Workshop Report

Human and Social Forces in the Spread of the IED Threat: Innovation, Diffusion and Adaptation

Thursday, November 20, 2008
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Innovation, Diffusion and Adaptation

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Thursday, November 20, 2008
University of Maryland Inn & Conference Center
College Park, Maryland

Report Compiled By:
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Table of Contents
Personnel........................................................................................................................................1
Participants......................................................................................................................................1
Observers........................................................................................................................................1
Workshop Agenda ..........................................................................................................................2
Executive Summary .........................................................................................................................3
Introduction.....................................................................................................................................10
 a) Background................................................................................................................................10
 b) Workshop Goals .......................................................................................................................11
 c) Pre-Workshop Activities ........................................................................................................12
Session Reports ..............................................................................................................................14
 Session 1: Welcome and Introduction ..........................................................................................14
 Session 2: Where We Are - Developing a Knowledge Base ..........................................................14
 Session 3: Where to Go - Identifying Research Gaps and Priorities with respect to
 IED Innovation, Diffusion and Adaptation ....................................................................................17
 Session 4: How to Get There - Establishing a Research Agenda for Understanding
 Terrorist IED Innovation, Diffusion and Adaptation .....................................................................19
 Session 5: Wrap-up ........................................................................................................................21
Analysis and Recommendations......................................................................................................23
 a) Research Topics ........................................................................................................................23
 b) Research Approach ....................................................................................................................27
 c) Research Program ......................................................................................................................29
Conclusion .........................................................................................................................................33
Appendix A: Participant Biographies ..............................................................................................34
Appendix B: Existing Research Findings ..........................................................................................40
Human and Social Forces in the Spread of the IED Threat

Personnel

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  Maranda Sorrells, START Graduate Assistant
- Event Logistics: Danielle Hawkins, START Coordinator

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- Dr. Martha Crenshaw, Senior Fellow, Center for International Security and Cooperation, Stanford University
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- Dr. Michael Kenney, Assistant Professor in the School of Public Affairs, Pennsylvania State University
- Dr. Gary LaFree, Director, National Consortium for the Study of Terrorism and the Response to Terrorism, University of Maryland
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- Dr. Stephen Markham, Associate Professor in the College of Management Studies, North Carolina State University
- Dr. Clark McCauley, Solomon Asch Center for Study of the Ethnopolitical Conflict, Bryn Mawr College
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Observers

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- Kevin Spence, Department of Homeland Security, Human Factors and Behavioral Sciences Division
- Alexis Zeiger, Homeland Security Institute
## Workshop Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 am</td>
<td>Breakfast and Registration</td>
</tr>
<tr>
<td>8:30 am</td>
<td>Session 1: Welcome and Introduction</td>
</tr>
<tr>
<td>9:00 am</td>
<td>Session 2: Where We Are - Developing a Knowledge Base</td>
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<tr>
<td>12:00 pm</td>
<td>Lunch</td>
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<td>12:45 pm</td>
<td>Session 3: Where to Go - Identifying Research Gaps and Priorities with respect to IED Innovation, Diffusion and Adaptation</td>
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<td>3:00 pm</td>
<td>Session 4: How to Get There - Establishing a Research Agenda for Understanding Terrorist IED Innovation, Diffusion and Adaption</td>
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<td>4:30 pm</td>
<td>Session 5: Wrap-up</td>
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Executive Summary

The National Consortium for the Study of Terrorism and Responses to Terrorism (START) conducted a workshop entitled “Human and Social Forces in the Spread of the IED Threat: Innovation, Diffusion and Adaptation” on Thursday, November 20, 2008, at the University of Maryland in College Park. The objectives of the workshop were to explore certain aspects of the social and behavioral elements of the threat of terrorists using improvised explosive devices (IEDs), specifically those aspects related to the evolution and spread of IED usage, and to set the stage for future research in this area. After START researchers set the workshop parameters, initial presentations and discussion provided a baseline of current knowledge (both qualitatively and quantitatively derived) regarding innovation and diffusion in the terrorist use of IEDs. Group discussions and breakout sessions explored the future directions that research in this area might take.

Analysis and Recommendations

Participants unanimously agreed that there was substantial scope for research into the human elements of the IED threat, and specifically into the important issues of innovation, diffusion and adaptation of IEDs. Understanding these issues was felt to be vital to efforts to counter the use of IEDs by terrorists. The following represents a summary of participant recommendations for future research in this area, separated into three main categories. These are a) **Research Topics**: specific topics related to IED diffusion, innovation and adaptation that require further study; b) **Research Approach**: those recommendations relating to establishing an intellectual and empirical infrastructure for conducting the research, including theories, methods and data that should be utilized by researchers; and c) **Research Program**: recommendations that deal with programmatic concerns.

a) **Research Topics**

**General IED Innovation, Diffusion and Adaptation Topics**

- Develop an overall conceptual model of IED diffusion, innovation and adaptation by terrorists that can be revised and updated as additional research is conducted.
- Research investigating the extent to which methods and findings from business / management science carry over into the IED context and hence can be used to explain IED diffusion and innovation dynamics.
- Research on whether IEDs are different from other terrorist attacks and other types of bombings and therefore whether treating IEDs as a separate topic of study is the most efficient approach.
- Testing the National Research Council IED Threat Chain Model against one or more in-depth case studies to assess its validity.
- Developing measures of IED mission effectiveness (both objectively and from the perpetrator’s point of view) and analyzing the interplay of factors that impact these measures.

**Awareness of IED-related Information**

- Investigate whether information about IEDs and by their effectiveness is exogenously or endogenously driven and whether this varies by context. In other words, do terrorists seek out information on IEDs as a tactic, or are they influenced from external sources in their social network or ideological milieu?
- Explore the types of media and other information sources that perpetrators use to learn about IEDs.

**Terrorists’ Decision to Employ IEDs**
- Compare cases of terrorist groups that do adopt IEDs with those that opt not to employ them, with a view towards understanding the factors - contextual and otherwise - that affect such decisions.
- Analyze IED use from a “consumer” perspective, where users select innovations depending on a number of different variables (including ease of use, cultural compatibility, and relative advantage) in order to assess the relative interplay and importance of “internal” vs. “external” factors. Explore the importance of technological advances, including “invention can become the mother of necessity.”
- Examining who makes the decision to utilize IEDs and at what organizational level this occurs. This includes studying the role of leader charisma and group organizational structure on innovation, diffusion and adaptation.
- Investigate whether particular personality types (either psychologically, or on a Keirsey Temperament scale) are associated with particular roles in the IED process (e.g. bombmaker, bomber, cell leader).
- Investigate the balance between instrumental and expressive motivations for using IEDs. This entails looking at whether the adoption of IEDs as a tactic is driven primarily by the technology itself, expediency in weapon choice, an inherent predilection or social learning through formal or informal networks. It includes consideration of how culture impacts IED use (for example, whether the type, frequency or rate of diffusion of IEDs is mediated differently across cultures), as well as the non-rational influences on IED use, including religious drivers and inhibitors.
- Investigate the role played by opportunity: does IED use increase as a result of the availability of explosive materials (through analyzing such variables as military action, size of military forces, and use of left-behind military ordinance)?
- Assess the role of finances in IED campaigns, including whether economic gain is a driver for some of the actors involved. Test the interaction between funding/sponsors and the use of IEDs.
- Investigate to what degree the level of community support impacts the decision to use or continue to use IEDs and whether this varies across cultural and contextual settings.

**IED Learning Curve**
- Use multivariate models to provide information on the necessary antecedents to IED use. This includes gaining a better understanding of the level of training needed for the construction and implementation of IEDs of varying levels of complexity.
- Conduct in-depth case studies of various terrorist groups’ prior use of IEDs (cf. Brian Jackson et. al. at RAND’s studies with respect to organizational learning), both those that were successful and those that either failed or were interdicted. Include assessments based on explicit vs tacit knowledge propagation and Kenney’s techne and métis model. This includes comparing the prospects of “amateur” versus “professional” terrorists with respect to IEDs, in particular investigating whether it will be more difficult for self-styled “revolutionaries” or “mujahidin” to launch sustained IED campaigns unless they acquire more firsthand operational experience in deploying IEDs or create an efficient logistical infrastructure of some type.
- Investigate the role of imitation vs innovation (especially comparing professional bomb-makers to clever amateurs). Explore the extent to which terrorists engage in trials (and tinkering) before embarking on a full-fledged campaign.
- Evaluate the practical value of existing online terrorism manuals.

How IEDs are Used
- Investigate the choice of techniques, tactics, and procedures of terrorist groups with respect to IEDs. For example, why do ideologically and organizationally similar terrorist groups adopt different tactics?
- Analyze the intelligence and information gathering requirements for IED use and how terrorists have actually acquired this intelligence, with the objective of identifying early warning indicators.
- Explore how different terrorist groups adapt and improvise IED production and usage techniques. What drives adaptation or improvisation: necessity (for example, a shortage of materials) or some other motivation (for example, competitiveness or self-aggrandizement of the bomber)?

Spatio-Temporal Aspects of IED Innovation, Diffusion and Adaptation
- Extend existing geo-spatial analysis of IED attacks by incorporating social movement perspectives.
- Compare locations that have been the target of IED attacks with similar targets that have not, using case control methods. In this approach, one would compare empirical target locations (e.g. buildings or monuments) where IED attacks have occurred with a drawn control sample where attacks did not occur, in order to examine target selection and points of interdiction.
- Explore IED use from an epidemiological perspective: do IED use or designs spread a) outward spatially from particular geographic centers, first to adjacent and thence to further removed territories (usually gradually); b) with the movements of particular individuals (more rapid spatial “jumps”) or c) spread virtually, aspatially and extremely rapidly?
- Assess the salience of “virtual diffusion,” i.e., whether in light of the Internet as a communications mechanism, the diffusion of IED know-how is dependent on a gradual expansion from specific geographic nodes, the movements of knowledgeable people, or hard copy bomb-making manuals.
- Investigate which factors influence the rate of diffusion of IED use by terrorists and how these factors operate, including comparing groups that have demonstrated either rapid or slow adaptations in the use of explosives.
- Investigate whether there are discrete and identifiable stages / segments of innovation, diffusion and adaptation with respect to IEDs (as, for example, with commercial products). If so, are there optimal stages / segments for interdiction?
- Explore the links between innovation, success and subsequent escalation.
- Study past cases of desistance from the use of IEDs by extremists. Why did they desist? Can interventions facilitate the process with current actors?
- Conduct a temporal analysis of IED diffusion according to Rogers’ S-curve theory and include measures of the efficacy of attacks.
- Investigate whether different elements of the IED threat – intent, resources, technical capability, but also different physical components like triggers, explosives and detonators – diffuse simultaneously or asynchronously, and whether there is any discernible sequence.
• Explore whether there are certain types of preparatory behavioral actions (besides the obvious acquisition and production of the actual devices) that must be completed in order to carry out IED attacks. In particular, examine whether certain types of criminal incidents act as precursors to IED attacks.

