A SOCIO-TECHNOLOGICAL APPROACH TO DETERMINING APPROPRIATE LEVELS OF PROTECTION FOR PUBLIC SPACES

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Abstract

Since September 11, 2001, the vulnerabilities to terrorism of our urban areas, and how best to address them, have been subject to considerable discussion, debate, and reflexive defensive measures. However, despite the continued threat of terrorist vehicle-bomb attacks worldwide, a coherent strategy for protecting public spaces while maintaining access to them has yet to emerge. Protecting people, building and other public spaces from bombing attacks essentially has been framed as a binary decision problem with “security” and “openness” constituting mutually exclusive poles. This has limited discussion of critical issues such as what the public views as appropriate levels of protection, what constitutes a prudent government response, and the sustainability of long-term public expenditures. Although the imposition of direct physical barriers as a response to such frightening events is certainly understandable, it is not based on a true assessment of risk, nor does it necessarily represent an effective, let alone cost effective, approach to addressing the threat of urban terrorism. This paper will discuss how methods from the social and policy sciences can be used to develop balanced approaches to physical security and help to establish realistic priorities for implementing them. It will seek to demonstrate that a holistic strategy that integrates social values with technical and fiscal objectives is achievable and will achieve far greater long-term security than reliance on physical measures alone.

Introduction

Since September 11, 2001, the vulnerabilities to terrorism of our urban areas, and how best to address them, have been subject to considerable discussion, debate, and reflexive defensive measures. Physical access control measures have ranged from “temporary” concrete barriers, to planters and street furniture, to permanent bollards. These are usually supplemented by armed guards aided by closed circuit TV cameras and other surveillance measures. Buildings have received retrofit window treatments and structural enhancement of columns and slabs to mitigate blast effects, and some buildings are being considered for systems of sensors and filters to guard against chemical and biological agents. Although these direct physical responses to the frightening events of September 11th are certainly understandable, they are driven more by the desire to protect people and assets from what could happen rather than what is likely to happen. In other words, these measures address the *vulnerability* of people, buildings, and other public spaces to certain

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types of attack and not a true assessment of the *risk* of that attack. This approach essentially removes the public from the decision process and eliminates from consideration any willingness on the part of the public to accept some portion of that risk. It is not surprising then, that the debate over appropriate security for public places has often degenerated to a simple binary set—secure but unaesthetic on one side and attractive but vulnerable on the other.

Providing Physical Protection

Until modern explosives and aerial bombardment rendered them moot, most physical protection strategies for cities and towns were aimed at keeping an attacker at bay by means of moats, walls, and other physical obstacles. Even today, *standoff* (the distance between a bomb and its intended target) is still considered the most effective defense against a terrorist vehicle bomb because blast energy falls off with the cube of the distance and dissipates very quickly. It is for this reason that the initial reaction of those faced with "doing something" to enhance security is often to move in the concrete barriers and checkpoints in the hope of maintaining an adequate standoff distance. However, when effective standoff distance is not available or cannot be enforced by these measures, other steps can be taken to protect targeted buildings from bomb damage.

The numerous terrorist bombing attacks experienced in the past twenty-five years have generated considerable research into the effects of bomb blasts on buildings and people (NRC, 2000). As a result, the vulnerabilities of buildings to deliberately placed bombs are reasonably well understood, as are the relative effectiveness of various countermeasures (Little, 2002). Blast-resistance in buildings is generally provided by passive features such as additional reinforcement and connections in the structural frame for increased ductility, composite fiber wraps to prevent shattering of columns and slabs, and high-performance glazing materials that resist blast pressures (AMPTIAC, 2003). When such structurally-enhanced buildings have been attacked, these measures have been shown to be effective in reducing damage and casualties (Mlakar, et al, 2003).

