Applying Optimal Capital Allocation Methods to Homeland Security Resources:

A Case Study of California's Allocation of the Buffer Zone Protection Plan Grants

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CREATE Resource Allocation Project

- Develop practical decision analysis tools for allocating Department of Homeland Security funds
- First case study
  - Buffer Zone Protection Plan (BZPP) funds for California
  - Conducted with the California Governor's Office of Homeland Security

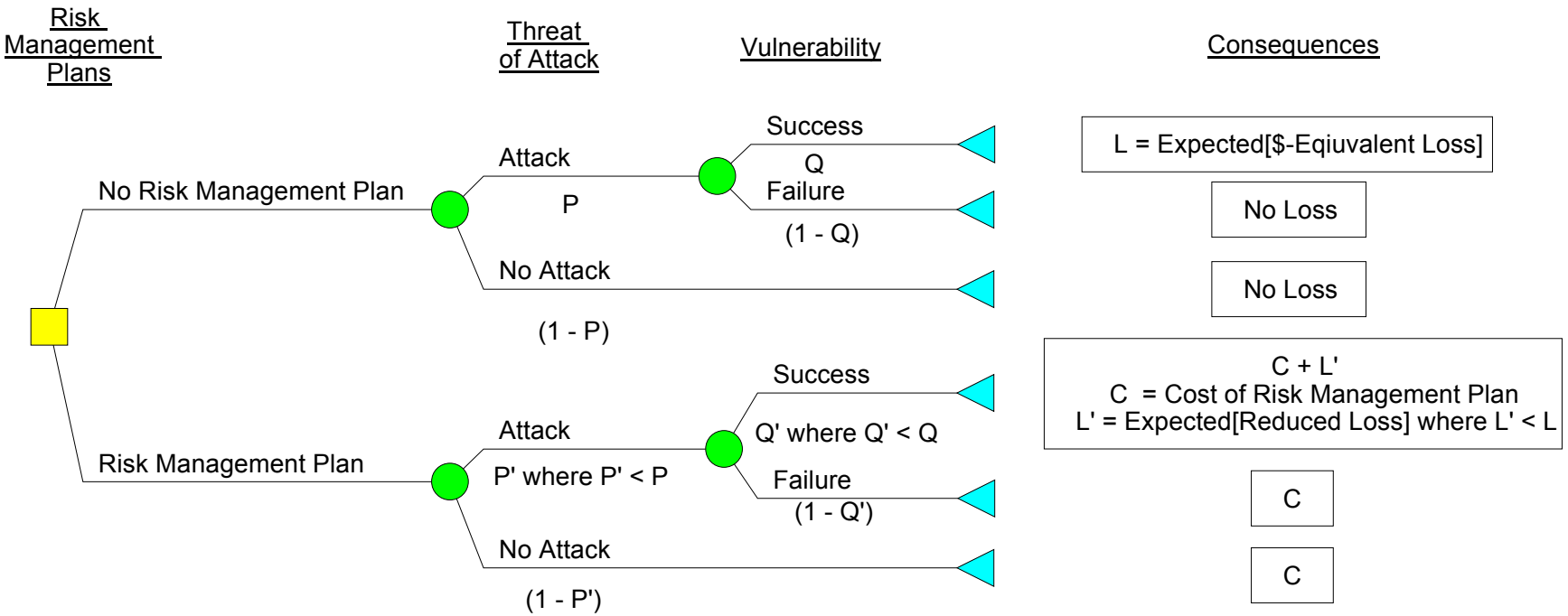
What is the Buffer Zone Protection Program?

- The BZPP is a DHS grant program that provides funds to State and local authorities to prevent and protect against attacks against critical infrastructure and key resources
- Buffer Zone Protection Plans (BZPPs)
  - *Preventive and protective measures that make it more difficult for terrorists to conduct surveillance or launch attacks within immediate vicinity of high-risk assets*
  - BZPs are developed in cooperation between DHS and State and local officials
  - BZPs are intended to help increase the preparedness capabilities of local jurisdictions

Decision Analysis Is Commonly Applied to Resource Allocation Problems

- Problem structure
  - Traditional DA: Select one of several competing alternatives
  - Resource allocation DA: Select a subset of alternatives – a portfolio - usually with a budget constraint
- Examples
  - Funding several of many research proposals (NSF)
  - Capital allocations in companies
  - Allocating resources to protect infrastructure from terrorism

Cost-Effectiveness of Risk Management is a Simplified Framework for Plan Evaluation



