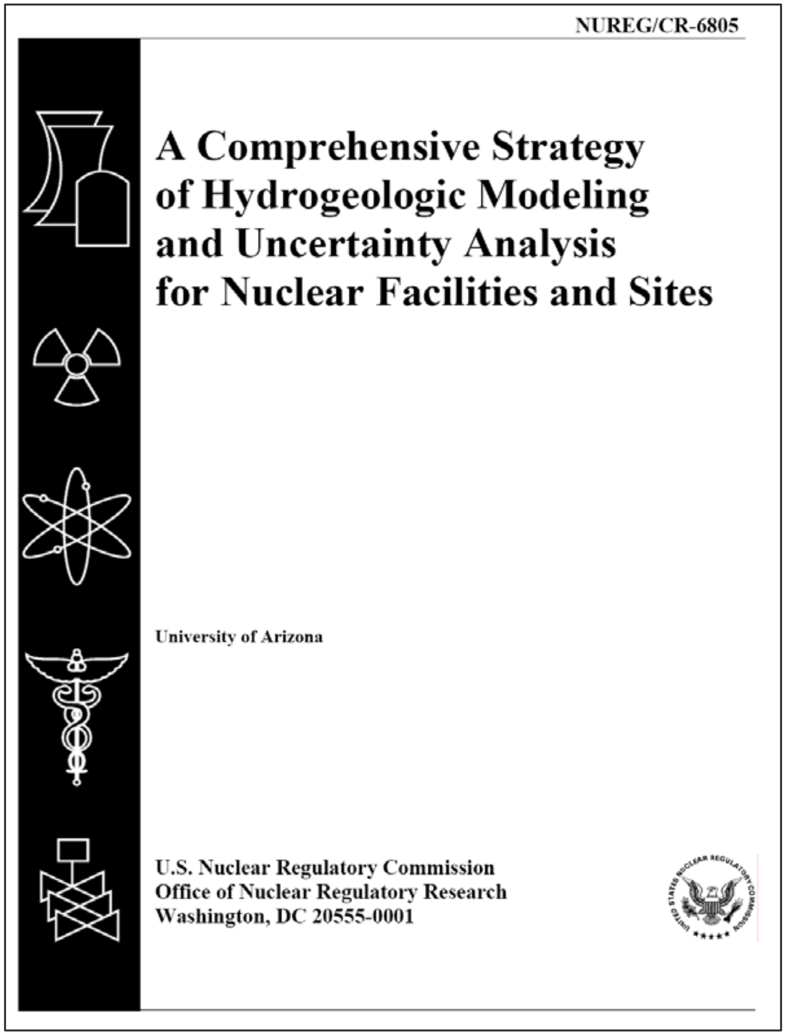
M&S Use	Description
Operations	Analysis of the status, anomalies, and corrective actions during mission operations/simulations.
Manufacturing, Assembly, Test, and Evaluation	Manufacturing/assembly/evaluation/verification of hardware and software artifacts. This includes the simulation environment of control systems and displays, e.g., the atmospheric properties and aerodynamic database for a flight simulator.
Design and Analysis	Evaluate and explore solution spaces for current and future systems and subsystems. This includes design and analysis performed to support acquisition decisions or mission planning.
Natural Phenomena Prediction	Whenever the simulation of natural phenomena is a NASA responsibility and used for operational decisions affecting safety and mission success, e.g., space weather forecasting.

Table 2—Uses of M&S for Which the Standard is NOT Required[1,2]

M&S Use	Description
Technology Investment	Identification and evaluation of candidate advanced technologies for future missions and systems.
Scientific Data Analysis	Processing of data collected by scientific instruments.
Scientific Understanding	Simulation of natural phenomena used for advancement of scientific knowledge.
Training and/or Education	Use of M&S to produce learning.
M&S Research	Conception, development, and evaluation of knowledge and practices for M&S.

Homeland Security

NRC



NUREG/CR-6805

A Comprehensive Strategy of Hydrogeologic Modeling and Uncertainty Analysis for Nuclear Facilities and Sites