Security and Risk

Although governments and other stewards of the public welfare have a clear responsibility to provide for the safety of those entrusted to their care, , the government must also consider the cost of providing that level of safety to buildings and infrastructure. Ultimately, a choice must be made whether an investment to reduce risk to those directly affected is of greater benefit to society than expending the funds for some other purpose (NRC, 1985). Given the high cost of providing security to all public buildings and spaces, this is a question that reasonably should be considered by the public at-large. In any event, as has already been determined in the provision of seismic resistance, questions of this type are not for engineers to answer alone (NIST, 1994).
Risk assessment has classically been defined by three questions (Kaplin and Garrick, 1981):

- *What can go wrong?*
- *What is the likelihood that it would go wrong?*
- *What are the consequences of failure?*

Although these questions are relatively straightforward, in practice they often prove difficult to define precisely. Therefore, risk management seeks answers to a second set of questions (Haimes, 2002):

- *What can be done and what options are available*? (What is the mix of site selection and configuration, building features, and management practices that will provide the desired level of protection?)
- *What are the associated trade-offs in terms of all costs, benefits, and risks*? (For example, reduced risk and improved confidence in security normally would be traded off with increased cost.)

- *What are the impacts of current management decisions on future options*? (Policy options that seem cost-effective at present must be evaluated under plausible future changing conditions. For example, providing certain physical protective features may preclude building modifications to increase functionality in the future.).

These questions are particularly relevant to the current discussion because experience has shown that all too often "temporary" security measures become *de facto* permanent solutions (NRC, 2003). In effect, these measures represent a precautionary approach to the possibility of future attacks without further discussion or assessment of risk, costs, or benefits. Such physical protective features typically target generic vulnerabilities and are not generally selected based on a quantified (even if somewhat subjective) risk calculation.

Given the high cost of implementing an effective physical security strategy for public buildings and spaces, the participation and knowledge of all affected parties, including citizens, policy-makers, law-enforcement officials, building owners and occupants, planners, architects, engineers, and security specialists should be elicited. Much of the current debate on security in an open society is unproductive because it fails to recognize the distinct difference between the technical elements in the risk calculation (e.g., terrorist threat levels, tactics, bomb sizes and delivery methods, building construction, etc.) on the one hand, and community value judgments (i.e., architectural aesthetics, freedom of movement, etc.) that must be incorporated on the other. The social and policy sciences provide some interesting and useful tools to frame this complex and often emotionally charged discussion and three of these tools will be discussed.

Three Useful Tools for Goal Setting and Decision-Making

Three useful tools for goal setting and decision-making within the context of protecting public spaces are judgment analysis, the Taylor Russell diagram, and the system dynamics model. Each of these tools was developed for a different purpose and adapted for policy formulation over time. The first, judgment analysis, can be used to design a safety indicator for a given public space that is based on a consensus judgment of a group of technical experts. The method of judgment analysis and the theory surrounding it, Social Judgment Theory (SJT), is about 50 years old (Cooksey, 1996; Stewart, 1988; Hammond, 1955; Brunswik, 1955). SJT was recently reviewed by Meacham (in press) as a potentially useful approach to fire risk problems. The second, the Taylor-Russell diagram, can be used to engage public values in a decision about the appropriate threshold for that safety indicator, that is, how much safety is "enough." This tool dates back to signal detection theory (Swets et al., 1991; Green and Swets, 1966) and has been effectively applied to a variety of policy formulation questions (Swets, 1992; Hammond, 1996). The final tool, the system dynamics model, can be used to investigate a management or regulatory structure to allow for changes to the indicator threshold over time and across contexts. The system dynamics model is a computer simulation tool developed by an electrical engineer who addressed business strategy problems (Forrester, 1961). Like the Taylor-Russell diagram, this tool has been applied outside its original domain to great effect; these applications have been reviewed in depth by Sterman (2000). Each tool is presented in turn, together with the scenario for its application, the method, and the outcome or deliverable that would result.

Judgment Analysis

In the development of a physical protection strategy for public spaces and buildings, it is important to have an index or indicator of safety. One way to construct such a safety indicator would be to gather historical data about how spaces with particular attributes performed in the past under a range of actual bombing attacks. Next, a regression analysis of building performance could be conducted with respect to the various features of the buildings and attacks (e.g., bomb size, standoff distance, building type). Once the regression parameters were established, other buildings could be scored on how secure they would be against a given type of attack. This approach requires abundant and accurate data that is often difficult or impossible to obtain. But even without such data, it is still possible to develop an indicator by analyzing the judgment of experts.

The development of an indicator using judgment analysis involves the following steps (Cooksey, 1996). First, experts could be interviewed about the attributes of the problem that constitute the cues to the judgment of safety, including active security measures, standoff, and building features. While experts might differ on the importance of each of these to overall safety, they may be able to agree on a list.

