Terrorism Risk Analysis

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Risk Regulation Seminar
University of Pennsylvania
The US Department of Homeland Security

- Formed in 2002 in response to the 9/11 attacks
- Combines 22 agencies
- 240,000+ employees
- $60 billion budget
- Major science and technology effort ($800 million)
- University programs ($40 million)
- University-based Centers of Excellence
University Centers of Excellence

- 10 Centers of Excellence and over 150 partners
- Each Center has a specific focus on an area critical to homeland security
- Each Center is aligned with at least one DHS S&T Division
CREATE

• First Center of Excellence funded by DHS
  – Competition of 72 universities in 2003
  – Focused on risk and economic analysis

• Research Areas
  – Risk Analysis
  – Behavioral Research
  – Economic Analysis
  – Risk Management
    • Benefit-Cost Analysis
    • Decision Analysis
    • Game Theory
12 Years of CREATE
CREATE Research Partners

Arizona State University (Tempe, AZ)
Blue Marble Space (Seattle, WA)
California State University, Los Angeles (Los Angeles, CA)
California State University, Long Beach (Long Beach, CA)
Carnegie Mellon University (Pittsburgh, PA)
Claremont McKenna College (Claremont, CA)
Cornell University (Ithaca, NY)
Decision Research (Portland, OR)
Duke University (Durham, NC)
Elizabethtown College (Elizabethtown, PA)
Georgetown University (Washington, DC)
Global Catastrophic Risk Institute – Tony Barrett
Haskell Indian Nations University (Lawrence, KS)
Howard University (Washington, DC)
London School of Economics (London, UK)
Monash University (Victoria, Australia)
New York University (New York, NY)
Oak Ridge National Laboratory (Oak Ridge, TN)
Princeton University (Princeton, NJ)
RAND Corporation (Santa Monica, CA & Pittsburgh, PA)
RTI International (Triangle Park, NC)
Rutgers University (New Brunswick, NJ)
Stanford University (Palo Alto, CA)
Structured Decisions (Boston, MA)
Technion Israel Institute of Technology (Israel)
University at Buffalo, SUNY (NY)
University of California, Irvine (Irvine, CA)
University of California, Los Angeles (Los Angeles, CA)
University of California, San Diego (San Diego, CA)
University of Hawaii, Hilo (Hilo, HI)
University of Kentucky (Lexington, KY)
University of Maryland, Baltimore County (Baltimore, MD)
University of Maryland, College Park (College Park, MD)
University of Massachusetts Dartmouth (Dartmouth, MA)
University of Pennsylvania Wharton School (Philadelphia, PA)
University of Puerto Rico, Mayagüez (Puerto Rico)
University of Southern California (Los Angeles, CA)
University of Texas, Dallas (Dallas, TX)
University of Texas, San Antonio (San Antonio, TX)
University of Virginia (Charlottesville, VA)
University of Wisconsin (Madison, WI)
Vanderbilt University (Nashville, TN)
Victoria University (Australia)

*Minority Serving Institution (MSI)
CREATE’s Research Framework

Threat Analysis → Vulnerability Analysis → Consequence Analysis → Behavioral Analysis

- Deterrence & Prevention
- Defense & Protection
- Response & Recovery

Economic Analysis

Cost-Benefit & Decision Analysis, Game Theory
The Importance of T-V-C

“….We have to identify and prioritize risks -- understanding the threat, the vulnerability and the consequence. And then we have to apply our resources in a cost-effective manner…..”
Risk Analysis - 50 Years of History

- Origins in the 60s in Aerospace Safety
- 1974: Natural Hazards Risk Analysis (White)
- 1975: Nuclear Safety Report (Rasmussen)
- 1983: National Academy’s “Red Book” (EPA)
- Agencies using risk analysis before 9/11
  - DOD
  - DOE
  - NRC
  - EPA
  - NASA
  - FEMA
  - OMB
The Big Question in 2003

• Can we use risk analysis in the context of terrorism?

