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UCRL-CONF-216425

Risk Assessment Using The Homeland-Defense Operational Planning System (HOPS)

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October 21, 2005

Safety and Security of Energy Infrastructures - A Comparative View
Brussels, Belgium
November 14, 2005 through November 16, 2005

Updated October 14, 2003

Risk Assessment Using The Homeland-Defense Operational Planning System (HOPS)

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Abstract – *The Homeland-Defense Operational Planning System (HOPS), is a new operational planning tool leveraging Lawrence Livermore National Laboratory's expertise in weapons systems and in sparse information analysis to support the defense of the U.S. homeland.*

HOPS provides planners with a basis to make decisions to protect against acts of terrorism, focusing on the defense of facilities critical to U.S. infrastructure. Criticality of facilities, structures, and systems is evaluated on a composite matrix of specific projected casualty, economic, and sociopolitical impact bins. Based on these criteria, significant unidentified vulnerabilities are identified and secured. To provide insight into potential successes by malevolent actors, HOPS analysts strive to base their efforts mainly on unclassified open-source data. However, more cooperation is needed between HOPS analysts and facility representatives to provide an advantage to those whose task is to defend these facilities.

Evaluated facilities include: refineries, major ports, nuclear power plants and other nuclear licensees, dams, government installations, convention centers, sports stadiums, tourist venues, and public and freight transportation systems.

A generalized summary of analyses of U.S. infrastructure facilities will be presented.

I. INTRODUCTION

Lawrence Livermore National Laboratory (LLNL) is one of the USA's former nuclear weapons design laboratories. It is now a top research and development site, with unique expertise.

The Homeland-Defense Operational Planning System (HOPS) is a new operational planning tool which leverages LLNL expertise in analysis for protection of critical infrastructure to support the defense of the U.S. homeland. The HOPS Program provides a powerful base of data and engineering tools for assessing critical infrastructure facilities. The close organizational connection between existing LLNL programs and HOPS permits managers to readily leverage LLNL's analytic expertise as well as technologies and analytic tools as they become available. The analyses that the HOPS program requires have their own specific attributes, and additional experts have been brought in to meet these demands.

HOPS primary customers are the National Guard and USNORTHCOM. HOPS has been vetted in several state and national level exercises. HOPS has also been recognized by multiple organizations as being superior to existing planning tools.

HOPS provides planners with the basis to make decisions to defend against acts of terrorism, focusing on the defense of facilities critical to the infrastructure of the United States and its territories, as well as critical elements within these facilities. HOPS is currently involved in assisting multiple states as they establish their Protection of Critical Infrastructure plans. The program further provides strategic planners with a means to seamlessly communicate with other elements associated with defense and emergency response, and provides computer-based tools to support planning and response activities. HOPS has been an integral part of several exercises involving response to postulated WMD events in the United States.

II. Structure Of HOPS Analyses

There are four major aspects to the program:

- Criticality assessments of high value facilities. These assessments provide high-resolution analyses that identify the specific attributes of a facility that make it critical as well as its impact to the nation or state were it to be compromised.
- Vulnerability assessments of critical infrastructures associated with industry, agriculture, transportation, government/military installations, and large public structures such as sports arenas and convention centers. When

appropriate, these assessments involve systematic analyses of the infrastructure to identify single points of failure and other critical nodes.

- A robust communications network that enables strategic planners engaged in homeland-defense to access the HOPS database to make decisions for strategic planning, and to communicate with subordinate and parallel organizations engaged in homeland-defense and to emergency responders in the event of an attack. HOPS is designed to reach its analysts directly at their work desks by operating on whatever classified or unclassified networks are required, including JWICS and SIPRNet (secure communications networks used by the Department of Defense).
- Analytic tools, such as three dimensional atmospheric plume modeling that utilizes real time wind conditions and conflict simulations that model the effectiveness of security plans. HOPS is also able to integrate with current data sets maintained by cities, counties or other jurisdictions. In this way organizations can leverage data that is already being maintained without requiring additional effort or resources.

II.A. Criticality Analysis Methodology

Criticality analysis attempts to prioritize infrastructure elements within a given area or sector of interest by the magnitude of the impacts created by the element's destruction or disablement. The ranking is performed based on "element criticality," defined as a function of the magnitude of potential casualties, economic impacts, and sociopolitical impacts.