IEDs and Social Networks
• Characterize in detail the social network necessary to carry out an IED operation and perform various social network analyses of terrorist networks and how IED production and tactical techniques spread through networks. Include the topology of networks, especially the role of brokers.
• Investigate whether specific groups act as feeders or gateways for suspects who ultimately become involved with IEDs.
• Analyze terrorist IED use in terms of a “communities of practice” model, especially whether participants involved in a community of practice are more prone to IED campaigns.

Counter-IED Operations
• As a complement to research establishing measures of IED mission effectiveness, develop rigorous measures of the effectiveness of counter-IED efforts (which take into account both objective measures as well as perpetrator expectations of the future effectiveness of their continuing to use IEDs). This would include case studies of both successful and unsuccessful counter-IED operations as well as investigating behavioral changes in the elements of IED networks as a result of counter-IED efforts.
• Assess the feasibility and potential effectiveness of conducting IED disinformation campaigns.

b) Research Approach
1. Develop Robust Common Terminology: Several participants voiced concerns that the elements of the topic were insufficiently defined, starting with the term “IED” and including what precisely is denoted by the terms innovation, diffusion and adaptation in the context of the terrorist use of IEDs. One solution is to develop a precise taxonomy of core and related terms, including the actors involved, the nature of materials, the processes of learning, etc. In short, an essential initial research effort is required to develop a human social typology of IEDs that can be added to existing technical typologies.
2. Utilize the Existing Knowledge Base: While disparate and not linked by a common research architecture, incorporating extant results (see Appendix B) into future work is essential.
3. Use a Variety of Theories: In addition to developing new theories specifically directed at the research question, participants submitted that the problem of terrorist use of IEDs could benefit from applying a variety of theoretical paradigms, including: procedural learning theories (especially the distinction between techne and métis as conceptualized by Michael Kenney); social learning theories, drawn from the criminological literature about learned norms and behaviors; routine activity and other situational criminological theories; general innovation diffusion theories, such as Everett Rogers’ four elements of innovation across the entire social system surrounding the use of IEDs; rational choice-based theories of decision making; reflexive control theory; and charismatic leadership theory.
4. **Apply Multiple Methods:** Participants agreed that a wide range of methodological tools were required to analyze the research questions, beyond the standard qualitative and quantitative methods of the social sciences. There was also significant interest in using mixed methods to analyze the research questions, e.g. applying both large-sample statistical analysis and controlled case studies in analyzing a single topic and using each type of analysis to inform the other. Recommended approaches included: standard quantitative statistical analyses; cross-case comparisons; portfolio analysis techniques; rational choice (bounded) analysis, including game theoretical approaches; case-control design, with suitable comparisons to non-events; standard business organizational analyses applied to terrorist IED use, including SWOT analysis, Five Forces analysis and value chain analysis; tracking community support through surveys, focus groups, and text analysis; field studies and interviews; and social network analysis techniques.

5. **Collect and Synthesize Data:** Participants agreed that any research must be based upon empirical data of actual terrorist uses of IEDs. While several open-source terrorist incident databases exist, there was consensus that researchers required access to more detailed data, usually held by government agencies and that it was imperative that government agencies collaborate with researchers to make as much of this data as possible available for the type of rigorous analysis described above. The particular issues of terrorist innovation, diffusion and adaptation of IEDs would also require the collection of new data. Participants believed that the data must be synthesized and coded in a coordinated manner and that the questions and the universe of cases must at all times inform the data collection agenda, rather than the converse. Data to be collected includes: data not only on IED events, but also on the individuals involved as units of analysis, especially variables that can be used for social network analysis; qualitative historical data on past "IED" or sabotage campaigns, e.g. Arabs against Ottomans in WWI; data on different functional components of IEDs (e.g. explosive, detonator, and trigger).

c) **Research Program**
While further research into the human elements of the IED threat is crucial for national security, this will only succeed if it is part of a structured and dedicated research program. It is in this context that the following recommendations and suggestions are offered.

**Role of academia**
Research is necessary to properly understand and characterize the threat, and hence to enable practitioners to interdict and prevent IED attacks on the U.S. homeland and U.S. interests. The academic community is best suited to develop the basic theories and models and to conduct rigorous, scientifically-based testing of these theories. Academic scholars have the most experience in leveraging open-source information and are often well positioned to conduct fieldwork. In some cases, academia could also support more operational activities, such as countering adversary propaganda, network analysis and even interviewing prisoners, although these functions will likely involve classified information and thus would limit academic freedom to disseminate results.
Strategy
The following presents the broad strategic orientation of any future research program:
1. **Involv e stakeholders**: As mentioned during the workshop: “Academia is good at and for conducting research; industry is skilled at implementation and application of theory and developing products; and government has the required data”. The various parties can build on each other’s work and expertise in a synergistic way, but this will require a functional partnership. As such, a primary element of the research program will be the involvement of stakeholders at all phases of the process. This is especially important in ensuring that the required data can be transferred to the research community, with due regard for security concerns and constraints.
2. **Formulate a cohesive research agenda**: Working in concert with all stakeholders, researchers need to prioritize research topics and ensure that research is conducted in the optimum sequence by the most experienced researchers. Specific attention should be paid to answering questions that have operational value to practitioners and policymakers.
3. **Build cross-disciplinary, multi-institutional research teams**: The human elements of the IED threat transcend traditional academic disciplinary and institutional boundaries and therefore require a collaborative approach.
4. **Secure resources**: This effort should secure a dedicated funding stream to support sustained activities.
5. **Ensure proper management and oversight**: A multi-faceted research effort of this nature will require careful coordination and validation. This can be achieved through a small, dedicated research infrastructure, in addition to both internal and external review processes.

Specific Further Steps
Participants suggested the following steps to initiate and sustain the proposed research effort. These have been loosely divided into a short term (within 18 months) and medium term (18 months to 5 years) steps.

**Short Term**
- Develop a rigorous terminology and set of definitions that will guide all future research in this area.
- Work with the START team to develop a robust database entry model for representing the entire social complexity of IEDs that would allow for statistical analysis. This data model must also be able to integrate with existing technical IED databases.
- Begin integrating existing data streams.
- Begin assembling extensive open source data on a specific test case, such as the use of bombs by the Provisional Irish Republican Army, and enter data into new collection model.
- Conceptualize a multi-dimensional metric for terrorist success in the use of IEDs, and a multi-dimensional metric for state success in response to terrorist use of IEDs.
- Circulate a list of hypotheses/projects from the workshop to various stakeholders and obtain an average rank ordering in terms of priority research questions and projects.
- Begin developing a network of interested parties who represent all types of stakeholders. Identify “champions” within various organizations who are...
interested in long-term support of this work. This would include obtaining buy-in from technical experts who would be willing to contribute their expertise towards the human-oriented research.

- Conduct initial quantitative and geo-spatial analysis and disseminate results.
- Encourage workshop participants to generate white papers on projects to start moving forward.
- Arrange for a special journal issue devoted to IED innovation, diffusion and adaptation by terrorists. The journal issue would feature state-of-the-art research in this area, as currently being conducted by participants in the workshop and others.

**Medium Term**

- Secure dedicated funding sources sufficient to support at least several of the key research projects.
- Conduct all necessary data gathering and consolidation.
- Complete a number of major research projects.
- Supply practitioners with policy- and operationally-relevant findings.
- Build a robust theoretical model of terrorist tactical innovation, diffusion and adaptation that can be transferred to other contexts.
- Publish several substantial academic products (e.g., books, edited volumes, research reports).

**Conclusion**

In terms of its primary stated objectives, the workshop collected a baseline set of existing knowledge and data and generated a blueprint for moving forward. The workshop firstly highlighted the need for establishing the basic intellectual groundwork for further research in this area, including producing rigorous and collaborative definitions of IEDs and their social context, collecting, coding and consolidating appropriate data streams, and borrowing theoretical models from a variety of related topic areas (such as business innovation). Second, it mapped the spectrum of research lacunae in this area, as well as supplying an extensive list of suggested research topics to address these gaps. Third, it provided a preliminary agenda for moving forward. Last but not least, the workshop established that any successful advances in this agenda will require partnership with government agencies in both setting priorities and gaining access to data and research subjects.
Introduction

The National Consortium for the Study of Terrorism and Responses to Terrorism (START) conducted a workshop entitled “Human and Social Forces in the Spread of the IED Threat: Innovation, Diffusion and Adaptation” on Thursday, November 20, 2008, at the University of Maryland in College Park. The objectives of the workshop were to explore certain aspects of the social and behavioral elements of the threat of terrorists using improvised explosive devices (IEDs), specifically those aspects related to the evolution and spread of IED usage, and to set the stage for future research in this area. Initial presentations and discussion provided a baseline of current knowledge (both qualitatively and quantitatively derived) regarding innovation and diffusion in the terrorist use of IEDs. After START researchers set the workshop parameters, group discussions and breakout sessions explored the future directions that research in this area might take. This report provides a conceptual overview of each session, as well as describing the topics discussed and future recommendations.

a) Background

Although improvised explosive devices (IEDs)\(^1\) have long been staple weapons of violent non-state actors who lack access to the sophisticated armaments produced by military manufacturers, such weapons have only quite recently risen to the upper strata of concern among those responsible for dealing with the tactical manifestations of the terrorist threat. It is therefore hardly surprising to find that there is a relative paucity of past analytic and scholarly material examining terrorists’ weapon selection,\(^2\) particularly in the case of improvised explosives. This is especially true when one considers the behavioral and decision-making aspects of weapons selection and how these relate to broader contextual factors. The first major survey of research on IEDs, conducted by the National Research Council, stated that: “The human terrain—the political, social,

\(^1\) There is no universally-recognized definition for what precisely constitutes an “improvised” device. The definition used by the United States Department of Defense and NATO is as follows: “A device placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic, or incendiary chemicals and designed to destroy, incapacitate, harass, or distract. It may incorporate military stores, but is normally devised from nonmilitary components” (DOD Dictionary of Military and Associated Terms). This is also the definition adopted by the National Research Council Committee on Defeating Improvised Explosive Devices. Alternative definitions have been suggested, including: “a bomb that is constructed in part or wholly from military or commercial explosives or commercial components, and used in a manner other than intended by the manufacturer” (Richard Legault, START researcher).

cultural, and economic environment—is a critical element at all stages of an IED attack, and it probably is also the most complex and the least well understood."³

One area in which the social and behavioral sciences have the potential to make a substantial contribution is in understanding how the use of IEDs, particularly in terrorist campaigns, spreads from one actor and geographic location to another. This involves not only physical networks of personnel and resources, but also less tangible networks of knowledge propagation and behavior emulation. Furthermore, any assessment of how the use of IEDs diffuses between terrorist cells and organizations must take into account the influence and feedback potential of the human terrain in which these activities take place, especially how this influences the manner in which existing tactics and weapons are adapted and in which adversary innovation takes place. Studying how IED use is chosen and diffuses is also likely to have much broader application for the understanding of terrorist behavior, since it necessitates exploring general mechanisms of tactical innovation and weapons selection.