• What are the alternatives?
  – Game theory
  – Possibility theory
  – Soft risk scoring methods
A Lot of Skepticism

• We cannot assign probabilities to adversarial actions – let’s use possibility theory!
• Adversaries observe and adapt to our defenses – let’s use game theory!
• We cannot quantify anything – let’s use risk scoring systems!
• Let’s try, but remain skeptical (CREATE)
### Lugar Survey

#### Probabilities of Major Attacks

<table>
<thead>
<tr>
<th>Event</th>
<th>Median Probability (5 Years)</th>
<th>Median Probability (10 Years)</th>
<th>Appr. Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Attack</td>
<td>10%</td>
<td>20%</td>
<td>80</td>
</tr>
<tr>
<td>Biological Attack</td>
<td>10%</td>
<td>20%</td>
<td>80</td>
</tr>
<tr>
<td>Chemical Attack</td>
<td>15%</td>
<td>15%</td>
<td>80</td>
</tr>
<tr>
<td>Radiological Attack</td>
<td>25%</td>
<td>40%</td>
<td>80</td>
</tr>
</tbody>
</table>

Lugar Survey (ca. 2005)
Selected Participants in the Lugar Study

- Richard Allen
- Graham Allison
- Frank Carlucci
- Bill Cohen
- James Dobbins
- Amitai Etzioni
- Bob Galluci
- Sig Hecker
- Ron Lehman
- Michael Moodie
- Sam Nunn
- Norman Schwarzkopf
- Strobe Talbott
- James Woolsey

+ 70 others
We Can Do Better

• **Use the right experts**
  – Intelligence analysts
  – Social scientists studying terrorists’ behavior
  – Journalists

• **Ask the right questions**
  – Create a complete set of attack scenarios
  – Ask about motivations and capabilities
  – Ask for relative likelihoods

• **Use the right procedures**
  – Train experts and provide practice
  – Use state-of-the-art elicitation protocols
  – Document carefully
The First Terrorism Risk Analysis: Bioterrorism Risk Assessment (BTRA)

- Bi-annual report to the President
- Prioritize biological threats
- Guide investments for risk management

CREATE’s role was to help select a risk analysis approach and to design the expert elicitation process
Huge Event Tree

- 28 biological agents
- Target of attack
- Amounts of agents released
- Weather and other exposure conditions
- Exposure
- Toxicity
- Health impacts
Example Biological Agents

**Bacillus Anthracias (Anthrax)**
Partly communicable
100 kg fatal to 3 million people
25% mortality rate

**Yersinia Pestis (Plague)**
Communicable
One infected person creates ten more
15% mortality rate

**Raciness Communis (Ricin)**
Non-communicable
1 milligram can kill one adult
50 to 85% mortality rate
Expert Elicitation

• Elicitation of threat probabilities of 28 agents
• Four bioterrorism experts (proof of principle)
• Two risk analysts (Hora, von Winterfeldt)
• Ranking of risks, followed by ratios
• Software support
Example Output
“Bad Guys” with MANPADS

SA-18

SA-14

STINGER

Chechnya

Two insurgents in Iraq with SA-7b and SA-14 MANPADS. (Photo Courtesy: U.S. Department of Homeland Security)
Close Call, Baghdad, 2003
Defender-Attacker Decision Trees

• MANPADS I (covered 8 years ago right here)
• MANPADS II
  – multiple attack modes
  – deterrence effects
  – shifts in attack modes after defenses
  – Second decision stage: “End game”

• Protecting the ports of LA and Long Beach against a dirty bomb attack
• Choosing a radiation portal monitoring technology (PVT vs. ASP)
• Protecting Dulles Airport against an imminent terrorist attack (ongoing)
Generic Defender-Attacker Decision Tree

\[
\min\{EC(D_i)\} = \min \{ \sum_{j,k} p_{ij} p_{ijk} \min [EC(D_{ijkl})] \},
\]
Extended Tree – No Defenses
Extended Tree - Defenses
### Parameters