"Only" Five Inputs Required per Site

1. Threat: Probability of Attack (P)
2. Vulnerability: Probability Attack Succeeds (Q)
3. Consequences: Expected Loss if Attack Succeeds (L) [$-equivalent losses]
4. Loss Reduction: Loss Reduction with RMP (0 < R < 1)
5. Cost: Cost of Risk Reduction (C)

Expected loss: No RMP: $EL = P \cdot Q \cdot L$

With RMP: $EL' = P \cdot Q \cdot L \cdot (1-R) + C$

Net loss reduction: $\mathbf{(EL - EL') = P \cdot Q \cdot L \cdot R - C}$

Optimal Resource Allocation Chooses Several Among a Set of Options

- Find associated costs, C_j , of all N competing projects, j=1,2,…N.
- Evaluate the loss reduction potential for all N competing projects/alternatives such that $E_j=(P_jQ_jL_jR_j - C_j)$.
- Determine the subset of m projects/alternatives, such that

$$\sum_{j=1}^{N} E_j X_j \text{ is maximized, subject to } \sum_{j=1}^{N} C_j X_j \leq F$$

  where F is the budget constraint and X_j = {0 or 1}.
- Find optimal portfolio using:
  - Binary integer program, or
  - Heuristic solution by prioritizing on ratio of risk reduction benefit to cost:

$$\frac{\left(P_j \cdot Q_j \cdot L_j \cdot R_j\right)}{C_j}$$

Assisting CA OHS Move Towards Risk-Based Allocation of Counterterrorism Funds

- CA OHS = California Office of Homeland Security
  - Sought assistance with allocation of funds associated with the Buffer Zone Protection Plan (BZPP)
  - Between 90 and 100 sites eligible for funding
  - Process objective: Provide significant funding to 10 to 20 sites
- Multiple meetings involving numerous people
  - Facilitated/led by team from CREATE & RAND

Implementing Optimal Portfolio Allocation Faced Two Challenges

- Incomplete / incomparable data sets
- Assessing risk and risk reduction parameters across 100 sites
  - 5 parameters × 100 sites
- Approach:
  - Focus on consequences, qualitative considerations of threat, vulnerability and effectiveness of risk reduction
  - Combine several risk analysis approaches
    - Vulnerability analyses: HOPS, FSIVA
    - Commercial risk analyses: RMS, AIR
    - Site specific analyses: SRA
    - Additional risk analyses by CREATE and RAND
  - Identify high risk sectors by looking for “order of magnitude” differences in risk exposure

Three Sectors Appeared to Be Higher Risk

Sector Comparisons (CREATE)

	Fatality Range	Economic Impacts	Threat and Vulnerability	Risk Reduction	Notes
Chemical and Hazmat	1,000-50,000	0.1b – 1.3b	Medium	Medium	High fatalities
Dams	100-10,000	~100b	Medium	Effective	High economics
Commercial (Buildings / Tourism)	100-8,000	2b – 10b	High	Medium	High threat
Oil Refineries	10-100	0.1b -- 0.6b	Low	Medium	Mostly economics
Electrical Grid	10-100	0.7b – 2.8b	Low	Medium	Mostly economics
Transportation - Bridges	10-100	0.01b – 0.04b	Medium	Medium	Mostly psychological
Transportation - Rail	100-1000	0.5b – 7.4b	High	Medium	Mostly psychological
Water Treatment	100-1000	0.1b – 1.3b	Low	Medium	Mostly chemicals
Defense Industry Base	10-100	?	Medium	Medium	DHS/DOE responsibility
Postal and Shipping	10-100	?	Medium	Medium	DHS responsibility
Nuclear Power Plants	0-100,000	12b – 40b	Medium	Medium	NRC/DHS responsibility

Preliminary Conclusions

- Dams, chemical plants and selected commercial sites are the most risky sectors
- Each sectors deserves funding for different reasons
  - Chemical: High fatality potential
  - Dams: Fatality and economic impact potential, effective risk reduction
  - Commercial: High threat
- The main question:

  Mix sectors or focus on one or two?
  - OHS' inclination was to pick one sector and fund all