The National Consortium for the Study of Terrorism and Responses to Terrorism (START) therefore convened a one-day workshop to synthesize and extend current understanding of how the use of IEDs by terrorist actors spreads across time, space and actors. Although there has been sparse research in the diffusion of terrorist tactics,⁴ the literature on the diffusion of innovations and other practices is robust and the workshop attempted to draw on the long history of research in this area to inform its activities.

b) Workshop Goals

Primary Goals
The main objectives of the workshop included:

- To explore the social elements involved in the diffusion of IED use among and between terrorist organizations, including those factors influencing learning and adaptation.
- To synthesize a knowledge base from relevant fields upon which to build future research.

Secondary Goal
If possible under time and resource constraints, the workshop also sought:

- To develop operationally-relevant preliminary findings and recommendations that can be communicated to practitioners.

³ Committee on Defeating Improvised Explosive Devices, Countering the Threat of Improvised Explosive Devices: Basic Research Opportunities (Summary), National Research Council (2007), p.3.
⁴ An excellent study of terrorist learning more generally is: Brian A. Jackson, et. al. Aptitude for Destruction, Organizational Learning in Terrorist Groups and Its Implications for Combating Terrorism, Volumes 1 and 2 (Santa Monica: RAND, 2005)
c) Pre-Workshop Activities

Under the direction of the workshop chair, START selected and invited twelve scholars and practitioners to participate in the workshop. Participants were intentionally selected to represent a broad range of disciplinary expertise, including social psychology, criminology, management science, history, political science, public policy and applied physics. Although several of the participants were recognized experts on various aspects of terrorist behavior, organizers ensured that broader expertise was present, including a senior explosives ordinance disposal technician and an expert on business innovation. Participant biographies are included as Appendix A.

Participants were each supplied with a brief that outlined the purpose of the workshop and were requested to submit a thought piece prior to the workshop. Participants were given significant discretion in selecting the topic of their thought pieces, but were provided with sample research questions as a guide.

These sample research questions included:

- How do IED attacks diffuse spatially? For example, is the spread geographically contiguous or not?
- How do IED attacks diffuse temporally? What is the rate of diffusion? When do IED campaigns escalate / deescalate?
- Is the decision to adopt or pursue IEDs predominantly strategic and instrumental or is it also governed by affective / psychological / expressive factors?
- Does the diffusion of a) the intent, b) the resources (including human capital in the case of suicide bombers), and c) the technical capability (knowledge / skill sets) to successfully use IEDs occur (relatively) simultaneously or are there separate processes involved?
- Is there a trial period before adoption of a full-fledged IED campaign? How long does this last?
- What does the learning curve look like? Are there differences in the propagation of explicit vs. tacit knowledge of IEDs?
- How do terrorists become aware of IED-related information – do they seek it out or is it presented to them by a change agent? This encapsulates the broader question of whether the decision to pursue IEDs is endogenously or exogenously driven.
- To what extent are IED campaigns opportunistic, relying, for example, on abandoned or captured ordinance?
- How much adaptation takes place? Which terrorists are best equipped to implement any needed adaptations?

Participants were also requested to list any relevant prior research (both theoretical and empirical), to attempt to apply this research to the workshop topic area and to think about testable hypotheses that might consequently be generated. Organizers distributed participant thought pieces to all participants in advance of the workshop.

In order to facilitate the recording and organization of information gathered during the workshop, organizers developed a structured way to capture information. This consisted
of a matrix whose rows represented various sub-topics and whose columns captured information on: Relevant Existing Findings, Applicable Theories / Models, Available Data / Evidence, Suggested Research and Hypotheses. The baseline matrix was constructed prior to the workshop using participants’ thought pieces, and was supplemented with new sub-topics suggested during the workshop. Part of the final matrix summarizing existing research can be found in Appendix B.
Session Reports

Session 1: Welcome and Introduction

During the welcome and introductions, the Workshop Chair described the purpose of the workshop, which was to bring together a select group of diverse, exceptional individuals to explore a pressing topic. He explained the necessity of brainstorming the future of academic research surrounding IEDs and their use or potential use in terrorism.

The Chair presented the matrix approach to the workshop. The matrix divided topics directly related to IEDs into a table and provided the opportunity to insert current knowledge and suggested directions for future knowledge.

The Chair also presented a video of IED explosions to demonstrate the extremity of the danger surrounding IEDs and to provoke thought regarding potential uses. Following this video, a technical expert provided an impromptu overview of the circumstances related to IED use, how bomb experts attempt to deactivate IEDs, and how charges are measured. This presentation prompted discussion about the definition of exactly what kinds of explosives constitute IEDs. One participant pointed out the difference between landmines and IEDs, but further conversation was deferred since this was the topic of the following presentation.

Session 2: Where We Are - Developing a Knowledge Base

One of the participants introduced the status of quantitative research concerning IEDs at START, specifically findings that START has been able to derive from the Global Terrorism Database (GTD). He began by attempting to define “improvised explosive device” and this portion of his presentation prompted further discussion surrounding the definition of the topic. The participant proposed the following definition: “A bomb that is constructed wholly or in part from military or commercial explosives or commercial components, and used in a manner other than intended by the manufacturer.” Questions about this definition were concerned with which materials constitute commercial components, how we distinguish between homemade explosives and homemade detonation devices, and how we should categorize IEDs. In fact, participants concluded that so much controversy surrounds this definition that this is one direction future research should pursue.
The workshop continued with a look at prior related work, specifically that undertaken by the National Research Council.

**Presentation: The National Research Council’s “Disrupting IED Terrorist Campaigns” Workshop Overview**

Another participant presented an overview of the NRC’s series of workshops titled “Disrupting IED Terrorist Campaigns” and provided highlights from each of the two workshops. He pointed out the lack of substantive findings in areas related to adaptation, diffusion, and innovation, but introduced how some elements of the NRC workshop presentations could be considered in light of these three dimensions. Several of the participants that had attended the NRC workshops described their experiences and concurred with the presenter’s conclusions.

**Mapping Current Research**

Following the introductory presentations on prior research on the general topic of terrorist IED use, participants were tasked with sharing research that they felt to be directly or indirectly relevant to the particular issues of adaptation, innovation and diffusion. These contributions included existing findings, theories, models, methods and data, which together constituted the existing knowledge base that could be applied to understanding the current topic. Beginning with relevant findings, and then moving on to theories, models and data, participants recorded their contributions on Post-Its™ and subcategorized each contribution as directly or indirectly relevant to the topic at hand. Participant contributions were then transferred to the electronic matrix, which was presented on a large screen so that participants could ensure the accuracy of recording. Following the research findings tally, one of the participants presented a technical brief on the general processes of innovation and diffusion and how these might relate to IED use.
Presentation: Basics of Innovation and Diffusion

This presentation looked at various elements of the innovation and diffusion process, including Rogers’ elements of diffusion, market segmentation, the effect of norms and performance, and centralized and decentralized diffusion systems. In each of these areas, this presenter provides hypotheses pertaining to IEDs that required further testing. During this presentation, one participant offered the example of the Apple iPod as an illustration of innovation, but the presenter suggested the iPod was actually an advancement in design, rather than an advancement in technology because the MP3 existed prior to the iPod. Another participant suggested that an assumption underlying diffusion and innovation in commercial markets is the goal of making more money whereas the desired outcome regarding IED use is to gain more control.

After the presentation, participants were asked to brainstorm applicable theories and models to add to the matrix. During this session, a participant provided an impromptu overview of the techne vs. métis approach that he discussed in his thought piece. Another participant suggested looking at alternatives to IEDs, specifically their risks and rewards, to better understand not just why groups choose to use IEDs, but how using portfolio analysis techniques including Valley of Death, Expectancy, and Platform analysis, might enable better understanding of why IED use is so popular. A third participant recommended looking at improvisation in similar terms to the construction used in the book Guns, Germs, and Steel by Jared Diamond. The Chair suggested that researchers often utilize a pure rational choice model, but the situation should also be considered from the opposite direction – some terrorists use an IED simply because they feel drawn to it, and offered Ramzi Youssef as an example. A participant proposed applying learning theory and explained that people are not born knowing how to put IEDs together, but that they learn that it is acceptable to behave in a certain way and then they learn the techniques that go along with it. He further explained that criminology focuses on rationalization, not techniques. One participant suggested using case control design and stated that most terrorism research is event-based, which means that there is really no comparison to the non-event. Looking at databases that compare events can provide a tremendous amount of information on characteristics of IED use, but we should also look at possible targets that are not selected – to see why similar potential targets in an area where IED attacks occur are not targeted. One of the observers mentioned using databases like the GTD to suggest case controls – perpetrators or targets that are “eligible” to be in the event population, but are not actually involved. According to two participants, by doing this scholars might obtain a better idea of how IED perpetrators perceive risk. Another participant mentioned the challenge presented by needing a large sample of non-event space to be certain of a statistically significant comparison.

Participants were then tasked with providing examples of relevant IED-related data, which were captured on the matrix.