<table>
<thead>
<tr>
<th>Probabilities</th>
<th>Var. Name</th>
<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
</tr>
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<tbody>
<tr>
<td>pA</td>
<td>Attempted Attack</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>pCL</td>
<td>Attack with CLOS/LBR/Attempt</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>pMP</td>
<td>Attack with MANPADS/Attempt</td>
<td>0.6</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>pRPG</td>
<td>Attack with an RPG/Attempt</td>
<td>0.3</td>
<td>0</td>
<td>1</td>
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<tr>
<td>qCL</td>
<td>Interdiction/Attempt with CLOS/LBR</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>qMP</td>
<td>Interdiction/Attempt with MANPADS</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>qRPG</td>
<td>Interdiction/Attempt with RPG</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>hCL</td>
<td>Hit/Attack CLOS/LBR</td>
<td>0.8</td>
<td>0</td>
<td>1</td>
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<tr>
<td>hMP</td>
<td>Hit/Attack with MANPADS</td>
<td>0.8</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>hRPG</td>
<td>Hit/Attack with RPG</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
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<tr>
<td>rCL</td>
<td>Crash/Hit by CLOS/LBR</td>
<td>0.8</td>
<td>0.5</td>
<td>1</td>
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<tr>
<td>rMP</td>
<td>Crash/Hit by MANPAD</td>
<td>0.8</td>
<td>0.5</td>
<td>1</td>
<td></td>
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<tr>
<td>rRPG</td>
<td>Crash/Hit RPG</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
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</table>

**Deterrence Effect**

<table>
<thead>
<tr>
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<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>dCL_H</td>
<td>Deterrence of Hardening on CLOS/LBR</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
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<tr>
<td>dMP_H</td>
<td>Deterrence of Hardening on MANPADS</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
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<tr>
<td>dRPG_H</td>
<td>Deterrence of Hardening on RPG</td>
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<td>0</td>
<td>0.5</td>
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<tr>
<td>dMP_DI</td>
<td>Deterrence of DIRCM on MANPADS</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dCL_DI</td>
<td>Deterrence of DIRCM on CLOS/LBR</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>dRPG_DI</td>
<td>Deterrence of DIRCM on RPG</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>dRPG_PC</td>
<td>Deterrence of Perimeter Control on RPG</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dCL_PC</td>
<td>Deterrence of Perimeter Control on CLOS/LBR</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>dMP_PC</td>
<td>Deterrence of Perimeter Control on IR</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
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</tbody>
</table>

**Substitution Effect**

<table>
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<th></th>
<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>sRPG_DI</td>
<td>Substitution Effect of DIRCM on RPG usage</td>
<td>2</td>
<td>1</td>
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<tr>
<td>sCL_DI</td>
<td>Substitution Effect of DIRCM on CLOS/LBR usage</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>sMP_PC</td>
<td>Substitution Effect of Perimeter Control on MP usage</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>sCL_PC</td>
<td>Substitution Effect of Perimeter Control on CLOS/LBR usage</td>
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<td>1</td>
<td>2</td>
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</tbody>
</table>

**Effectiveness of Countermeasures**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>qRPG_PC</td>
<td>Interdiction Effectiveness of Perimeter Control on RPG</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>qCL_PC</td>
<td>Interdiction Effectiveness of Perimeter Control on CLOS/LBR</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>qMP_PC</td>
<td>Interdiction Effectiveness of Perimeter Control on MP</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>eMP_DI</td>
<td>Diversion/Destruction Effectiveness of DIRCM on MP</td>
<td>0.8</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>rCL_H</td>
<td>Crash Reduction Effectiveness of Hardening on CLOS/LBR</td>
<td>0.25</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>rMP_H</td>
<td>Crash Reduction Effectiveness of Hardening on MP</td>
<td>0.25</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>rRPG_H</td>
<td>Crash Reduction Effectiveness of Hardening on RPG</td>
<td>0.25</td>
<td>0</td>
<td>0.5</td>
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</table>

**Consequences**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>Lives Lost</td>
<td>Crash</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>CP</td>
<td>Cost of Plane (millions)</td>
<td>200</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>ELFC</td>
<td>Economic Loss</td>
<td>Fatal Crash (billions)</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>pcEL_SL</td>
<td>Percent of Economic Loss</td>
<td>Hit and Safe Landing</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>pcEL_M</td>
<td>Percent of Economic Loss</td>
<td>Miss</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>CH</td>
<td>Cost of Hardening (billions)</td>
<td>15</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>CDI</td>
<td>Cost of DIRCM (billions)</td>
<td>30</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>CPC</td>
<td>Cost of Perimeter Control</td>
<td>5</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

**Tradeoffs**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Base Case</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of Life (millions)</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Base Case Analysis