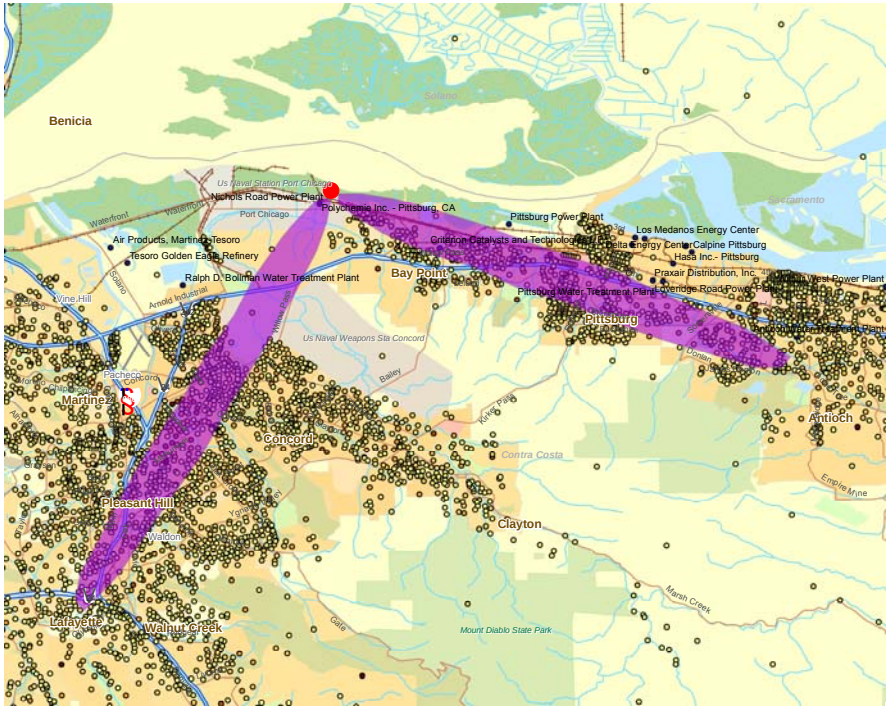
Consequence Analysis for Dams

Sector Prioritizations: Dams

Facility	Storage Capacity	Inundation Area	Population	Jobs
Dam 6	3,964,960	1872 sq-mi	175,000	48,743
Dam 1	3,540,000	1341 sq-mi	138,055	52,125
Dam 2	2,420,000	1161 sq-mi	570,055	210,442
Dam 8	2,030,000			
Dam 3	1,961,320	925 sq-mi	370,582	136,799
Dam 9	1,030,000			
Dam 10	969,600			
Dam 4	894,000	188 sq-mi	448,000	110,132
Dam 12	651,000	Arizona	low	low
Dam 7	221,600	Catastrophic fatalities		
Dam 14	170,000			
Dam 5	41,110	Catastrophic fatalities		
Dam 13	28,640			
Dam 11	20,790	Mission critical		

Not selected
Selected

Consequence Analysis for Chemical Plants



Sector Prioritizations: Chem./Hazmat

Chem/Hazmat Facilities	Affected Population (one plume)	Affected Population (LD50)	Affected Population (TEEL-3)
Facility 1	839,262	54,795	52,273
Facility 4	321,840	18,262	27,279
Facility 10	259,130	14,650	46,500
Facility 8	343,409	13,932	27,027
Facility 13	197,127	12,909	37,160
Facility 7	303,679	12,279	54,100
Facility 12	110,748	5,593	43,267
Facility 5	452,984	2,709	19,843
Facility 2	131,423	2,705	45,643
Facility 9	380,217	2,366	33,532
Facility 3	329,031	1,257	60,143
Facility 11	322,522	1,039	29,926
Facility 6	732,982	138	32,235

Selected
Not Selected

Impact on CA OHS:

- CA OHS found the analysis useful
  - They recognized that although the analysis was incomplete, it was also a quantum leap ahead of the previous year's process
  - Involvement of credible outside analysts lent credibility to the entire process and improved acceptance of decisions
  - Sector-based screening and within-sector analysis can reduce the information requirements considerably
- Identified critical needs for future analyses:
  - Quantitative assessments of relative threat are potentially very useful
  - ASSESSING RISK IS NECESSARY BUT NOT SUFFICIENT!
    - Risk-based allocation is about risk management as much as risk assessment
    - Require standardized vulnerability analyses and risk management plans for EVERY site
    - It is difficult (if not impossible) to assess cost-effectiveness if you don't know how funds will be used

Future Work

- Further case analyses:
  - Assist CA OHS on 2007 BZPP prioritization
  - Identify other case analysis opportunities
    - Allocating funds to protect against bioterrorism
    - Allocating funds across threat areas (bio, chem, nuclear, infrastructure, etc.)
- Understanding challenges involved when analyzing LARGE numbers of sites, threats, and risk management alternatives
  - Risk management plans often incomplete or incomparable—makes it hard to evaluate cost-effectiveness!
  - Information required for risk assessment hard to get, hard to use, hard to analyze
  - Explore utility of robust resource allocation strategies