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INVESTMENT PLANNING AND ANALYSIS FOR CBRN

Patricia D. Hough, Christine L. Yang, Zach Heath, Marilyn F. Hawley,
Katherine Dunphy-Guzman, Heidi R. Ammerlahn
Sandia National Laboratories*
Livermore, CA 94450

Victor M. Vergara, Frank L. Gilfeather, Thomas P. Caudell
University of New Mexico
Albuquerque, NM 87131

ABSTRACT

The increasing complexity of developing and deploying chemical, biological, radiological, and nuclear (CBRN) defense architectures on limited budgets is fueling the critical need for better tools to evaluate the impact of technology procurement. Planners are tasked with determining applicable requirements and architectures; however, they lack a means for comparing the potential impact of different procurement options on the effectiveness of proposed defense systems in protecting critical assets against a multitude of different CBRN attack scenarios.

We have developed a *CBRN Investment Planning and Analysis Tool* to enable transparent, quantified cost/benefit estimates for CBRN attack prevention, detection, and response options. We leverage the BioDAC simulation environment from Sandia National Laboratories and the Risk Analysis Investment Decision Support (RAIDS) tool from the University of New Mexico. We present an example of an end-to-end experiment in which BioDAC is used to generate scenario outcome data that is subsequently fed into RAIDS for investment analysis.

INTRODUCTION

When making procurement, investment, and deployment decisions to help the nation better prevent, protect against, and respond to chemical, biological, radiological, and nuclear (CBRN) attacks, installation response planners must answer numerous questions such as:

- What WMD countermeasure systems are most effective against a suite of perceived threats at various levels of investment?
- What detection and incident characterization equipment should be purchased?
- How should military installations deploy the purchased capabilities for optimum effect?

Answering these questions requires careful consideration of a multitude of threat scenarios, equipment and technology options, and concepts of operation (CONOPS). In addition, the metrics that define effectiveness for base response planners can be intricate and consist of maintaining mission capabilities, minimizing damage and casualties, and ensuring lifecycle sustainability of the system. The multivariate combinations of threat scenarios and response

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measures that result in effectiveness metrics create such a complex, multi-dimensional space that tradeoffs are often made without full consideration of all critical factors.

To address these questions, we have developed a *CBRN Investment Planning and Analysis Tool* to enable transparent, quantified cost/benefit estimates for CBRN attack prevention, detection, and response options. We leverage the BioDAC simulation environment from Sandia National Laboratories and the Risk Analysis Investment Decision Support (RAIDS) tool from the University of New Mexico.

PREVIOUS WORK

BioDAC[1] was developed through BioNet, a program funded by the Department of Homeland Security (DHS) and executed by Defense Threat Reduction Agency (DTRA) to improve regional response to a bioterrorism attack by integrating and enhancing local civilian and military detection and characterization capabilities. The simulation integrates a number of features related to CBRN events such as the following:

- Geographical region and threat agent dispersion
- Spread of contagious and non-contagious diseases
- Infrastructure and assets
- Detection and characterization architecture and logistics
- Response policies and resources
- Population movement and treatment-seeking behavior
- Consequence metrics

Furthermore, the BioDAC environment contains vetted attack scenarios for contagious and non-contagious biological agents, and is extensible to chemical, radiological, and nuclear attack scenarios.

The Risk Analysis Investment Decision Support Tool[2] (RAIDS) was developed through the DTRA Joint Science and Technology Office Modeling and Simulation program to support the complex analysis process currently used to assess program priorities and funding support as well as to give guidelines for investing in a portfolio of defensive technology. RAIDS analysis tools include:

- Return on investment analysis
- Portfolio analysis
- Sensitivity analysis
- “What if” analysis
- Ranking analysis
- Optimal portfolios
- Cognitive-based visualization

The input consists of data that captures the impact each technology has on the consequences of an attack. That data is generated by a simulation or a subject matter expert (or both) and is used to create a set of “micro-models”. RAIDS fuses the micro model data and optimizes the funding distribution to obtain an efficient technology portfolio.