Second, real buildings could be sampled to assemble a representative set of cases with attributes that occur together in plausible ways. (For more on representative design, consult Hammond & Stewart, 2001; Cooksey, 1996; Stewart, 1988; Brunswik, 1955). Third, once a set of representative cases has been gathered, each expert could rate each case for safety. Finally, regression analysis could be used to model each expert's "policy" for making judgments of safety. The judgment policy would represent a weighted combination of important safety factors, with the importance weights determined from expert judgment as influenced by past experience, research results, and so on.

Note that the reason for using regression analysis is that people (including experts) are not always accurate about the judgment policies they hold or that they assume others hold. The use of statistics greatly increases the likelihood that the exercise will produce actual expert judgments rather than the experts' guesses about how they make judgments. The policy of a given expert could then be applied to any building to determine a safety score.

If all the experts' judgment policies matched, the result would be a consensus safety indicator. However, consider a scenario in which there was no clear expert consensus. Perhaps one expert thinks that active physical security is the most important factor in safety and another thinks that passive features such as standoff and physical hardening are paramount. Where experts show differing judgment policies, one could cluster expert approaches. In this case, indices might be developed to represent the different clusters.

A judgment analysis could provide insight into how diverse experts rate buildings on safety, as well as models of the judgment policies of clusters of experts. With time, one could conduct research to assess the relative effectiveness of the differing judgment policies. Meanwhile a policy maker, or advisory group charged with developing policy recommendations, could craft a compromise among the judgment policies to create an acceptable indicator of safety. The result would be an experience-based safety index for security features.

The Taylor-Russell Diagram

If it is assumed that there is an indicator with a known success rate at predicting building safety, whether developed by analyzing past data or by analyzing expert judgment, the next step is to select a safety threshold or cut-off point, such that buildings above the threshold would be considered "safe," and those below it would be considered "unsafe." Unless the indicator is perfect, any threshold for a safe/not-safe decision will result in some buildings rated as safe when they are not (false positives) or some buildings being rated as unsafe when they are safe (false negatives). A Taylor-Russell diagram can be used to clarify the components of this situation (Hammond, 1996; Green & Swets, 1966).

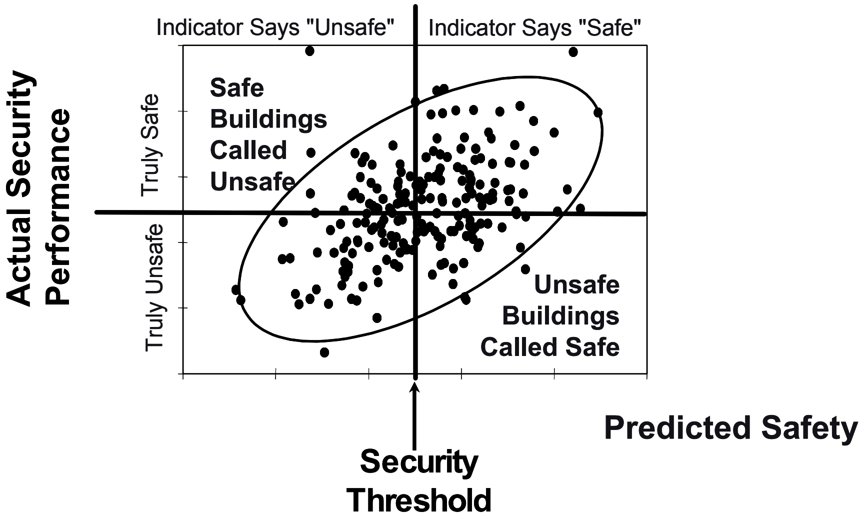
A Taylor-Russell diagram is presented in Figure 1. Along the horizontal axis are building safety indicator scores. Along the vertical axis are building security performance scores. Each point represents a particular building. The quality of the indicator is shown by the spread of the points around a line angled at 45 degrees.

A lower or "lenient" threshold for an acceptable level of building security may reduce costs, but there is a risk of constructing buildings that will turn out to be unsafe if attacked (false positives).