Once participants were confident that they had listed all the existing knowledge of which they were aware, discussion turned to identifying gaps in current knowledge. One participant pointed out the need to consider learning with respect to IEDs from an inherently procedural approach – the act of gathering and acting on knowledge. Another participant then suggested putting together a database that focused on
individuals, rather than events. A third participant recommended applying the previously discussed *technē vs. métis* approach to the radicalization process (i.e. earlier in the threat chain) to study when and how actors first conceive of using IEDs. One of the participants mentioned his work on terrorism involving weapons of mass destruction and suggested investigating whether the diffusion of IED use as a favored tactic of terrorists was driven by exogenous sources or whether it was driven by actors internal to a particular grouping, who then must seek out knowledge and train themselves. In this regard, a participant referred to the work of Quan Li and noted the importance of exploring how people discover information about terrorism amid different forms of media. The Chair followed with the need to look at the motivation behind acting – is this driven more by a charismatic personality or the broader context, or a little of both? For example, does a cell leader utilize a subscription to Jane’s Defence Weekly to discover new ideas for weapons or does he wait for someone in his wider network to recommend a new tactic – in other words, what are the agents of change? A participant then suggested examining past experiences of desistance from using IEDs and provided the Weather Underground as an illustrative example of a group that abandoned bombs after an accident (an explosion in a Greenwich Village apartment). Another participant concluded with the need to look at the role played by a leader’s charisma versus the way a group is actually organized.

**Session 3: Where to Go - Identifying Research Gaps and Priorities with respect to IED Innovation, Diffusion and Adaptation**

During lunch, an external expert delivered a presentation on terrorist innovation.

**Presentation: Ideas Regarding Terrorist Innovation**

This presentation looked at the culture of IEDs and the groups that use them. The presenter began by asking the questions, “What are IEDs? Why are we concerned?” and reminded participants of the importance of context. To really examine IED usage, the presenter suggested we use a comparative approach, one that compares IEDs to other methods of terrorism and compares groups that use IEDs to those that do not. Finally, the presenter discussed the importance of focusing on process and noted her work on innovation, where she employed strategic, tactical, and organizational approaches. She finished by suggesting further work on innovation that should look at organizational theories of entrepreneurship.

Following this presentation, participants were asked to identify further gaps in light of previous discussions and information delivered during the presentation. These ideas were then recorded in the matrix under the heading of “suggested research.” During this discussion, one participant observed that there was a lot of confusion regarding terminology and suggested that a taxonomy should be developed to better understand IED use. He recommended that the following items be included in that taxonomy: who the combatants are, what are they using, how the technology is diffused - in short, a human social typology or ontology of the combatants. He explained that Everett
Rogers, one of the foremost scholars of innovation diffusion, talks about four elements of innovation diffusion and that so far IED research has only focused on one. Research should consider all the elements of innovation, including actual communication channels, time, diffusion, and the social system (i.e., not just the terrorists, but the people surrounding them, those that sympathize, etc.). He went on to say that groups should be segmented into earlier, medium, latter adoption segments – both the nature of the groups and the types of materials they use. This participant also observed that one in five Americans have an innovative-type personality and suggested that research into IEDs might consider Geert Hofstede’s research on intercultural differences⁵ and Geoffrey Moore’s work, Crossing the Chasm,⁶ which looks at the different drivers in each of the categories. This would help inform further data collection and the formulation of a sound research methodology, which he believed to be lacking. Another participant went one step further in suggesting that researchers look at the impact of culture on IED use and whether we can use this to make projections relevant to homeland security. A third participant concluded the discussion by recommending that we consider concepts that bridge all available theories.

Following this discussion, participants were asked to propose specific research hypotheses, which were subsequently recorded in the matrix under the heading “Hypotheses.” At this point, two further presentations were delivered, one on suicide attacks in Afghanistan and one on how IEDs diffuse in practice, based on experiences in Iraq.

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**Presentation: Human and Social Forces in the Spread of the IED Threat: Suicide Attacks in Afghanistan**

A participant presented the data she has collected on suicide attacks in Afghanistan. This data demonstrated that the highest number of attacks occurred during September 2006 and 2007. She explains this trend as an effort to escalate violence before the expected slowdown that occurs during brutal Afghan winters. She also demonstrated that 2007 was a marked improvement in sophistication and lethality of attacks and there has been an overall increase in suicide attacks in Kabul.

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Presentation: Diffusion Process of IEDs
This presentation covered the basics of an IED network and how the IED maker fits into the overall organization of a terrorist group. The IED maker’s relationships with the other members of the organization can best be described in terms of “six degrees of separation” in that not every member is directly linked to the bombmaker, but often connecting with a so-called broker will lead to a bombmaker. This presenter also described the close coupling between the productivity of the main components of an IED mission, namely, leader skills, IED maker efficiency, and overall cell productivity.

Following these presentations, a participant asked about the centrality measures of the IED bombmaker within a cell and the need to minimize his connections. The presenter explained that his work related to depicting the tremendous amount of information sharing occurring, not necessarily the centrality of the bombmaker within the group.

Session 4: How to Get There - Establishing a Research Agenda for Understanding Terrorist IED Innovation, Diffusion and Adaptation

During Session 4, participants were broken into groups numbering 3-4 persons and tasked with spending 45 minutes completing a worksheet that would assist in setting a practical agenda for moving forward with research in this area. Using the research gaps, hypotheses and ideas for future research discussed up to this point in the workshop, participants were asked to answer the following questions:

1. What should the role of academia be in addressing issues of innovation, diffusion, and adaptation with regards to the IED threat? Which elements of this problem are best dealt with inside/outside of academia?
2. What would a general strategy for conducting research in this area look like?
3. What is the perceived timeline of these efforts? What can be done in the short term (within 18 months) and what research aspects are likely to take many years?
4. Which disciplines, types of institutions and/or individual researchers should take the lead in this research? In other words, if we were to proceed down this research track, who should be involved?
5. How can the resources be obtained to carry out the research?

Group 1 Response:
1. Role of academia: Academia is good at developing theories and models and for conducting research; industry is skilled at implementation/application of theory and developing products; and government has the required data, but it may not be accessible until long after an event, if at all. The various parties can build on each other’s work and expertise in a synergistic way, but government must be willing to assist academia with data collection. Academic researchers also often
have international connections (including with extremists), which are difficult for government or industry to maintain.

2. **Core elements that a strategy would consist of:** a) In-depth qualitative studies of real world groups and their use of IEDs; b) answering questions that have operational value to practitioners; and c) developing indicators that will help security agencies interdict or respond to IED attacks (e.g., identifying crucial network nodes and indicative behavior patterns).

3. **Timeline:** 5 years of synergistic cooperation would allow academics to answer many crucial questions. One could employ “brokers” (champions with this specific task) to facilitate cooperation between stakeholders. 1-2 years would be enough to identify preliminary indicators, but certain projects (e.g., how do terrorists learn?) will be longer-term efforts.

4. **Who should be involved:** There is a need to involve people who understand extremist and insurgent groups, world history, foreign cultures, experts on commercial innovation and organizational learning, operational experts, “beat cops,” tactical and technical experts.

5. **Source of resources:** The government, private industry, academia, foreign nationals or entities – multiple sources, which will help alleviate charges of bias or co-optation.

**Group 2 Response:**

1. **Role of academia:** Produce analytical results from data and present them to varying fields of academia, thus multiplying disciplinary perspectives addressing to the same problem. Different fields may illuminate different aspects amid the complexity of the data.

2. **Core elements of a strategy would consist of:** Convincing the government, which is focused on the problem of the moment, to use data from the past, such as Northern Ireland and relate it to current threats. Approaching the problem both deductively: how do we design theory to test and inductively: how do we get the data to test it. Conceptualize and testing as some sort of cycle

3. **Timeline:** Results need to be produced within 18 months, depending on the data, to attract investment. “Moving targets” such as Iraq will essentially have no timeline in the foreseeable future as information access may be decades away.

4. **Who should be involved:** The government, as well as the innovation field, who already have models and methodologies that can utilize data quickly.

5. **Source of resources:** Branch out more into Corporate funding. Most large companies who are involved with international investments and trade also are involved in threat assessment and transportation security. Government sponsors can include the National Science Foundation, the National Institute of Justice, Center for Disease Control, and National Institutes of Health.

**Group 3 Response:**

1. **Role of academia:** Academia should develop theory, engage in fieldwork and comparative case studies, perform causal analyses of large-N data sets and conduct post hoc evaluations of the efficacy of interventions. Academia is best
poised to analytically determine causes of the behavior, to leverage open-source information and to rigorously test extant theories. In some cases, academia could also support more operational activities, such as countering adversary propaganda, network analysis and even interviewing prisoners, although these functions will likely involve classified information and thus would limit academic freedom to disseminate results.

2. **Core elements that a strategy would consist of:** a) Describing the phenomenon in a measurable way; b) field research and other methods of assembling primary source data; c) hypothesis testing with large, merged data sets; and d) ensuring that all research is policy relevant.

3. **Timeline:** In the short-term (within 18 months), existing data sets and streams could be merged to maximize the usefulness of current data, for instance by uncovering the geo-spatial distribution of IED attacks. A typology of the human elements of IEDs should also be created in order to direct and harmonize future research. Understanding terrorist innovation, adaptability and learning, especially with respect to IEDs, is likely to take longer and require multiple, multi-year efforts. There are no instant deliverables in this regard.

4. **Who should be involved:** there is a need for multidisciplinary cross-institutional collaboration, in order to leverage the best expertise, including START, ICST at Pennsylvania State University, John Jay College (CUNY), Kings College London, and the National Police Academy University in Oslo. Government agencies could contribute to this effort by providing technical expertise in order to code the complexity of IED artifacts in a standard way.

5. **Source of resources:** Federal government, especially Department of Defense, Department of Homeland Security, National Institute of Justice, and the National Science Foundation.

**Session 5: Wrap-up**

Following the breakout sessions, the Workshop Chair invited participants to reflect on the discussions for a few days and to supply what they believe are the top three priorities for research activities in the area of terrorist innovation, diffusion and adaptation with respect to IEDs. These research priorities, as subsequently supplied by participants, are incorporated into the analysis in the following section.