In reality, the element's criticality is affected, to some degree, by the cause of damage – for example, the sociopolitical effects of a terrorist attack resulting in the destruction of an airport terminal will be very different from those same effects resulting from the collapse of the terminal due to poor structural design. However, one must also keep separate the magnitude of effect due to the specific attack mode compared to the effect posed by the element. Any attack has an effect. Criticality analysis attempts to identify those elements that by their very nature magnify the effect of attack. Examples include national monuments and facilities storing large quantities of hazardous materials.

Vulnerability is a function of accessibility, attack deterrence capability (security measures, protective force), and the element's "hardness" or physical ability to withstand the attack or contingency stress. In a HOPS analysis, the criticality of an element is not influenced by its vulnerability. For example, a sports arena is always critical as a high value terrorist target because of the potentially high casualty rate regardless of the security and protective measures deployed.

It is assumed that a terrorist organization will consider the vulnerability of a target in a way that matches their available resources and capabilities with feasible interdiction or defeat modes. This would be done separately from assessing the criticality or value of the target that is, in turn, dependent only on the extent of potential casualties, economic impacts, and sociopolitical impacts, as discussed below.

Facilities deemed to be highly critical yet invulnerable, as well as facilities not critical but highly vulnerable, may not be of significant concern to homeland defenders. In both cases the interest may not be relevant, but it is the broad mix between these two extremes upon which HOPS focuses its efforts.

Casualties

Typically, the extent of casualties is thought of as "body count" resulting from explosion, fire, flood, structural collapse, or exposure to toxic chemical, radiation, chemical warfare agent, or biological agent.

A separate consideration is to distinguish between the casualties related to the type of a terrorist assault device used and the casualties that are related to the inherent characteristics of the infrastructure element. In a HOPS analysis, the focus is primarily on the effects stemming from the inherent characteristics of the infrastructure element being analyzed and not on the effects of different types of assault devices or modes of interdiction.

Key considerations in assessing the potential extent of casualties are:

- Type and quantity of hazardous materials stored or processed onsite, or those used in the attack
- Presence of materials that, upon purposeful contamination and subsequent consumption, can result in significant health impacts to offsite population – for example, a food processing plant could be of high value as a target for a surreptitious terrorist attack involving poisoning of the food or its ingredients.
- Number of people or workers present in the immediate impact area
- Proximity to population centers downwind of the impact area
- Population density of the affected downwind areas

Some cases may require additional modeling of thermal effects, blast overpressure effects, or atmospheric dispersion. A wealth of information that is needed for casualty assessment is available in open source literature and the public domain.

Economic Impacts

In HOPS analyses, a distinction is made between direct and indirect economic consequences of an attack. Key considerations in assessing direct economic impacts are as follows:

- Damage repair/restoration cost
- Lost revenue and profit due to disruption of element's operations
- Value of lost inventory or intrinsic value of damaged goods

Key considerations in assessing indirect economic impacts are:

- Duration of damage restoration effort
- Upstream and downstream ripple effects
- Effects of changes in customer spending patterns
- Loss of jobs
- Healthcare costs
- Government expenditures (emergency services, security, protection, etc.)
- Loss of efficiencies in patterns (road detours, makeshift offices etc.)

Indirect impacts also include changes in purchasing or spending patterns resulting from public fear – for example, both airline and tourism industries were severely impacted worldwide by the events of 9/11. In the nuclear power industry, direct costs associated with damage or destruction of a nuclear power plant will include the cost of replacement part procurement, installation and reconstruction. Indirect costs primarily include the cost of replacement power, which could be on the order of a million dollars per day.

While direct costs can be estimated with fair accuracy for most cases using standard techniques, the indirect costs are generally more difficult to estimate owing to the complexities involved and current unavailability of reliable models.

Sociopolitical Impacts

One of the main objectives of a terrorist organization is to instill widespread fear, anxiety, or outrage leading to instabilities and disruptions in the normal functioning of a society. Such instabilities and disruptions may take the form of reduced productivity, introduction of freedom-curtailing security measures, pressure on government to conform to the terrorists demands, and attendant changes in the laws, political climate, foreign policy, and even military actions abroad.

Assessing sociopolitical impact is the most difficult aspect of criticality because of the complexity and uncertainties involved in determination of specific potential consequences (especially long-term consequences), lack of clear metrics, and inherent reliance on subjective judgment of the analyst(s) in dealing with many intangible factors. In assessing sociopolitical consequences, the analyst must also consider loss of life and economic effects, past societal responses, political climate, and symbolic value of a target to the society and to terrorists.