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Cost (in $ billions)</th>
<th>Risk (in $ billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Countermeasures</td>
<td>10.4</td>
<td>9.9</td>
</tr>
<tr>
<td>Perimeter Control</td>
<td>29.0</td>
<td>26.8</td>
</tr>
<tr>
<td>DIRCM &amp; PC</td>
<td>35.8</td>
<td>15.3</td>
</tr>
<tr>
<td>DIRCM</td>
<td>32.1</td>
<td>25.2</td>
</tr>
<tr>
<td>Hardening</td>
<td>24.7</td>
<td>23.2</td>
</tr>
<tr>
<td>DIRCM &amp; Hardening</td>
<td>29.0</td>
<td>9.9</td>
</tr>
<tr>
<td>DIRCM, PC &amp; Hardening</td>
<td>45.7</td>
<td>7.9</td>
</tr>
</tbody>
</table>

The chart above illustrates the expected equivalent cost and risk for various countermeasures in the base case analysis. Each bar represents the total cost (green) and risk (red) associated with each countermeasure strategy.
Two-way Sensitivity Analysis 1 (C=$30b)
Two-way Sensitivity Analysis 2 (C=$10b)
Conclusions

• Main insight: With reasonable parameters, no countermeasures is the best action now
• If you want to choose countermeasures, you have to do both DIRCMs and perimeter control
• Lesson: Deterrence, substitution and the end game matter
Know Your Enemy!

- As part of the 2014 Strategic Multilayer Assessment (SMA) effort on understanding ISIL, CREATE formed a small study group.
- Our primary goal was to identify the values and objectives of ISIL’s leaders and its followers – part of predicting their actions.
- Specifically, we addressed the following three questions:
  - What are the objectives of the leaders of ISIL (i.e., what do ISIL’s leaders want to achieve)?
  - What are the objectives of followers of ISIL (i.e., why is ISIL attractive to its followers)?
  - More recently: Can we identify different types of leaders and followers by their objectives?
Methodology

- **Purpose**: To identify and structure values and objectives of ISIL
- **End result**: A tree of values and objectives, called an “Objectives Hierarchy” or “Value Tree”
- **Usually done**: In interviews with decision makers and stakeholders
- **Direct interviews**: Difficult and maybe impossible with terrorists
- **Previous application**: To terrorism by using Internet and written sources by leaders (Al Qaeda; Hezbollah)
- **In this study**: We applied the DA methodology to ISIL leaders and their followers
Unique Aspects of this Study

- Two completely separate data sources
  - one based on the transcripts of interviews with 59 subject matter experts (by NSI)
  - and one based on the speeches of ISIL leaders and selected Internet sources
- Each effort was led by a different decision analyst to avoid cross contamination of the sources and findings
- Matching leader and follower “type” with the resulting objectives
Identifying Value Relevant Statements

Using this source list of 353 statements, 24 objectives were identified, including 3 strategic objectives, 5 fundamental objectives, and 16 means objectives.
Defining and Structuring Objectives

- **Strategic objectives** are high-level and provide very general and broad guidance for decisions.

- **Fundamental or “Ends” objectives** are intermediate level and provide guidance in specific decision contexts.

- **Means objectives** are actions that can be pursued to promote fundamental and strategic objectives.
### Combined Objectives

#### Leaders' Objectives Based on All Sources

<table>
<thead>
<tr>
<th>Religion</th>
<th>Military Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreate the Power and Glory of (Sunni) Islam</td>
<td>Establish a Caliphate in Iraq and the Levant</td>
</tr>
<tr>
<td>Implement a Pure and Strict Version of Islam</td>
<td>Eliminate Current Rulers in Iraq and the Levant</td>
</tr>
<tr>
<td>Implement the Sharia with the Sword</td>
<td>Function as a State and Provide Services</td>
</tr>
<tr>
<td>Derive Legitimacy as Heirs/Descendants of Mohammed</td>
<td></td>
</tr>
<tr>
<td>Be Recognized as the Leader of the Jihad</td>
<td>Occupy, Defend, and Expand Territory</td>
</tr>
<tr>
<td></td>
<td>Have the Ability to Fight Like a Modern Army</td>
</tr>
<tr>
<td></td>
<td>Provide Internal Security, Semblance of Order</td>
</tr>
<tr>
<td></td>
<td>Fight Decadency and Corruption</td>
</tr>
<tr>
<td></td>
<td>Secure Supply Lines and Resources</td>
</tr>
<tr>
<td></td>
<td>Increase Numbers of Fighters and Followers</td>
</tr>
<tr>
<td></td>
<td>Provide Military Leadership and Resources</td>
</tr>
<tr>
<td></td>
<td>Be Recognized as the Leader of the Islamic State</td>
</tr>
<tr>
<td>Radicarize and Align Followers</td>
<td>Stabilize Economy and Offer Jobs</td>
</tr>
<tr>
<td>Take Over Other Islamic Movements</td>
<td></td>
</tr>
</tbody>
</table>