The Chair then asked each participant to provide suggestions for immediate follow-on steps in this research activity. Participants expressed the following:

- Encourage scholars to write short white papers to start moving projects forward. Other researchers can then leverage their own knowledge to contribute to these projects. The team can achieve quite a bit from taking advantage of datasets we already have.
- Look for opportunities for collaboration with various other parties interested in this research.
- The technical expert present offered to provide his technical expertise to assist in any follow-on efforts.
• More work should be conducted on defining IEDs in a formal manner, then describing characteristics of the units of observation – this effort alone will provide more information than is already available.
• Assemble sufficient preliminary research to publish a special issue of a scholarly journal (such as Dynamics of Asymmetric Conflict).
• Start to explore possibilities of using Northern Ireland as a baseline / test case.
• Another test case could be right-wing groups in the United States.
• Take advantage of opportunities to collaborate between research organizations and explore spatial and temporal geographic shifts in the phenomenon.
• We should try to establish a research infrastructure to address the question; much can be learnt from the robust terminology in the general innovation diffusion literature. This participant believes that applying innovation and diffusion models to this topic makes sense, and that we might also consider applying a technique known as reverse brainstorming.
Analysis and Recommendations

Participants unanimously agreed that there was substantial scope for research into the human elements of the IED threat, and specifically into the important issues of innovation, diffusion and adaptation of IEDs. Understanding these issues was felt to be vital to efforts to counter the use of IEDs by terrorists. There was also a consensus that the academic community had an important role to play in conducting this research. The following represents a summary of participant recommendations for future research in this area, separated into three main categories. These are a) Research Topics: specific topics related to IED diffusion, innovation and adaptation that require further study; b) Research Approach: those recommendations relating to establishing an intellectual and empirical infrastructure for conducting the research, including theories, methods and data that should be utilized by researchers; and c) Research Program: recommendations that deal with programmatic concerns, such as how to initiate and maintain the required momentum of interest amongst researchers, how to engage policymakers and practitioners, and how to secure sufficient resources to engage in the larger research effort.

a) Research Topics

The main research topics suggested during the workshop are listed below, organized according to sub-categories. These categories were developed based on the matrix categories and subsequent discussions during the workshop. Any categorization scheme is limiting, however, and many topics span more than one category, in which case the topic was listed in the category to which the Workshop team felt it was most germane. Furthermore, certain of the topics represent broader explorations and others are responses to specific hypotheses put forward by participants.

General IED Innovation, Diffusion and Adaptation Topics (Cross-Cutting Research Projects)

- Develop an overall conceptual model of IED diffusion, innovation and adaptation by terrorists that can be revised and updated as additional research is conducted.
- Research investigating the extent to which methods and findings from business / management science carry over into the IED context and hence can be used to explain IED diffusion and innovation dynamics. (Several specific topics below would stem from this).
- Research on whether IEDs are significantly different from other terrorist attacks and other types of bombings and therefore whether treating IEDs as a separate topic of study is really the most efficient approach.
- Testing the NAS IED Threat Chain Model against one or more in-depth case studies to assess its validity.
- Compare conflicts / campaigns where IEDs have been used to conflicts / campaigns where they have not for clues about structural and other environmental differences (inductive approach).
Developing measures of IED mission effectiveness (both objectively and from the perpetrator’s point of view) and analyzing the interplay of factors that impact these measures.

Related to the previous topic, conducting case studies of both successful and unsuccessful IED operations to determine key differences.

**Awareness of IED-related Information**

- Investigate whether information about IEDs and their effectiveness is exogenously or endogenously driven, and whether this varies by context. In other words, do terrorists seek out information on IEDs as a tactic, or are they influenced by external sources (agents of change) in their social network or ideological milieu?
- Explore the types of media and other information sources that perpetrators use to learn about IEDs.
- Related topics include:
  - Exploring whether the mere diffusion of IED knowledge and technology will necessarily cause extremist groups that have historically preferred other methods to employ IEDs in mass casualty attacks.
  - Assessing whether a terrorist group will be more likely to imitate groups with perceived similarities.

**Terrorists’ Decision to Employ IEDs**

- Compare cases of terrorist groups that do adopt IEDs with those that opt not to employ them, with a view towards understanding the factors, contextual and otherwise, that affect such decisions.
- Investigate the balance between instrumental and expressive motivations for using IEDs. This entails looking at whether the adoption of IEDs as a tactic is driven primarily by the technology itself, expediency in weapon choice, an inherent predilection or social learning through formal or informal networks. Among other questions, this would look at whether the flexibility and variation in design structure is a major reason for the appeal of IEDs to terrorists.
- Assess the extent to which data about the motivation of IED users can be gathered easily through interviews and field work.
- Explore the importance of technological advances, in other words “can invention become the mother of necessity?”
- Analyze IED use from a “consumer” perspective, where users select innovations depending on a number of different variables (including ease of use, cultural compatibility, and relative advantage) in order to assess the relative interplay and importance of “internal” vs. "external" factors.
- Similarly, research could describe the business and economic drivers of IED usage by treating it as an “industry” or market.
- Investigate who makes the decision to utilize IEDs and at what organizational level this occurs.
- Investigate whether particular personality types (either psychologically, or on a Keirsey Temperament scale) are associated with particular roles in the IED process (e.g. bombmaker, bomber, cell leader).
- Study the roles of leader charisma and group organizational structure on innovation, diffusion and adaptation.
Human and Social Forces in the Spread of the IED Threat

- Explore how culture impacts IED use, for example, is the type, frequency or rate of diffusion of IEDs mediated differently across cultures?
- Explore the non-rational choice influences on IED use, including religious drivers and inhibitors.
- Investigate the role played by opportunity: does IED use increase as a result of the availability of explosive materials (through analyzing such variables as military action, size of military forces, and use of left-behind military ordinance)?
- Assess the role of finances in IED campaigns, and whether economic gain is a driver for at least some of the actors involved.
- Investigate to what degree the level of community support impacts the decision to use or continue to use IEDs and whether this varies across cultural and contextual settings.

IED Learning Curve

- Use multivariate models to provide information on the necessary antecedents to IED use. This includes gaining a better understanding of the level of training needed for the construction and implementation of IEDs of varying levels of complexity.
- Conduct in-depth case studies of various terrorist groups' prior use of IEDs (cf. Brian Jackson et. al. at RAND’s studies with respect to organizational learning), both those that were successful and those that either failed or were interdicted. Include assessments based on explicit vs tacit knowledge propagation and the *technē* and *mētis* model. For example, militants in Europe might lack the *mētis* needed to execute their attacks more effectively - since even the Iraqi experience may not translate into the European environment.
- Related to the above, compare the prospects of “amateur” versus “professional” terrorists with respect to IEDs, in particular investigating whether it will be more difficult for self-styled “revolutionaries” or “mujahidin” to launch sustained IED campaigns unless they acquire more firsthand operational experience in deploying IEDs or create an efficient logistical infrastructure of some type.
- Investigate the role of imitation vs innovation (especially comparing professional bomb-makers to clever amateurs). Explore the extent to which terrorists engage in trials (and tinkering) before embarking on a full-fledged campaign.
- Investigate select cases to determine how effective particular terrorist cells can become, in terms of manufacturing and deploying IEDs, with or without obtaining hands-on training or actual experience.
- Evaluate the practical value of existing online terrorism manuals.

How IEDs are Used

- Investigate the choice of techniques, tactics, and procedures (TTPs) of terrorist groups with respect to IEDs. For example, why do similar terrorist groups adopt different tactics?
- Analyze the intelligence and information gathering requirements for IED use and how terrorists have actually acquired this intelligence, with the objective of identifying early warning indicators.
• Explore how different terrorist groups adapt and improvise IED production and usage techniques. What drives adaptation or improvisation: necessity (for example, a shortage of materials) or some other motivation (for example, competitiveness or self-aggrandizement of the bomber)?

**Spatio-Temporal Aspects of IED Innovation, Diffusion and Adaptation**

• Extend existing geo-spatial analysis of IED attacks by incorporating social movement perspectives.

• Compare locations that have been the target of IED attacks with similar targets that have not, using case control methods. In this approach, one would compare empirical target locations (e.g. buildings or monuments) where IED attacks have occur, with a drawn control sample where attacks did not occur in order to identify target selection and points of interdiction.

• Explore IED use from an epidemiological perspective: do IED use or designs spread a) outward spatially from particular geographic centers, first to adjacent and thence to further removed territories (usually gradually); b) with the movements of particular individuals (more rapid spatial “jumps”) or c) spread virtually, aspatially and extremely rapidly?

• Assess the salience of “virtual diffusion,” that is, whether in light of the Internet as a communications mechanism, the diffusion of IED know-how is still dependent on a gradual expansion from specific geographic nodes, the physical movements of knowledgeable people, or hard copy bomb-making manuals.

• Compare groups that have demonstrated either rapid or slow adaptations in the use of explosives. Northern Ireland was suggested as possibly the best proof of concept (with access to former IRA / Loyalist bombmakers through John Horgan), although domestic U.S. use may be also be considered since this might be of more interest to homeland security practitioners. In the U.S. case, researchers would most likely require support from government agencies to acquire the necessary information.

• Investigate whether there are discrete and identifiable stages / segments of innovation, diffusion and adaptation with respect to IEDs (as, for example, with commercial products). If so, are there optimal stages / segments for interdiction?

• Investigate which factors influence the rate of diffusion of IED use by terrorists and how these factors operate.

• Explore the links between innovation, success and subsequent escalation.

• Examine the Extremist Crimes Database to see whether certain types of criminal incidents act as precursors to IED attacks in the U.S.

• Study past cases of desistance from the use of IEDs by extremists. Why did they desist? Can interventions facilitate the process with current actors?

• Conduct a temporal analysis of IED diffusion according to Rogers’ S-curve theory and including measures of the efficacy of attacks.

• Investigate whether different elements of the IED threat – intent, resources, technical capability, but also different physical components like triggers, explosives and detonators – diffuse simultaneously or asynchronously, and whether there is any discernible sequence.
• Explore whether there are certain types of preparatory behavioral actions (besides the obvious acquisition and production of the actual devices) that must be completed in order to carry out IED attacks.

**IEDs and Social Networks**

• Characterize in detail the social network necessary to carry out an IED operation.
• Perform various social network analyses of terrorist IED networks and how IED production and tactical techniques spread through networks (dynamic network analysis).
• Investigate the topology of networks, especially the role of brokers, including whether connections occur because of similar interests, proximity or overlapping activities? Does personality play a role in the type of networks? Are there specific patterns for brokering a network? How does the bombmaker nurture the broker relationships in his network? Use this to build an accurate model of a terrorist IED network.
• Test the interaction between funding/sponsorship and the use of IEDs.
• Investigate whether specific groups act as feeders or gateways for suspects who ultimately become involved with IEDs.
• Analyze terrorist IED use in terms of a “communities of practice” model and investigate whether participants are involved in a community of practice will be more likely to effect IED campaigns.