On the other hand, as the threshold for the acceptable level of security is raised or made more "strict", unnecessary costs on the builder may be imposed as unnecessary security measures are implemented (false negatives). Hammond (1996) describes this tradeoff between false positives and false negatives for any choice of threshold as the duality of error, which is made instantly visible in a Taylor-Russell diagram.

A Taylor- Russell diagram is constructed by plotting individual buildings as points, with their predictive indicator score along the horizontal axis and their actual performance score along the vertical axis. Next, a threshold for true safety is set.

Figure 1: The Taylor-Russell Diagram



Finally, a value-based threshold on the predictive indicator is set that results in consequences (false negatives and false positives) that are tolerable to all stakeholders in the process. By splitting the diagram into quadrants, one discovers the number of true positives (i.e. "safe" according to the indicator and safe in reality), true negatives (i.e. "unsafe" according to the indicator and unsafe in reality), false positives (i.e. positive according to the indicator for safety, but unsafe in reality), and false negatives (i.e. negative according to the indicator for safety, but quite safe in reality) that result from the threshold selection, given the uncertainty or quality of the indicator.

Note that the number of false positives and false negatives depends not only on the threshold chosen, but also on the degree of association between the indicator and the true safety rating. The correlation between these values represents the quality of the indicator. The indicator will show as much uncertainty as is currently present in the predictive science regarding security measures and actual safety.

Working with a Taylor-Russell diagram, individuals can discuss the numbers of false positives and/or false negatives they are willing to accept and, given the quality of the indicator, they can select an appropriate threshold. The Taylor Russell diagram provides a means of envisioning simultaneously the connection between 1) the choice of threshold; 2) the effectiveness of an indicator; and 3) the resulting consequences.

The System Dynamics Model

Imagine that an indicator has been chosen, data obtained on its performance, and a threshold selected. Ideally, the community at large would accept this as a stable threshold. Unfortunately, it cannot be guaranteed that the selected tradeoff of false positives and false negatives will be shared by others or that the particular threshold selected will always be appropriate. In fact, if a highly salient event occurs for which there is a false positive, say, a building turns out unexpectedly to be unsafe (i.e., it performs less well than expected) those constituents concerned with safety will pressure policy makers to move the threshold higher. This debate is currently raging about the performance of the twin towers of the World Trade Center in New York with implication for both structural design and fire protection. As additional safety measures are implemented for buildings that were already safe enough, there will be diminishing returns on investment. The community concerned with the cost of buildings might then pressure the policy makers to lower the index. Swets (1992) has described the potential for a threshold to oscillate in light of recent salient events. Hammond (1996) suggested that the oscillation would occur as stakeholders respond to recent events and pressure policy makers to change the threshold. Weaver and Richardson (2002) designed a system dynamics simulation to analyze the systemic requirements for such an oscillation to occur.

As the selection of a threshold represents a value-based decision, it may become outmoded as societal values respond to recent events and as indicators improve. In order to have a responsive policy context that is protected from too rapid and vigorous an overreaction to recent events, it may be necessary to build in legal structures that manage or regulate the threshold in an appropriately responsive manner. These phenomena are particularly amenable to computer simulation that can model a much broader range of scenarios than would be found in practice.

A model that includes the legal and political regulatory structures that affect the policy threshold can be created that will permit the testing of different regulatory environments, including penalties for non-compliance, avenues for complaint, community values about outcomes, and the predictive quality of the safety indicator. The simulation might include stakeholder pressures to change the threshold, the quality of the index, the resulting false positives and false negatives and how the entire stakeholder community would react to an unacceptable number of either of these. It could include not only the information for which clear data are available, but also could embed the rich intuitions of experts, so that a broad range of possible scenarios could be tested. System dynamics has been used to simulate similar conditions in other contexts (Sterman, 2000).