#### Additional Objectives

- Kill, Frighten, and/or Convert Infidels
- Generate Revenue
### Leaders’ Objectives Overlays

<table>
<thead>
<tr>
<th>Religion</th>
<th>Expand Islam and Sharia Law Worldwide</th>
<th>Military Power</th>
<th>Control and Govern the Islamic State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recreate the Power and Glory of (Sunni) Islam</strong></td>
<td><strong>Establish a Caliphate in Iraq and the Levant</strong></td>
<td><strong>Function as a State and Provide Services</strong></td>
<td><strong>Control and Govern the Islamic State</strong></td>
</tr>
<tr>
<td>Implement a Pure and Strict Version of Islam</td>
<td>Implement a Pure and Strict Version of Islam</td>
<td>Implement a Pure and Strict Version of Islam</td>
<td>Implement a Pure and Strict Version of Islam</td>
</tr>
<tr>
<td>Implement the Sharia with the Sword</td>
<td>Give Meaning to the Lives of Sunnis</td>
<td>Purge the World of Anti-Islamic Forces</td>
<td>Eliminate Current Rulers in Iraq and the Levant</td>
</tr>
<tr>
<td>Derive Legitimacy as Heirs/Descendants of Mohammed</td>
<td>Stop Shia Violence and Discrimination</td>
<td>Attack Foreign Countries from Inside</td>
<td>Occupy, Defend, and Expand Territory</td>
</tr>
<tr>
<td>Be Recognized as the Leader of the Jihad</td>
<td>Guard and Treat Sunnis with Respect</td>
<td>Demonstrate Military Strength and Terroristic Capabilities</td>
<td>Have the Ability to Fight like a Modern Army</td>
</tr>
<tr>
<td>Radicalize and Align Followers</td>
<td>Sunnis Govern Iraq</td>
<td>Be a Feared, Authentic, Radical, Brutal, and Rigorous Movement</td>
<td>Provide Military Leadership and Resources</td>
</tr>
<tr>
<td>Take over other Islamic Movements</td>
<td>Fight Decadency and Corruption</td>
<td>Create Brand and Notoriety as Ruthless and Pure</td>
<td>Be Recognized as the Leader of the Islamic State</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent Foreign Powers to Interfere in Iraq and the Levant</td>
<td>Have the Ability to Fight like a Terroristic Underground Army</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increase Numbers of Fighters and Followers</td>
</tr>
<tr>
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**True Ideologues**

- Kill, Frighten, and Convert Infidels
- Generate Revenue
Leaders’ Objectives Overlays

**Religion**

**Recreate the Power and Glory of (Sunni) Islam**
- Implement a Pure and Strict Version of Islam
- Implement the Sharia with the Sword
- Derive Legitimacy as Heirs/Descendants of Mohammed
- Be Recognized as the Leader of the Jihad
- Radicalize and Align Followers
- Take over other Islamic Movements
- Give Meaning to the Lives of Sunnis
- Stop Shia Violence and Discrimination
- Guard and Treat Sunnis with Respect
- Sunnis Govern Iraq
- Fight Decadency and Corruption
- Prevent Foreign Powers to Interfere in Iraq and the Levant

**Expand Islam and Sharia Law Worldwide**
- Purge the World of Anti-Islamic Forces
- Attack Foreign Countries from Inside
- Demonstrate Military Strength and Terroristic Capabilities
- Be a Feared, Authentic, Radical, Brutal, and Rigorous Movement
- Create Brand and Notoriety as Ruthless and Pure

**Establish a Caliphate in Iraq and the Levant**
- Eliminate Current Rulers in Iraq and the Levant
- Occupy, Defend, and Expand Territory
- Have the Ability to Fight like a Modern Army
- Provide Military Leadership and Resources
- Be Recognized as the Leader of the Islamic State
- Have the Ability to Fight like a Terroristic Underground Army
- Increase Numbers of Fighters and Followers