**Counter-IED Operations**

• As a complement to research establishing measures of IED mission effectiveness, develop rigorous measures of the effectiveness of counter-IED efforts (which take into account both objective measures as well as perpetrator expectations of the future effectiveness of their continuing to use IEDs).
• Conduct case studies of both successful and unsuccessful counter-IED operations.
• Investigate behavioral changes in both the bombmaker and other elements of IED networks as a result of counter-IED efforts.
• Use case comparison with groups that are using IEDs, where adaptation to security force IED countermeasures has been either fast or slow (a suggested case study is the experience of Republicans versus Loyalists in Northern Ireland).
• Assess the feasibility and potential effectiveness of conducting IED disinformation campaigns.

**b) Research Approach**

1. **Develop Robust Common Terminology:** Several participants voiced concerns that the elements of the topic were insufficiently defined, starting with the term “IED” and including what precisely is denoted by the terms innovation, diffusion and adaptation in the context of the terrorist use of IEDs. Without disciplined foundational concepts people will talk past each other, thus making integrating and comparing future research results difficult if not impossible. One solution is to develop a precise taxonomy of core and related terms, including
the actors involved, the nature of materials, the processes of learning, etc.
Much can be learnt in this regard from the robust terminology in the general
innovation diffusion literature. In short, an essential initial research effort is
required to develop a human social typology of IEDs that can be added to
existing technical typologies.

2. **Utilize Existing Knowledge Base**: During the workshop, participants provided
several existing research findings relevant to the topic under consideration (see
Appendix B). While disparate and not linked by a common research
architecture, incorporating these results into future work is essential.

3. **Use a Variety of Theories**: In addition to developing new theories specifically
directed at the research question, participants submitted that the problem of
terrorist use of IEDs could benefit from applying a variety of theoretical
paradigms, drawn from multiple academic disciplines. Candidate theories
proposed included:
   - Procedural Learning theories, especially the distinction between *technne*
     and *mētis* (as conceptualized by Michael Kenney)
   - Social (Contextual) Learning theories, drawn from the criminological
     literature about learned norms and behaviors.
   - Routine Activity Theory (Criminology)
   - Situational Theories (Criminology)
   - General Innovation Diffusion theories, such as Everett Rogers’ Four
     Elements of Innovation across the entire social system surrounding the
     use of IEDs (akin to the human terrain discussed in the National
     Academies report)
   - Rational Choice-based theories of decision making
   - Reflexive Control Theory
   - Charismatic Leadership Theory

4. **Apply Multiple Methods**: Participants agreed that a wide range of
methodological tools were required to analyze the research questions, beyond
the standard qualitative and quantitative methods of the social sciences. There
was also significant interest in using mixed methods to analyze the research
questions, e.g. applying both large-sample statistical analysis and controlled
case studies in analyzing a single topic and using each type of analysis to inform
the other.
   - Standard quantitative statistical analyses
   - Cross-case comparison
   - Portfolio Analysis techniques, such as Valley of Death, Expectancy, and
     Platform analysis, which would explore alternatives to IED use / adoption.
   - Rational Choice (Bounded) analysis, including Game Theoretical
     approaches.
   - Using Case-control Design, with suitable comparisons to non-events.
   - Measures of IED Effectiveness developed by Samuel Musa
   - Standard business organizational analyses applied to terrorist IED use,
     including SWOT analysis, Five Forces analysis and value chain analysis.
   - Tracking community support through surveys, focus groups, and text
     analysis.
   - Social network analysis tools.
5. **Collect and Synthesize Data**: Participants agreed that any research must be based upon empirical data of actual terrorist uses of IEDs. While several open-source terrorist incident databases exist, there was consensus that researchers required access to more detailed data, usually held by government agencies and that it was imperative that government agencies collaborate with researchers to make as much of this data as possible available for the type of rigorous analysis described above. The particular issues of terrorist innovation, diffusion and adaptation of IEDs would also require the collection of new data. Participants believed that the data must be synthesized and coded in a coordinated manner, in order to ensure the broadest possible grist for the analytical mill. Furthermore, one participant cautioned that available data should not structure the research questions or the universe of cases, lest the resulting research end up only partially addressing the issue. Rather the questions and the universe of cases must at all times inform the data collection agenda.

   a. **Existing Data**
   
   i. Extremist Crimes Database
   
   ii. Global Terrorism Database (with IED codings)
   
   iii. *TEDAC (Terrorist Explosives Device Analytical Center) Data
   
   iv. *ATF Bomb Arson Tracking System (BATS) Database
   

   [* represents those data sets that will require government support to access and may have to be sanitized for use by researchers]*

   b. **Data to be Collected**

   i. Field research and other methods of assembling primary source data required for analysis but not available currently.

   ii. Collect data not only on IED events, but also develop a database with the individuals involved as units of analysis, especially variables that can be used for social network analysis.

   iii. Qualitative historical data on past "IED" or sabotage campaigns, e.g. Arabs against Ottomans in WWI.

   iv. Different functional components of IEDs (e.g. explosive, detonator, trigger) imply that different dynamics of innovation and diffusion can drive the same system, and any effort to analyze the diffusion of these weapons must take a multivariate approach and collect data on all IED components.

   c. **Data synthesis effort** will be needed to merge all acquired data.

### c) Research Program

While further research into the human elements of the IED threat is crucial for national security, this will only succeed if it is part of a structured and dedicated research program. It is in this context that the following recommendations and suggestions are offered.
Role of academia

- Research is necessary to properly understand and characterize the threat, and hence to enable practitioners to interdict and prevent IED attacks on the U.S. homeland and U.S. interests. The academic community is best suited to develop the basic theories and models and to conduct rigorous, scientifically-based testing of these theories.
- Academia is best poised to analytically determine causes of behavior.
- Academic scholars have the most experience in leveraging open-source information.
- Academic researchers are often best positioned to conduct fieldwork.
- Academic researchers often have international connections which are difficult for government or industry to maintain.
- In some cases, academia could also support more operational activities, such as countering adversary propaganda, network analysis and even interviewing prisoners, although these functions will likely involve classified information and thus would limit academic freedom to disseminate results.

Strategy

The following presents the broad strategic orientation of any future research program:

1. **Involve stakeholders**: To adequately understand and counter the human and social forces behind the IED threat, will require the combined efforts of scholars, industry and government agencies. As mentioned during the workshop: “Academia is good at and for conducting research; industry is skilled at implementation and application of theory and developing products; and government has the required data”. The various parties can build on each other’s work and expertise in a synergistic way, but this will require a functional partnership. As such, a primary element of the research program will be the involvement of stakeholders at all phases of the process. This is especially important in ensuring that the required data can be transferred to the research community, with due regard for security concerns and constraints.

2. **Formulate a cohesive research agenda**: Working in concert with all stakeholders, researchers need to prioritize research topics and ensure that research is conducted in the optimum sequence by the most experienced researchers. Specific attention should be paid to answering questions that have operational value to practitioners and policymakers. One example would be to orient research as much as possible towards yielding indicators that will help security agencies interdict and or respond to IED attacks (e.g., identifying crucial network nodes and indicative behavior patterns).

3. **Build cross-disciplinary, multi-institutional research teams**: The human elements of the IED threat transcend traditional academic disciplinary and institutional boundaries and therefore require a collaborative approach. Each research project under this effort needs to be conducted by the most appropriate team of researchers, to whomever they may be affiliated, while at the same time maintaining a clear focus on synergies between projects and policy-relevant deliverables.

4. **Secure resources**: Ideally, this effort should secure a dedicated funding stream to support sustained activities.
5. **Ensure proper management and oversight:** A multi-faceted research effort of this nature will require careful coordination and validation. This can be achieved through a small, dedicated research infrastructure, in addition to both internal and external review processes.

**Specific Further Steps**

Participants suggested the following steps to initiate and sustain the proposed research effort. These have been loosely divided into short term (within 18 months) and medium term (18 months to 5 years) steps.

**Short Term**

- Develop a rigorous terminology and set of definitions that will guide all future research in this area.
- Work with the START team to develop a robust database entry model for representing the entire social complexity of IEDs that would allow for statistical analysis. This data model must also be able to integrate with existing technical IED databases.
- Begin integrating existing data streams.
- Begin assembling open source data on a specific test case, most probably the use of bombs by the Provisional Irish Republican Army. Begin with a literature and newspaper search, preparatory to doing some research in Northern Ireland that would include gathering police reports and forensics and trying to get a complete record of the use of bombs during the “Troubles.” Ideally enter data into a new collection model.
- Conceptualize a multi-dimensional metric for terrorist success in the use of IEDs, and a multi-dimensional metric for state success in response to terrorist use of IEDs.
- Circulate a list of hypotheses/projects from the workshop to various stakeholders and obtain an average rank ordering in terms of priority research questions and projects.
- Look for opportunities for collaboration with various other parties interested in this research. This would include obtaining buy-in from technical experts who would be willing to contribute their expertise towards the human-oriented research.
- Begin developing a network of interested parties who represent all types of stakeholders. Identify “champions” within various organizations who are interested in long-term support of this work.
- Conduct initial quantitative and geo-spatial analysis and disseminate these results.
- Encourage workshop participants to generate short white papers on certain topics to start moving projects forward. Other researchers can then leverage their own knowledge to contribute to these projects.
- Arrange for a special journal issue devoted to IED innovation, diffusion and adaptation by terrorists. The journal issue would feature state-of-the-art research in this area, as currently being conducted by participants in the workshop and others, like Brian Jackson of RAND. A candidate journal for such a special issue would be the new journal *Dynamics of Asymmetric Conflict*. 

31
Medium Term
- Secure dedicated funding sources sufficient to support at least several of the key research projects.
- Conduct all necessary data gathering and consolidation.
- Complete a number of major research projects.
- Supply practitioners with policy- and operationally-relevant findings.
- Build a robust theoretical model of terrorist tactical innovation, diffusion and adaptation that can be transferred to other contexts.
- Publish several substantial academic products (for example, books, edited volumes, research reports).
Conclusion

The Workshop on “Human and Social Forces in the Spread of the IED Threat: Innovation, Diffusion and Adaptation” was convened to establish a knowledge base and a research program agenda for examining terrorist innovation, diffusion and adaption with respect to IEDs. The workshop brought together a multi-disciplinary group of academic experts to explore the issues surrounding the topic. In terms of its primary stated objectives, the workshop collected a baseline set of existing knowledge and data and provided a blueprint for moving forward. With regard to its secondary objective, while the workshop generated much discussion that should provoke consideration by the practitioner community, the state of current knowledge is too inchoate to provide specific recommendations without extensive further research.