University of Arizona

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

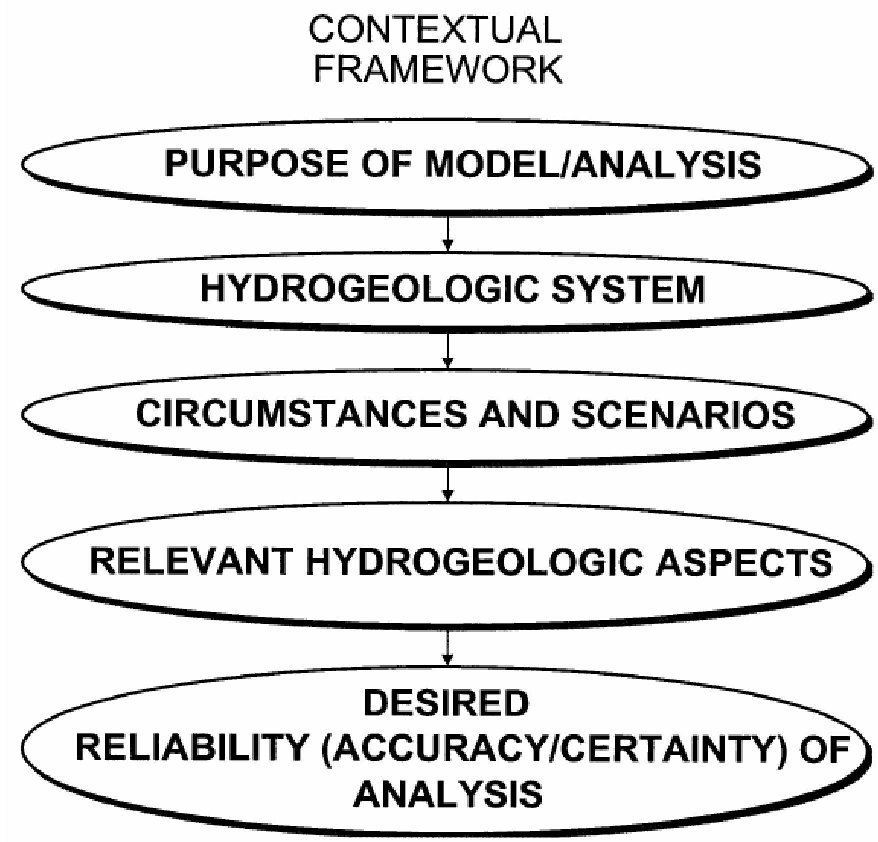


Figure 3-1. Contextual framework of modeling.

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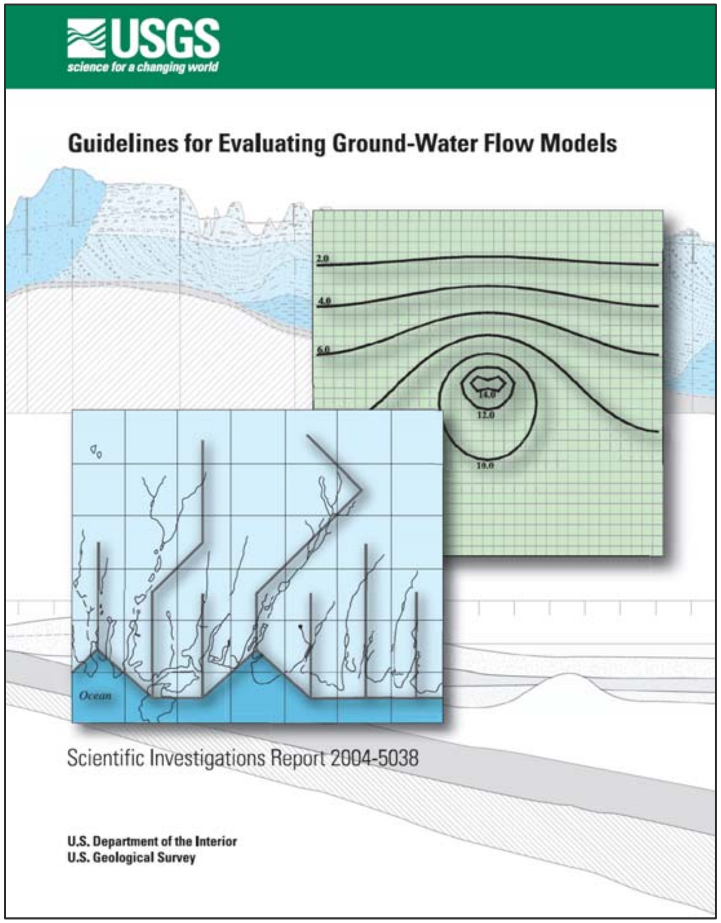
USGS


USGS
science for a changing world

Guidelines for Evaluating Ground-Water Flow Models

Scientific Investigations Report 2004-5038

U.S. Department of the Interior
U.S. Geological Survey

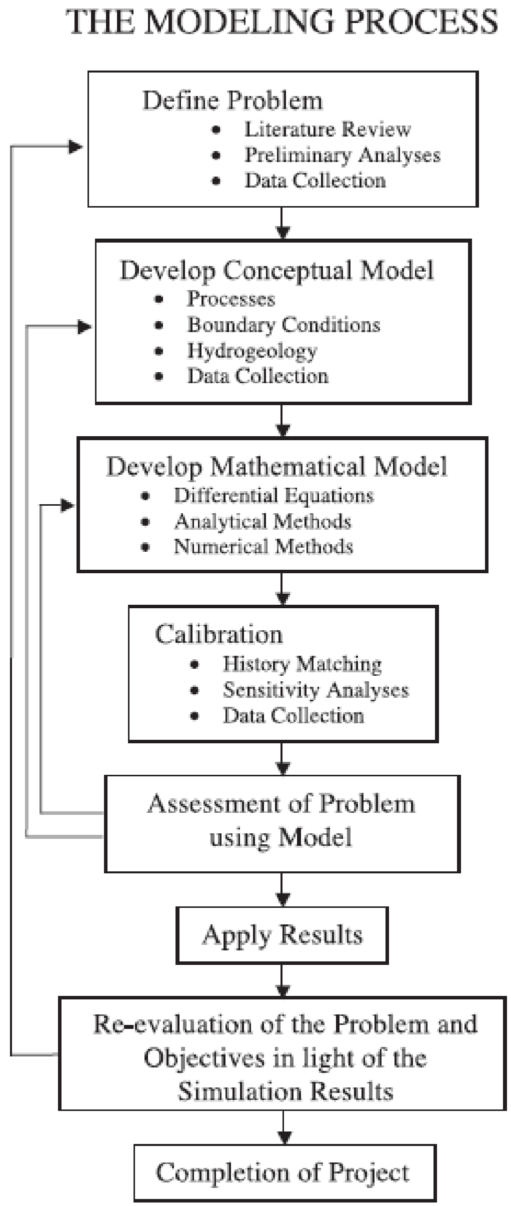


Figure 12. Flow chart of the ground-water flow modeling process. (From Reilly, 2001.)

Homeland Security

U.S. DEPARTMENT OF HOMELAND SECURITY

Homeland
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