A PROTOTYPE ANALYSIS

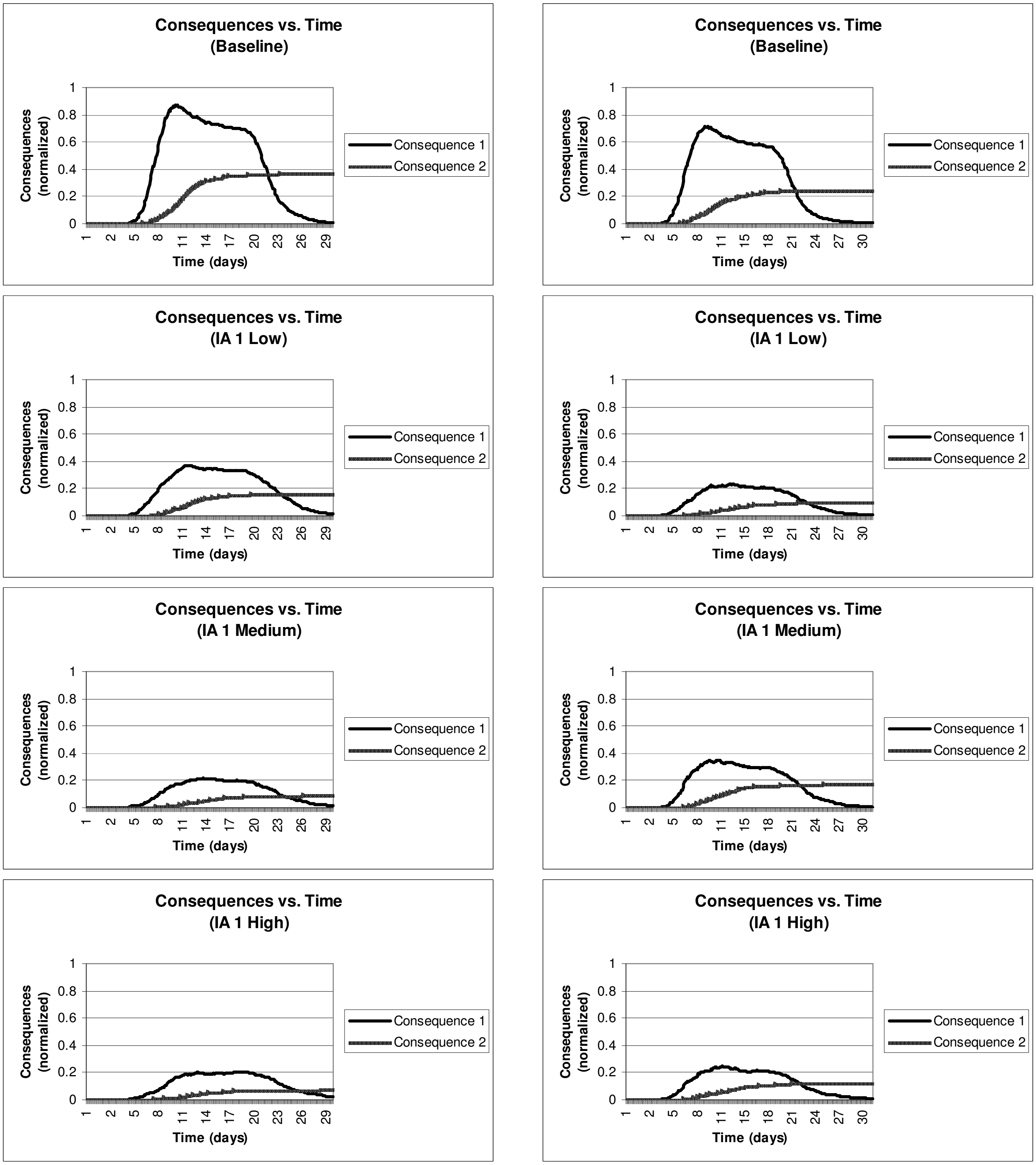
In order to demonstrate the *CBRN Investment Planning and Analysis Tool*, we walk through a proof-of-principle example. The analysis has several key ingredients:

- A suite of attack scenarios – In this example, the underlying threat was an aerosolized release of a biological agent in a major urban area. The date, time, size, and location of the release were varied.
- Consequence metrics – We considered two consequence metrics that are associated with the health of the population in the affected area.
- A set of defensive technologies under consideration – We considered two defensive technologies appropriate for mitigating the effects of the agent under consideration.
- Unit cost for each of the defensive technologies – We defined the unit cost of each technology to be the annual procurement, operation, and maintenance costs.
- Multiple deployment/investment levels for each of the defensive technologies – We considered three levels of deployment for each technology within the BioDAC simulation. These levels of deployment correspond to three levels of investment used in the analysis performed by RAIDS.

The BioDAC simulation was executed for each combination of scenario and defensive technology deployment level in order to generate consequence data. By examining that data, we can determine the effectiveness of the defensive technologies in mitigating consequences as a function of the investment level in those technologies. This information is used to seed the RAIDS micro-models, which are then used to evaluated investment trade-offs.