II.B. Criticality Assessment Methodology

The criticality assessment methodology encompasses the following steps:

1. Gather and review relevant information about the competing infrastructure elements within a given venue.
2. Eliminate those elements that are clearly of negligible criticality (i.e., those elements where the potential casualty rate, economic impacts, and sociopolitical impacts would be insignificant).
3. Systematically assess the remaining elements using both qualitative and, if at all possible, quantitative arguments.
4. Conduct a critical review of the draft assessment by qualified peer reviewers.

Each element is assessed and rated with regard to each category (casualties, economic impacts, and sociopolitical impacts) in terms of high, moderate, low, or minor impact. The following table provides abbreviated **example** criteria for these categories:

TABLE I. Example Criticality Metrics

METRIC	HIGH	MODERATE	LOW	MINOR
Casualty	≥ 5000 deaths	200 – 5000 deaths	1 - 200 deaths	No deaths
Economic	≥ $1 billion	$100 m - $ 1 billion	$10 m - $100 m	≤ $10 million
Sociopolitical	#1-3 in nation or world	Top 10 in nation	Multi-city impact	Local impact

A short narrative documents each assessment and provides the rationale and supporting discussion for the ratings assigned. The overall criticality of the element is then based on the individual criteria ratings and is generally the same as the highest individual criteria rating.

Facilities that are assessed as highly critical are then subjected to analysis at the facility level to identify those specific systems, equipment, or elements that, upon failure, would disable the functioning of the entire facility over a long time, cause the release of hazardous materials, cause fire or explosion, or instill widespread public fear. The focus of a facility-level analysis is to identify the critical equipment or systems within the facility that result in greatest impact or effect.

II.C. Analyses

The facilities considered in HOPS are grouped into five major categories:

- Agriculture
- Industry
- Military/Government
- Sports/Civic
- Transportation

These categories were derived from Department of Homeland Security Sectors and Department of Commerce listings. They were consolidated and grouped into the five sectors based on input from the State level Critical Infrastructure lists.

III. Example Analysis Summaries

Facilities evaluated to date include refineries, major ports, nuclear plants and other nuclear material users, convention centers, sports stadiums, dams, transportation facilities, government installations, and public transportation.

Typically, risk and reliability analyses of nuclear power plants have focused on prevention of damage to the reactor core and resultant releases of radioactive material, and vulnerability analyses focus on physical security measures, i.e., “gates and guards”. However, this approach fails to recognize the high symbolic value resulting from an attack on a nuclear power plant, regardless of actual damage caused by the attack. Furthermore, any disruption of plant operation would result in a significant economic impact due to factors such as repair costs, replacement power costs, etc.

As introduced above, our analyses of domestic nuclear power plants were based solely on open source data found on the internet and other publicly available resources. This material included basic descriptions of the facilities, documents from public hearings regarding environmental and regulatory issues, up to a complete set of operator system training guides. A generic analysis summary is presented below to illustrate the HOPS structure and methodology.

The analysis presentation starts with an overview of the facility listing major systems and components, as well as a satellite image and color-coded schematic that summarizes the criticality analysis for the facility, with red signifying the most critical. If there are important subsystems or structures in the facility, the schematic also allows the user to navigate to the desired analysis.

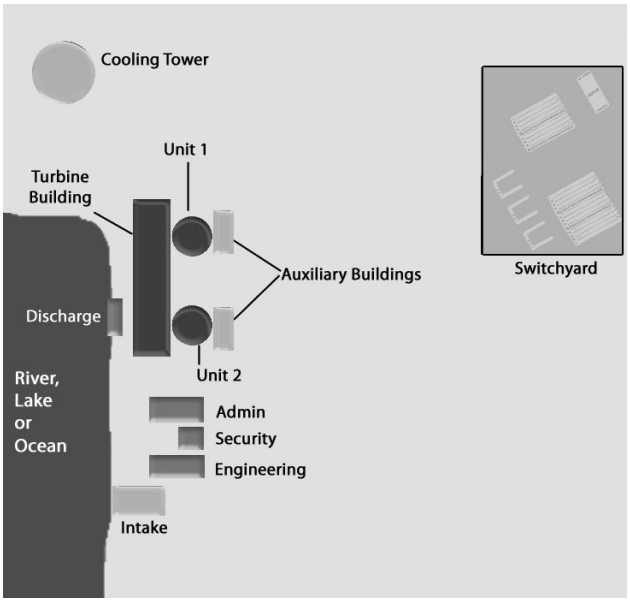

Fig. 1. Example Nuclear Facility

In the case of the generic nuclear facility depicted above, the two reactor containment buildings are deemed highly critical structures. Most would expect this to be the case from a casualty standpoint. However, although irradiated fuel is extremely hazardous, the robustness of the reactor vessel and the containment buildings themselves leads to a moderate criticality rating from a casualty standpoint. Rather, it is the economic impact that leads to high criticality. If the containment structures and major systems within them were damaged, the replacement time is judged to be significantly longer than other structures and systems at the plant, and the resultant costs for replacement power – on the order of a million dollars a day – would be significant. The turbine building is also highly critical, primarily due to economic concerns.