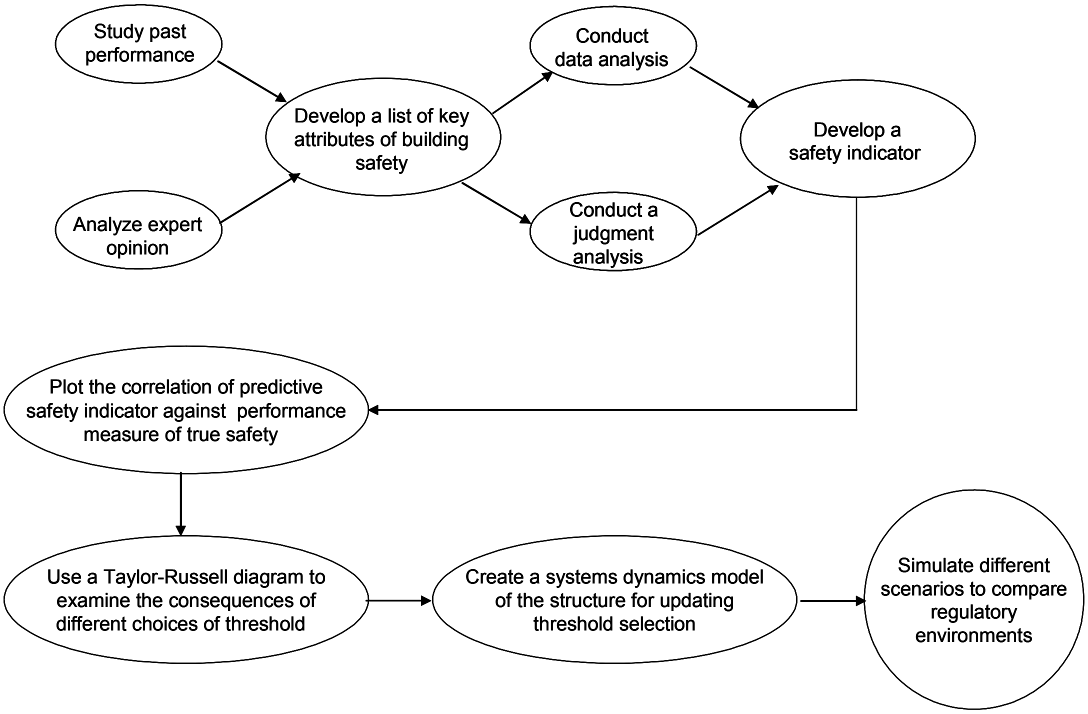
The outcome of such a modeling effort would be a simulation that would allow policy makers to test the consequences of various threshold choices and a safety index that improves its predictive quality over time or with resource investment. In addition, it would allow them to set up and test a management and regulatory environment that would build in constraints against too sensitive a response to recent events, while guaranteeing the flexibility to update the model.

Summary and Conclusions

Unfortunately, we find ourselves in a time where former contexts of threat, vulnerability, and target have all changed and continue to do so. Threats are unpredictable and the full range of threats probably unknowable. We will never be able to anticipate all possible threats and even if we could, there is not enough money to deploy technologies to address them. Security in this situation needs to be flexible and agile and capable of addressing new threats as they emerge while still meeting the demands of the public for attractive architecture and free access to public spaces. This cannot be a one-time investment but rather an effort that will need to be revisited periodically as threats, resources, and community values continue to change.

Three tools from the social and policy sciences have been introduced for use at different stages of the process of developing a rational and holistic approach to security. Judgment analysis could be used to develop an index of safety; the Taylor-Russell diagram to select an appropriate policy threshold for that index; and the system dynamics model to simulate a policy environment that would respond to unexpected events with appropriate adjustments. Figure 2 illustrates how these three tools could be used together to include all stakeholders, experts and lay persons alike, in the development of consensus levels of security for public buildings and spaces that achieves aesthetics and openness with reasonable security and safety.

Figure 2: A model for applying three useful tools for goal setting and decision-making.



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Author Biography

Richard G. Little is Director of the Board on Infrastructure and the Constructed Environment of the National Research Council (NRC). He has directed NRC study activities, participated in workshops and panels, and written several papers dealing with physical security and critical infrastructure protection. He served as the Study Director for the 1995 NRC report, *Protecting Buildings from Bomb Damage* the 2001 report, *Protecting People and Buildings from Terrorism: Technology Transfer for Blast-effects Mitigation,* and a review of the Interagency Security Committee (ISC) Security Criteria.

Mr. Little has over thirty years experience in planning, management, and policy development relating to public facilities. He is a member of the American Institute of Certified Planners and the Federal Planning Division of the American Planning Association. Mr. Little holds a B.S. in Geology and an M.S. in Urban-Environmental Studies, both from Rensselaer Polytechnic Institute.

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