The workshop firstly highlighted the need for establishing the basic intellectual groundwork for further research in this area, including producing rigorous and collaborative definitions of IEDs and their social context, collecting, coding and consolidating appropriate data streams, and borrowing theoretical models from a variety of related topic areas (such as business innovation). Second, it mapped the spectrum of research lacunae in this area, as well as supplying an extensive list of suggested research topics to address these gaps. Third, it provided a preliminary blueprint for moving forward with research in the area of terrorist innovation, diffusion and adaptation with respect to IEDs. Last but not least, the workshop established that any successful advances in this agenda will require partnership with government agencies in both setting priorities and gaining access to data and research subjects.

It is hoped by the organizers that the work begun by the workshop will serve as a springboard to future energetic academic research of the topic, so that the research community can make a significant contribution to countering the spread of the terrorist IED threat.
Appendix A: Participant Biographies

Jeffrey M. Bale is a professor at the Monterey Institute of International Studies (MIIS) and Director of the Monterey Terrorism Research and Education Program (MonTREP) at MIIS. Prior to joining the Monterey Institute faculty and staff, he taught at the University of California at Berkeley, Columbia University, and the University of California at Irvine; was the recipient of postdoctoral fellowships from the Society of Fellows in the Humanities at Columbia, the Office of Scholarly Programs at the Library of Congress, and the Center for German and European Studies at Berkeley; and worked as a Senior Research Associate at the Center for Nonproliferation Studies at MIIS.

Dr. Bale has been studying extremist and terrorist groups for nearly two decades – long before it suddenly became “fashionable” in the wake of the 9/11 tragedy – and has published numerous articles on terrorism, right-wing extremism, Islamism, and covert operations. He is in the process of updating a large book manuscript on neo-fascist terrorist networks in Cold War Europe, co-editing a volume on New Religious Movements and Extremist Politics, and preparing three new monographs, one on Islamist networks operating in Europe, another on the alleged links between dissident left- and right-wing radicals in the West and Islamist groups, and still another on “conspiracy theories” about 9/11 and other major terrorist attacks. His research responsibilities at MonTREP include preparing detailed terrorist group profiles and other in-depth qualitative studies on terrorist ideologies, motivations, and operational techniques.

Dr. Bale has recently published articles in Patterns of Prejudice, Terrorism and Political Violence, and Democracy and Security. He is currently a member of the Editorial Advisory Board of the journal Totalitarian Movements and Political Religions (Routledge), and regularly serves as a consultant for government agencies and private organizations on matters related to terrorism and ideological extremism.


Bloom is an assistant professor in the School of International and Public Affairs at the University of Georgia in Athens and a term member of the Council on Foreign Relations. She has held research and teaching appointments at Princeton, Cornell, Harvard, and McGill Universities. She has a PhD in political science from Columbia University, a Masters in Arab Studies from Georgetown University and a Bachelors from McGill University in Russian and Middle East Studies and speaks nine languages. She appears regularly on CNN, Fox News, CSPAN, NBC Nightly News, and has been interviewed by Jim Lehrer, Ted Koppel, and Jesse Pearson for MTV.
Martha Crenshaw is a senior fellow at Center International Security And Cooperation and Freeman Spogli Institute and a professor of political science by courtesy. She was the Colin and Nancy Campbell Professor of Global Issues and Democratic Thought and professor of government at Wesleyan University in Middletown, Conn., from 1974 to 2007. Her current research focuses on innovation in terrorist campaigns, the distinction between "old" and "new" terrorism, why the United States is the target of terrorism, and the effectiveness of counterterrorism policies.

She has written extensively on the issue of political terrorism; her first article, "The Concept of Revolutionary Terrorism," was published in the Journal of Conflict Resolution in 1972. Her recent work includes "Terrorism, Strategies, and Grand Strategies," in Attacking Terrorism (Georgetown University Press), "Terrorism and Global Security," in Leashing the Dogs of War: Conflict Management in a Divided World (United States Institute of Peace Press), and "Explaining Suicide Terrorism: A Review Essay," in the journal Security Studies. She is also the editor of a projected volume, The Consequences of Counterterrorist Policies in Democracies, for the Russell Sage Foundation in New York.

She served on the Executive Board of Women in International Security and chaired the American Political Science Association (APSA) Task Force on Political Violence and Terrorism. She has also served on the Council of the APSA and is a former President and Councillor of the International Society of Political Psychology (ISPP). In 2004 ISPP awarded her its Nevitt Sanford Award for Distinguished Scientific Contribution and in 2005 the Jeanne Knutson award for service to the society. She serves on the editorial boards of the journals International Security, Orbis, Political Psychology, Security Studies, and Terrorism and Political Violence. She coordinated the working group on political explanations of terrorism for the 2005 Club de Madrid International Summit on Democracy, Terrorism and Security. She is a lead investigator with the National Center for the Study of Terrorism and the Response to Terrorism (START) at the University of Maryland, funded by the Department of Homeland Security. She was a Guggenheim Fellow in 2005-2006. She served on the Committee on Law and Justice and the Committee on Determining Basic Research Needs to Interrupt the Improvised Explosive Device Delivery Chain of the National Research Council of the National Academies of Science. She was a senior fellow at the National Memorial Institute for the Prevention of Terrorism in Oklahoma City for 2006-2007.

Joshua D. Freilich is an associate professor in the Criminal Justice department at John Jay College of Criminal Justice. He received his Ph.D. in Criminal Justice from the University at Albany, SUNY in 2001 and his J.D. from Brooklyn Law School in 1993. Freilich is a lead investigator for the National Consortium for the Study of Terrorism and Responses to Terrorism (START), a Center of Excellence of the U.S. Department of Homeland Security (DHS). His research has been funded by DHS directly as well as through START.

Freilich is the Principal Investigator (with Dr. Steven Chermak, Michigan State University) on the United States Extremist Crime Database (ECDB) study. The ECDB is a large-scale data collection effort that is building the first of its kind relational database of all crimes committed by far-right extremists in the United States from 1990 to the present.
reported in an open-source. The ECDB contains over 350 variables on the incidents, suspects, victims, groups and an assessment of the quality of the open source information used for each incident. Freilich's terrorism research has appeared, or will appear, in Crime Prevention Studies; Criminology and Public Policy; Criminal Justice and Behavior; Journal of Contemporary Criminal Justice; Journal of Criminal Justice; Justice Quarterly; Law and Human Behavior; and Terrorism and Political Violence.

**Michael Kenney** is assistant professor of political science and public policy in the School of Public Affairs. He is a student of organization theory, international security, and illicit non-state actors, including drug traffickers and terrorists. Dr. Kenney has held research fellowships with the Center for International Security and Cooperation at Stanford University and the Center for International Studies at the University of Southern California.

Dr. Kenney recently published a book-length study on drug trafficking and terrorism, *From Pablo to Osama: Trafficking and Terrorist Networks, Government Bureaucracies, and Competitive Adaptation*. His published work has also appeared in *Survival, Global Crime, the International Journal of Intelligence and Counterintelligence, and Transnational Organized Crime*, among other publications. He has presented his research at the National Academy of Sciences, the Center for Advanced Studies in the Behavioral Sciences at Stanford University, and the Institute for International and Regional Studies at Princeton University, among other institutions.

Dr. Kenney is currently conducting research on Islamic activism in Spain, the United Kingdom, and Morocco. This research is funded by the National Institute of Justice. Previously, his research was funded by the National Science Foundation, the Tinker Foundation, and other organizations.

Dr. Kenney has worked and/or conducted research in Brazil, Colombia, Israel, and Morocco. From 1992 to 1994, he was a Peace Corps Volunteer in Ecuador, South America. From 1990 to 1992, he was an Americorps/VISTA volunteer at the Center for Drug-Free Living in Orlando, Florida.

At Penn State Harrisburg, Dr. Kenney teaches courses on international relations, U.S. foreign policy, terrorism and crime, drug control policy, and Latin American politics.

**Gary LaFree** is Director of the National Consortium for the Study of Terrorism and Responses to Terrorism (START) at the University of Maryland, as well as professor in the Department of Criminology and Criminal Justice. He received his PhD in Sociology from Indiana University in 1979. Dr. LaFree served as President of the American Society of Criminology (ASC) in 2005-6006 and has also served as the President of the ASC's Division on International Criminology (1991-1993), the Chair of the American Sociological Association's Section on Crime, Law and Deviance (1991-1993) and a member of the Executive Committee of the Justice Research Statistics Association (2000-2001; 1993-1994). While at the University of Maryland, Dr. LaFree was a founding member of the Democracy Collaborative and an invited member of the National Consortium of Violence Research. Before joining the faculty at UMD, Dr. LaFree served as Chair of the Sociology and Criminology Department at the University of New Mexico for six years. He served as the Director of the New Mexico Criminal Justice Statistics...
Analysis Center for thirteen years. Dr. LaFree received the G. Paul Sylvestre Award for outstanding achievements in advancing criminal justice statistics in 1994, and the Phillip Hoke Award for excellence in applied research in 1994 and 1998, from the Justice Research Statistics Association. Dr. LaFree helped found and later served as Director of the Institute for Social Research at the University of New Mexico. Much of Dr. LaFree’s current research is related to the development and analysis of the Global Terrorism Database, a major project being supported by START.

Richard Legault is Co-Director of the Terrorism and Preparedness Survey Archive (TaPSA) project at START, and a DHS Post-Doctoral Research Fellow. He received his Ph.D. from the School of Criminal Justice at the State University of New York at Albany in 2006 where he was also an Assistant Editor at the Sourcebook of Criminal Justice Statistics. Dr. Legault performs research in quantitative analysis of survey data, policy evaluation, data usage and measurement, and violence reduction strategies.

Jeffrey Lewis received his bachelor’s in history from Case Western Reserve University in 1992, and his master’s and Ph.D. in European history from The Ohio State University in 1994 and 2002. His dissertation was on the history of molecular biology in 20th century Germany. Lewis’s research focuses on the history of science and technology, particularly their importance for national security policy. He has published several articles and book chapters on the history of biology as well as on technology and security issues. He is currently revising his dissertation for publication as a book tentatively titled Scientists after Hitler: Molecular Biology Research in the Federal Republic of Germany. Lewis was the recipient of a Fulbright Grant in 1999-2000, a German Academic Exchange Service (DAAD) grant in 2001, and a guest scholar post at Germany’s Max-Planck-Society for the Advancement of the Sciences in 2002.