We first present a snapshot of the raw consequence data generated by BioDAC. This shows the effect of each defensive technology on the consequences. Furthermore, it elucidates the value of considering a suite of scenarios. To illustrate, consider Figure 1. The series of graphs on the left depict results for one scenario; the series on the right depict those for another. In this set of results, the level one defensive technology (IA 1) is varied while the other is held constant. In both cases, deployment of technology IA 1 reduces consequences over the baseline case (in which no technology is deployed); however, the trends are slightly different for the two scenarios. More specifically, in the first scenario, the consequences decrease for the first two levels of deployment and then level out for the third. In the second scenario, the consequences decrease for the first level of deployment, increase for the second, and decrease again for the third. This seemingly non-intuitive behavior can be explained by underlying assumptions associated with the strategy used for deploying the strategy. Considering multiple scenarios has therefore revealed not only variation in trends, but also a dependence on technology deployment and usage strategies that should be considered in future studies. Figure 2 shows the same two scenarios, but in this set of results, the second defensive technology (IA 2) is varied while the first is held constant. In this case, the trends are more intuitive, with consequences decreasing as deployment level increases.

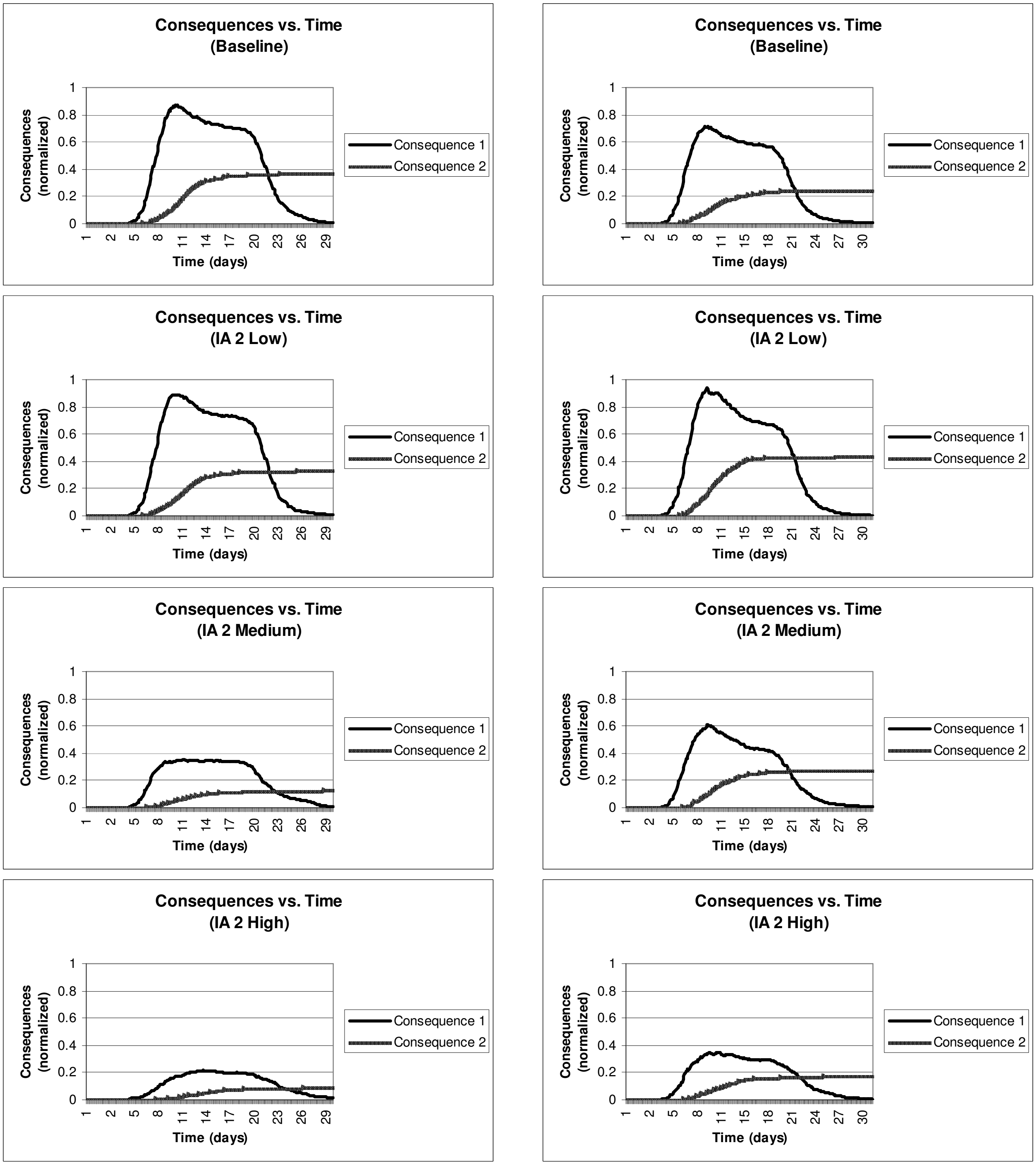
FIGURE 1: This figure depicts the consequences for each of two scenarios. The top figures show the baseline case in which no defensive technology is deployed. The amount of one defensive technology (IA 1) increases from top to bottom while the second is held constant.



