

MODELING and SIMULATION IMPACTS COMPLEX DESIGN and PROGRAMMATIC DECISIONS

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The Guardian Installation Protection Program (IPP), a program within the Joint Program Executive Office for Chemical and Biological Defense to protect 200 military installations world-wide from chemical, biological, and radiological (CBR) threats, developed and accredited the IPP System Effectiveness Model. This model is composed of a set of modeling and simulation tools to help evaluate installation designs and make programmatic decisions.

This suite of tools, called the Homeland Defense Analysis Toolkit (HDAT), was developed by Booz Allen Hamilton, Inc., (BAH) under the IPP technical support contract for Modeling and Simulation System Effectiveness. The HDAT assists a product manager to make a myriad of acquisition and design decisions and measure the performance of a design before it is fielded. By catching key design flaws before they are fielded, HDAT can perform analysis to help define alternative operational procedures and new design requirements early in the acquisition process and avoid fielding delays and unexpected costs. This innovative toolset is the first of its kind that has the ability to effectively model complex military environments, multiple threats, and innovative designs that combine materiel (e.g. sensors, warning systems, etc.) and non-materiel components (i.e. operational procedures, training, and exercises) into one Family of Systems (FoS).

Acquiring, designing and fielding an IPP FoS capable of protecting military installations from chemical, biological, and radiological threats is a challenge that has been laid out by various requirements to include the Department of Defense directive 2000.12 "DoD Antiterrorism Programs," 18 August 2003. The goals of the IPP are to ensure continuity of operations of critical missions, protect installation personnel and restore the essential functions of an installation. To meet those goals, the Guardian program relies on a FoS that consists of:

- CBR detection equipment
- Warning systems
- Collective Protection
- Individual Protective Equipment
- Information Management / Decision Support Systems
- Response Operating Procedures
- Training & Exercises

Two of the challenges facing IPP are to design a cost-effective FoS solution and to determine how this tailored FoS will improve upon the current operational capabilities and procedures at the installation. The Joint Project Manager, Col. Camille Nichols, adopted a decision support methodology that utilizes a suite of computer simulations to help perform this analysis.

The HDAT was designed to be easily modified, incorporate the materiel solutions chosen by the program and represent the impacts of operational procedures (CONOPS) and training on installation protection. To reduce development cost and maximize confidence in the results, HDAT was designed to incorporate government and commercial-off-the-shelf (COTS) modeling software as much as possible consisting of validated threat plume models Hazard Prediction & Assessment Capability (HPAC), Vapor Liquid Solid Tracking Model (VLSTRACK), and Areal Locations of Hazardous Atmospheres (ALOHA). The use of one modeling software versus another is dependent on the type of threat scenario being modeled. The use of Extend®, a COTS tool used to create the Response Effectiveness Model (REM), allows for easy modification of the model and accounts for variations in threats (CBR), base/facility geography, design, and service specific policy and operating procedures, to enable a quick turn around analysis of any installation.

The REM, a discrete event Monte Carlo simulation, depicts

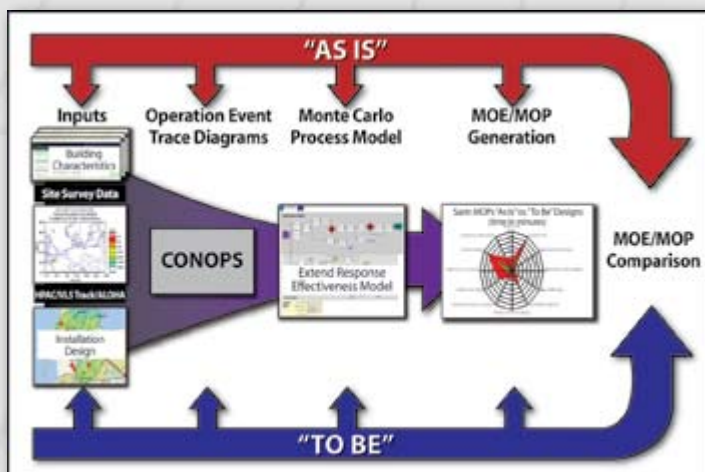


Figure 1. The System Effectiveness Process Using HDAT

the 'race against the clock' to detect, warn and protect populations, before they succumb to the effects of CBR agents. Figure 1 is a representation of how HDAT is used to determine the system effectiveness of FoS designs for an installation. The end product is the comparison of Measures of Effectiveness (MOE) and Measures of Performance (MOP) of the installation prior to Guardian IPP, "As Is" and after, represented by the "To Be" Design.