Since January 2003, Lewis has been teaching in OSU’s International Studies Program, where his courses focus on current security issues. Among those courses are Terror and Terrorism; The Development and Control of ‘Weapons of Mass Destruction”; and Science, Technology, and the Cold War. His article “Precision Terror: Suicide Bombing as Control Technology” will appear in Terrorism and Political Violence this spring.

Clark McCauley is Professor of Psychology and co-director of the Solomon Asch Center for Study of Ethnopolitical Conflict at Bryn Mawr College, and co-director of the National Consortium for Study of Terrorism and Responses to Terrorism (NC-START). He received his Ph.D. in social psychology from the University of Pennsylvania in 1970. His research interests include stereotypes and the psychology of group identification, group dynamics and intergroup conflict, and the psychological foundations of ethnic conflict and genocide. With colleagues he edited The Psychology of Ethnic and Cultural Conflict (2004), and with Dan Chirot he is author of Why Not Kill Them All? The Logic and Prevention of Mass Political Murder (Princeton University Press, 2006). He is a consultant and reviewer for the Harry Frank Guggenheim Foundation for research on dominance, aggression and violence, and founding editor of the new journal Dynamics of Asymmetric Conflict published by Taylor and Francis.
Stephen K. Markham is an Associate Professor in the College of Management Studies at North Carolina State University. He is also the Director of Technology Commercialization Clinic. Dr. Markham has been the co-founder of LipoMed, Inc, Raleigh, NC, a bio-medical company that uses NMR spectroscopy for lipoprotein analysis, LIPSinc, Raleigh, NC, an animation software company that uses digital signal processing to automate lip synchronization, and Kyma, Raleigh, NC, a material science company. He has also been the founder and past president of the Greater Carolina chapter of the Product Development and Management Association, Research Triangle Park, NC. He has gained immense expertise in the areas of technology management and new product development. His research focuses on the roles individuals play in developing and implementing high technology. Dr. Markham did his undergraduate work at the Brigham Young University, Provo, UT in Social Psychology. He also earned his master's degree from Brigham Young University, Provo, UT in Social Psychology. He did his MBA from University of California, Irvine, CA with emphasis in Entrepreneurship. Later, he earned his doctorate from Purdue University, West Lafayette, IN in Organizational Behavior and Human Resource Management. He is an active member of various professional society memberships such as the Academy of Management, Organizational Behavior Division, IEEE Engineering Management Society, Product Development and Management Association and Institute for Operations Research and Management Studies.

Samuel Musa is a Senior Research Fellow at the Center for Technology and National Security Policy. Previously, he was Associate Vice President for Strategic Initiatives and Professor of Electrical and Computer Engineering at Northwestern University (1999-2005). From 1995 to 1999, he was Executive Director, Center for Display Technology and Manufacturing, University of Michigan. Prior to that, he was Corporate Vice President for Research and Advanced Technology, E-Systems (1983-1995). From 1979 to 1983, he served as Staff Specialist and then Deputy Director, Military systems Technology, in the Office of Undersecretary of Defense for Research and Engineering. He was also Deputy Director for C3 Policy and Requirements Review in OSD (1978-1979). He served as Project Leader and Research Staff Member at the Institute for Defense Analyses (1971-1978). Also, he was Assistant Professor of Electrical Engineering at the University of Pennsylvania (1967-1971).

Dr. Musa served on Defense Intelligence Advisory Board, Army Science Board, Air Force Scientific Advisory Board, Air Force Foreign Technology Division Advisory Board, Air Force Logistics Command Scientific Advisory Board, and was Executive Secretary of Defense Science Board Summer Studies and Task Forces, and member of Scientific and Technical Intelligence Committee of the Director of Central Intelligence. He was a member of the Board of Directors of Semiconductor Research Corporation, Chairman of Aerospace Industries Association Technical and Operations Council, Member of Editorial Advisory Board of Journal of Electronic Defense, Technical Editor on Environmental Monitoring of IEEE Transactions on Geoscience and Remote Sensing, and Co-chair of Association of Old Crows Technical Symposia.

Dr. Musa received Decoration for Exceptional Civilian Service from the Secretary of the Air Force, Certificate of Appreciation from Secretary of Defense, Certificate of Commendation from Society of Information Displays. He is a Fellow of the IEEE, Member
of Sigma Xi, Tau Beta Pi, and Pi Mu Epsilon. He has published and presented over 85 papers in scientific journals and technical meetings.
Dr. Musa received his B.A. and B.S. in Electrical Engineering degrees from Rutgers University, and M.S. and Ph.D. degrees in Applied Physics from Harvard University.

Stephen Veyera joined the FBI in 1984. He was initially assigned to the Springfield, IL Division as a Resident Agent, detailed to the Peoria, IL Resident Agency, up until 1989. He was then transferred to the New York Office where he served on the FBI-NYPD Joint Terrorist Task Force until his selection as a Supervisory Special Agent and reassignment to the Counterterrorism Section at FBI Headquarters in 1995. While in NY, he was the principle relief supervisor for an International Terrorism Squad and worked on the first World Trade Center bombing investigation, and the follow plot to destroy the Holland and Lincoln Tunnels, the UN and attack the Federal Building by Sheik Omar Abdul Rahman and his followers. Upon his assignment to FBIHQ he managed the FBI’s Chemical and Biological Counterterrorism Program, the Bombing Investigation Program, and Domestic Terrorism investigations in the Southeast U.S. He also served as the acting Unit Chief of the Domestic Terrorism Operations Unit, prior to his selection in 1998 as the Chief of the Bomb Data Center. While Chief, he supervised the Hazardous Devices School at Redstone Arsenal, AL, the FBI Special Agent Bomb Technician program and the technical publications and Law Enforcement Online efforts of the BDC. He served in that capacity until June, 2007 when he was assigned to his current position as a Liaison Officer for the FBI Critical Incident Response Group, dealing with the Department of Homeland Security, and various agencies within the Department of Defense, to include the Counter Terrorism Technology Support Office, the Joint IED Defeat Organization and the Army Asymmetric Warfare Office.

Prior to joining the FBI, SSA Veyera served 8 years on active duty as a U.S. Army Military Police Officer, retiring from the USAR as a Major in 1999, and was a Police Officer for the City of North Charleston, SC. He received a Bachelor of Science from The Citadel in 1975 and a Master of Science in National Security Strategy from the National War College in 2007. He is a graduate of the SC Criminal Justice Academy and the FBI Hazardous Devices School. He is a certified Bomb Technician, FBI Crisis Management Coordinator, and Firearms Instructor. He is married with three children.
### Appendix B: Relevant Existing Research Findings

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<th>Sub-Topic</th>
<th>Existing Findings</th>
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<tr>
<td><strong>General</strong></td>
<td>- Since 1970, most terrorist attacks worldwide involved explosions and firearms. - Inside the US, in addition to many non-fatal bombings, there have been a host of “thwarted” incidents where explosives were found.</td>
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<td><strong>Spatial Diffusion of IED Use</strong></td>
<td>- Different functional components of IEDs (e.g. explosive, detonator, trigger) imply that different dynamics of innovation and diffusion can drive the same system, and any effort to analyze the diffusion of these weapons must take a multivariate approach. - What we tend to see with the spread of IEDs is that their use will geographically radiate outwards in an attempt to keep the enemy off target. - Spatial variation is both a reflection of the organization’s strength while at the same time, provides an insight into the group’s limitation, possibly in terms of support. - Several findings from general diffusion dynamics might be applicable, including Rogers’ elements of diffusion, the notion of the “killer app,” and homophily. Innovations diffuse in highly segmented markets and IEDs would most likely fall into segment zero. - Asal and Rethemeyer have shown that groups with greater network connections to other groups are more deadly. - Innovations are usually promoted by champions.</td>
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<td><strong>Temporal Diffusion of IED Use</strong></td>
<td>- While terrorist attacks and IED attacks have increased overall in the period from 1970 to 1997, the percentage of all attacks that use IEDs has decreased. - Innovations follow S-Curves</td>
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<td><strong>Strategic / Instrumental vs Affective / Expressive Basis of IED Decisions</strong></td>
<td>- Culture plays some role in IED use – e.g. PIRA opposes suicide bombings. - Fighting is norm controlled (reaction, amplitude, trajectory, velocity). - Expressive “strategic” goals can be combined with instrumental operational means - Organizational structure affects innovation—centralization, standardization, formalizations. - Net present value is an analogy for innovation decisions and all innovations are measured on payback.</td>
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<tr>
<td><strong>Trial Period Prior to Full-fledged Campaign?</strong></td>
<td>- The easier something is to try out the more likely it is to diffuse. - State counterterrorism pressure affects the trial period.</td>
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<td><strong>Learning Curve for IEDs</strong></td>
<td>- IEDs require different skill sets to construct and use, which will vary based on the complexity of the device and its components. - Success rates for the use of IEDs have varied considerably as well - see Afghan example. - Innovation is accomplished first by vicarious learning. - Efficiency is not the only value - terrorists sometimes learn to be less efficient. Organizational structure matters, for example, compartmentalization often impedes learning.</td>
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<tr>
<td><strong>Robustness of IED Diffusion</strong></td>
<td>- Iraqi IED networks have proven themselves robust, with membership based on recommendations, trust and performance.</td>
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<td><strong>Effects of Community Radicalization on Spread of IEDs</strong></td>
<td>- Innovation is socially complex information and the process of radicalization impacts the speed of diffusion. - The crucial issue for community support of insurgent IEDs is not whether bombs are used but whether bomb damage is limited to acceptable targets. - Use of IEDs cannot exceed what the population will accept. If it does, the group loses support and may even be forced to abandon the tactic.</td>
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<tr>
<td><strong>Adaptation Capacity</strong></td>
<td>- Most adaptation is made in tactical movements to better exploit existing capabilities. - Dominant design is achieved over time. - As has already become clear in Iraq, different groups of insurgents are both very adaptive and very innovative in terms of employing locally available materials in creative ways and devising techniques to circumvent U.S. efforts to discover IEDs, dismantle them, or jam the signals that are used to detonate them. - Provisional IRA vs. British counterterrorism forces is a case of an arms race / action-reaction. - An IED arms race can be versus an in-group competitor, not just versus state forces.</td>
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