A low level of technology IA 1 results in a significant decrease in consequences. Consequences further decrease with a medium level of investment but then level off.

A low level of technology IA 1 results in a significant decrease in consequences. Consequences non-intuitively increase with a medium level of investment and then drop again with a high level of investment. The seemingly non-intuitive trend is due to underlying assumptions regarding deployment of the technology.

FIGURE 2: This figure depicts the consequences for each of two scenarios. The top figures show the baseline case in which no defensive technology is deployed. The amount of the second defensive technology (IA 2) increases from top to bottom while the first is held constant.



A low level of technology IA 2 results in no decrease in consequences. Consequences decrease significantly with a medium level of investment and decrease further with a high level of investment.

A low level of technology IA 2 results in no decrease in consequences. Consequences continue to decrease with medium and high levels of investment.

Once the consequences relative to defensive technology deployment levels have been computed by BioDAC, they are converted to be relative to technology investment levels through the use of the unit costs. These values are used to seed the RAIDS micro-models, which in turn are used to determine optimal technology portfolios and to evaluate investment tradeoffs. Screen shots of RAIDS analyses are shown in Figures 3 and 4. Figure 3 shows how much consequences are reduced given the optimal distribution of a range of total funding amounts. Knees in the curves also identify the points at which return on investment begins to diminish.