This process incorporates multiple CBR worst case attack scenarios, the physical geometry and attributes of the installation, and the design of the installation. The design, however, is not limited to the physical components of the system such as sensors, individual protection and collective protection. It also incorporates operational procedures and performance improvements due to training and advanced warning to mitigate the threat of a CBR attack. These procedures and associated times to complete these procedures are captured in event trace diagrams that ultimately are the basis of design of the REM. These event trace diagrams are unique for each design and threat.

The REM utilizes simulated plume data generated for the appropriate threat scenario to estimate the exposure of personnel based on their location relative to the plume (Figure 2) and incorporates how they would respond to the incident. This response includes the time it takes the installation to detect the threat, warn its respective populations, take protective action and begin treatment. This



Figure 2. Example of Persistent Chemical Plume Dispersion

time-space-operational procedure sensitive exposure is the basis for determining if a member of a given population is a fatality, severe casualty or mild casualty. These casualties are estimated using the latest casualty estimation methods outlined in the Potential Military Chemical/Biological Agents and Compounds Field Manual (FM 3.11-9) adopted by each of the U.S Armed Services in June 2004.

In addition to casualties, other operational metrics are calculated by the REM. Estimates of the number of critical missions that have become inoperable due to the CBR event are calculated, as well as stochastic measures of the time it takes the installation to detect, make a decision, warn, protect

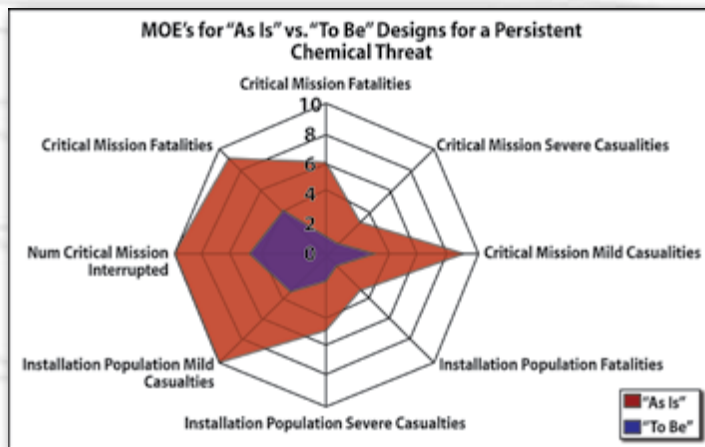


Figure 3. Example Radar Plot Representation of Measures of Effectiveness (MOE)

and begin treatment. These metrics combined with casualty metrics create a complete picture of system performance and are calculated for the current state of the installation ("As-Is") and compared against the IPP ("To-Be") design for identical threats (see figure 1). The As-Is and To-Be are displayed together in the form of 'radar plots' (Figure 3). These plots allow Guardian to easily identify the benefit of the program on each particular installation for each type of threat.

System effectiveness analysis is not the only type of analysis for which the IPP has used HDAT. Some examples of others studies include trade studies to compare the performance with alternate configurations, studies to determine which components in the FoS design provide the most benefit to the installation and sensitivity analysis to drive component design. Rapid analysis capability like this allows the Project Manager and her staff to make informed programmatic and design decisions with an analytic basis, measure the value of her program and be adaptable to swift programmatic change.

Modeling and simulation is used extensively by the IPP not only for engineering design, but also for programmatic purposes. Analysis based upon modeling and simulation runs are used to measure the system effectiveness of a candidate design before it is fielded, drive FoS designs, and to test alternative capabilities and procedures in the face of programmatic uncertainty. By incorporating modeling and simulation in the design process, the IPP has saved money and increased the effectiveness of FoS designs that will significantly reduce fatalities, casualties and critical mission interruptions in the event of a CBR attack.

In October 2005, the IPP System Effectiveness Model underwent the Verification, Validation, and Accreditation (VV&A) process judged by a panel of multiple DoD agencies. The System Effectiveness Model obtained final approval by the JPMG in December 2005. This major milestone provided the project manager with added flexibility allowing the use of this accredited tool to make faster and more accurate acquisition decisions. 