**Military Power**

**Control and Govern the Islamic State**
- Function as a State and Provide Services
- Improve Services in Occupied Territories
- Provide Internal Security, Semblance of Order
- Stabilize Economy and Offer Jobs
- Secure Supply Lines and Resources

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**True Ideologues**

**Violence Seekers**

**Kill, Frighten, and Convert Infidels**

**Generate Revenue**
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True Ideologues
??????
Violence Seeker
Pragmatists
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**Leaders’ Objectives Overlays**

- **True Ideologues**
- **Humanitarian Sunnis**
- **Violence Seeker**
- **Pragmatists**

**Leaders’ Objectives Overlays**

- Kill, Frighten, and Convert Infidels
- Generate Revenue
Conclusions - ISIL Leaders’ Objectives

- Some objectives are in conflict
  - A tension between religious and military objectives
  - A tension between “Occupy and Control” objectives and expanding ISIL worldwide

- Overlays of three “types”
  - Clear identification of “Ideologues”, Pragmatists” and “Violence Seekers”
  - Misses some humanitarian (Sunni/Salafi) objectives

- Uses
  - Predict actions (combined with capabilities)
  - Sow dissent (PSYOP)
  - Currently used in PSYOP simulation
Infrastructure Security Games

Air Travel
- 2007: Securing the Skies

Ports
- 2011: Statue of Liberty

Trains
- 2013: Train in motion

Screening
- 2016: Security checkpoint

Smart Randomization (Tambe et al.)

- *Terrorists monitor defenses, exploit patterns*
- *Examples: Patrols, inspections, surveillance*
- *Randomize defenses, maintain quality*
Security Resource Optimization: Not 100% Security

**Stackelberg Game**: Defender “moves” first; adversary responds

**Random Strategy**: Increase uncertainty to attackers, find Nash solution

**Challenges faced**: Massive scale games; difficult for a human planner

<table>
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**Defender**

**Adversary**
### Example Model: Stackelberg Security Games

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ARMOR System

Provide inputs, constraints

Schedule evaluation

ARMOR Knowledge Base

DOBSS: GAME THEORY ALGORITHMS

Weights for randomization

Randomized Schedule generation
The Element of Surprise
To help combat the terrorism threat, officials at Los Angeles International Airport are introducing a bold new idea into their arsenal: random placement of security checkpoints. Can game theory help keep us safe?

Security forces work the sidewalk at LAX
Visiting TSA Freedom Center
Scale Up Number of Defender Strategies

ARMOR Actions: \(~100\)

IRIS 1000 flights/day
Actions: \(~10^{41}\)

- ARMOR runs out of memory
- Incremental strategy generation: Not enumerate \(10^{41}\) actions
“…in 2011, the Military Operations Research Society selected a USC project with FAMS on randomizing flight schedules for the prestigious Rist Award…”

R. S. Bray (TSA)
Statement before Transportation Security Subcommittee
US House of Representatives 2012
Game Theory + Optimization + Uncertainty + Learning + …

- Massive-scale games
- Reason with uncertainty
- Learn adversary behavior from data
- Repeated Games
- + Conservation Biology, Criminology

Infrastructure Security Games
- Coast Guard
- LAX
- Argentina Airport
- LA Sheriff

Green Security Games
- Coast Guard
- TSA
- USC
- Panthera/WWF

Opportunistic Crime Games
- US Coast Guard
- Argentina Airport
- USC
- LA Sheriff
- IBM
The Survivors of the Risk Analysis Competition

• Probabilistic risk analysis
  – (BTRA, CTRA, RNTRA, ITRA)
• Defender-attacker decision trees
• Security games
The Future

• Terrorism Risk Analysis is here to stay
  – Many successful applications
  – Two volumes of Risk Analysis dedicated to TRA

• Need to include decisions

• Need to use better models of adversary behavior

• Game theory and decision theory are compatible, not opposing
Conclusions

- Risk analysis remains difficult
  - Too many possible attack scenarios
  - Adversaries seek vulnerabilities and high impact
  - Probabilities of threats and attacks shift with defensive actions

- Economic impacts are critical
  - Indirect economic impacts often overshadow direct ones
  - Public responses can create large indirect economic impacts

- Risk management focus helps
  - Focus on what can be done, not what to worry about
  - Many variables do not matter for decisions
  - Eliminate clearly inferior options