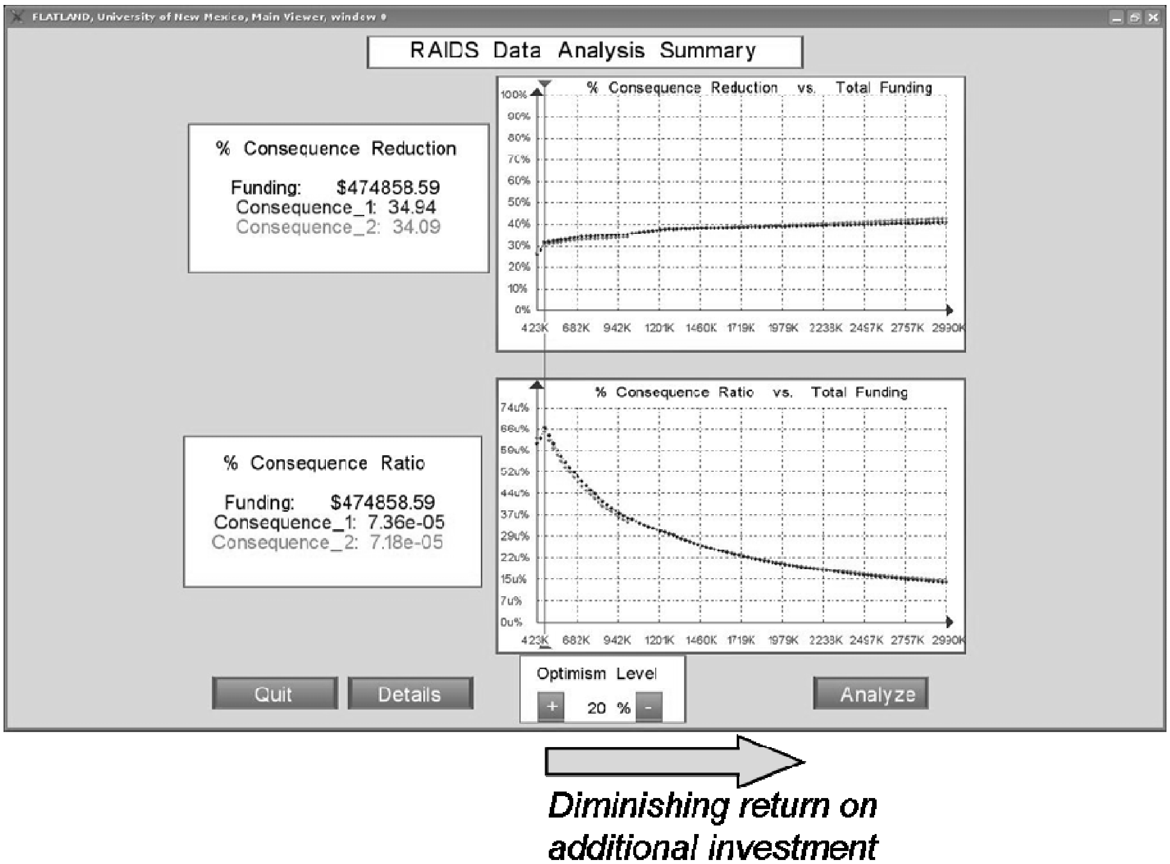


FIGURE 3: This screen shot of the RAIDS tool shows benefit to cost curves. It depicts the reduction in consequences for the optimal distribution of a range of total investment amounts. The knees in the curves, also marked by the vertical bar, identify the point at which return on investment begins to decrease.

Figure 4 shows a breakdown of results for a given total level of investment. It shows the consequences both before and after investment in defensive technology. One feature of RAIDS not captured in the screen shot is its interactive interface. This interface allows the user to adjust the funding distribution depicted in Figure 4 and observe the impact on the consequences.

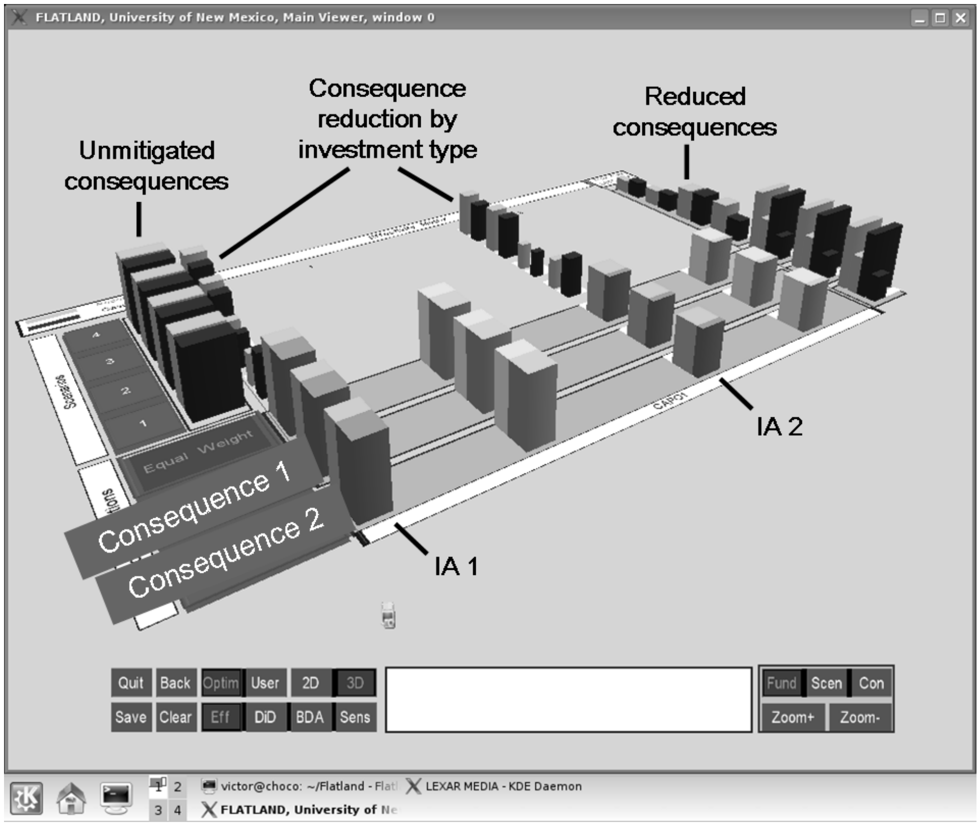


FIGURE 4: This screen shot shows a breakdown of results for a given total level of investment. It shows the consequences both before and after investment in defensive technology. The RAIDS interface allows the user to adjust the funding distribution and observe the impact on the consequences.

CONCLUSIONS

We have demonstrated the use of modeling and simulation to inform investment analysis by combining the BioDAC simulation environment from Sandia National Laboratories with the RAIDS investment analysis tool from the University of New Mexico. The end goal is to enable transparent, quantified cost/benefit estimates for CBRN attack prevention, detection, and response options. A significant advantage to this approach is the ability to conduct studies that cover a wide range of scenarios, technology options, and investment levels. Results gathered in this way bring an inherent robustness that cannot be found in point solutions. Furthermore, the richness of the data allows the study of the impact of procurement tradeoffs on the consequences of a CBRN attack. Future work includes building on this initial prototype to study more complex scenarios and a wider range of defensive technology options and consequences.

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