Once the most important structures have been identified, protective actions and other mitigation measures may be put in place. In some cases, systems or structures that were not previously identified as important may need additional security and mitigation measures.

In addition to nuclear power plants, HOPS has provided analyses of convention centers. Again the analysis presentation starts with an overview of the system showing floor plans and major components of the facility, such as utilities, air intakes and emergency generators. In the case of a convention center, criticality is a function of the event it is hosting, thereby leading the analysis to look at potential attacks on the population. An understanding of the facility's systems and how they affect each room of the center is provided. In this way defenders can understand what they need to protect and responders have a path to follow show an event occur.

Criticality of refineries is similar to that of nuclear plants, in that economic criticality contributes significantly to overall criticality. However, due to the presence of large quantities of hazardous materials, such as anhydrous ammonia or amines (monoethanol amine, diethanol amine, and methyl diethanol amine) used for sulfur extraction and recovery, health consequences also contribute significantly to overall facility criticality. In the example refinery below, the crude distillation unit, fluid catalytic cracking unit, catalytic reforming unit, and hydrocracker are assigned a high criticality rating based on economic considerations. Additionally, failure of the anhydrous ammonia tank and the sulfur unit would each result in significant casualties due to the toxic release, thus they are also considered highly critical. Of the remaining areas, the hydrotreating unit is a moderately critical area due to potential consequences of a release of hydrogen sulfide from the unit. The remaining moderate criticality areas are identified based on economic impacts.

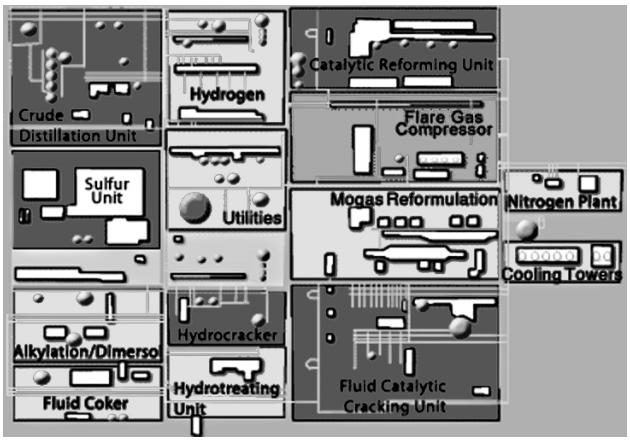

Fig. 2. Example Chemical Facility

Our analyses have in many instances identified vulnerabilities not previously identified. Unfortunately, although the specifics are based on unclassified data, the results are sensitive, thus we cannot discuss them in any detail in any public forum.

IV. CONCLUSIONS

Many of the facilities we have evaluated, whether they be nuclear power plants, refineries, or seaports, are generally unwilling to share their information, even with a nationally recognized institution such as a National Laboratory. In many cases, there are concerns about releasing proprietary information, but there is also the concern of inadvertent public dissemination for fear of incurring potential legal liability.

However, as we have repeatedly demonstrated, terrorists have access to the same information, and could conceivably reach the same conclusions with regard to heretofore unidentified vulnerabilities.

In addition, most facilities focus on physical security. While facilities are unwilling to unveil their physical security plans, they are often completely willing to talk about their processes. Thus, we strongly encourage more cooperation between HOPS analysts and facility representatives, either through sharing of additional information that may not be generally available to the public or by participating in the review process of HOPS analyses, such that we can provide a measurable advantage to those whose task is to defend these facilities.

We also encourage the facilities to focus on the technology and engineering aspects of their area as they perform their risk and vulnerability assessments, not simply the perimeter defense.

Acknowledgements

The authors would like to express their appreciation to the many people, agencies, institutions, and industrial partners that are diligently working to protect the homeland, including the National Guard. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract W-7405-Eng-48.