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Pacific Northwest
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FOCUS AREAS

Analytic Gaming

Analytic Gaming develops techniques and a systematic framework to enable the creation of games that provide a means for users to generate behavioral data that can be used to calibrate models and explore the outputs of technosocial predictive models. We seek to provide an environment in which the power of computational models can be seamlessly paired with the creativity of human players, facilitating a more robust decision-making process. We pursue this objective by extending gaming technology and methodologies to produce novel methods and tools for interaction with, and immersion in, the modeling and simulation process.

Technosocial Modeling

Central challenges faced in the modern world are a direct result and side-effects of actions of organizations and individuals. Our interest is in computational, predictive modeling for organizational behavior to help anticipate these challenges and the effects of policy. Computational behavior modeling is increasingly addressed as a research challenge. Computational modeling methods used for behavior modeling include ABMs, systems dynamics models, and cellular dynamics, among others. Technosocial modeling research is focused on representing dynamic human and organizational behaviors. We are investigating Bayesian networks, and their integration with other modeling approaches, to represent these evolving phenomena.

Technosocial Predictive Analytics Initiative

Integrated Technology Demonstration

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INTRODUCTION

Illicit nuclear trafficking networks are a national security challenge. These networks can directly lead to nuclear proliferation, as states or non-state groups attempt to identify and acquire nuclear weapons-related expertise, technologies, components, and materials. The ability to characterize these networks and improve our ability to anticipate the key nodes, and transit mechanisms associated with them, is essential to influencing, disrupting, destroying, or interdicting the function of the network and its processes.

As a capstone to the Technosocial Predictive Analytics Initiative (TPAI), the individual pieces of the TPAI research agenda – knowledge management tools, technosocial models, and analytical gaming – are being brought together into an integrated technology demonstration (ITD). The TPAI team has worked together to assemble an integrated demonstration that illustrates how the TPAI components work together to address analytical challenges faced by our clients.

- Energy efficiency, reliability, and related topics, with DOE/BTP, DOE/ARRA, DOE/FEMP and the DOE offices of Electricity Delivery and Energy Reliability and Energy Efficiency and Renewable Energy
- Pollution prevention, with EPA
- Social intelligence and crowd-sourcing, with DARPA
- Science and Innovation Policy, with NSF
- Bio-surveillance, with DHS Threat Characterization Program.

FOCUS AREA

KEF

The KEF comprises a suite of tools that enable SMEs to discover, gather, and arrange evidence and other material in support of modeling and simulation projects, as well as other domains that require collaborative workspaces for knowledge-work. The framework has multiple applications and can be used to:

1. Capture and investigate evidence, such as trusted material provided by the users (journal articles, government reports, etc.).
2. Discover new evidence automatically (harvested from web sources, covering both traditional and social media).
3. Enable collaboration and discussions through traditional wiki interaction mechanisms such as discussion tabs, synchronous chat, and social profiles.
4. Automatically generate semantic annotations and relationships.

Several challenges face our nation, including:

- Social and political unrest leading to acts of violence
- Weapons of mass destruction development by rogue countries
- Natural and man-made disasters
- Energy shortages
- Global climate change.

ABOUT TPAI

Events occur daily that challenge the security of our nation with significant elements of strategic surprise, and find government agencies unprepared for the catastrophic outcomes. If we are to help our nation meet the challenges that emerge from these scenarios, we must develop a new science of predictive analysis that can inform the decision-making processes of government agencies to anticipate strategic surprise, counter adversities, and leverage opportunities.

The Technosocial Predictive Analytics Initiative is taking the next steps toward addressing complex, interwoven issues with highly integrated, innovative models to help analysts and policy makers identify and counter strategic surprise. TPAI supports a multi-perspective approach to predictive analysis through integrated reasoning, drawing knowledge insights from both the natural and social sciences. More specifically, Technosocial Predictive Analytics define, develop, and evaluate novel modeling algorithms that integrate domain knowledge about interacting physical and human factors. In so doing, Technosocial Predictive Analytics enable its modeling algorithms with ancillary capabilities aimed at acquiring knowledge inputs and enhancing cognitive access.

The capabilities developed within the initiative led to projects with the following areas/partners:

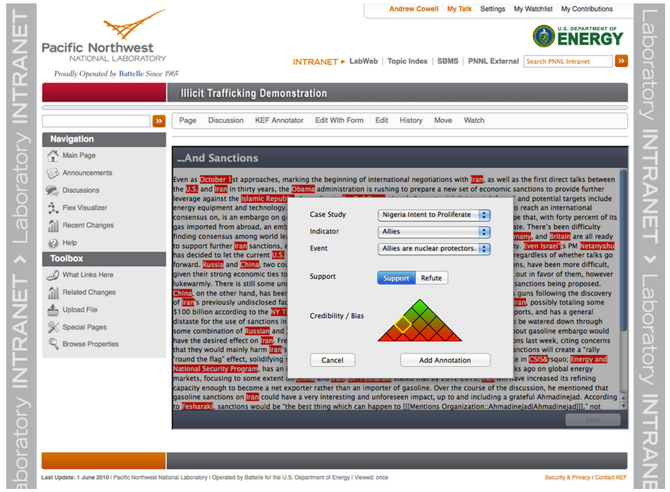
- Weapons of Mass Destruction-Terrorism, with DoD CWMD-T and RRTO Support Programs
- Nonproliferation, with NNSA NA-22
- Social Network Analysis, with the Naval Postgraduate School

APPROACH

Our contribution includes mathematics and computational collaborative methodology to forecast organization behavior using models, empirical data, and experts' opinions. Our approach combines tools, capabilities, and workflows in knowledge encapsulation, predictive modeling and analytical gaming.

Knowledge Encapsulation

Knowledge encapsulation methods enable the elicitation of subject matter expertise and the harvesting and analysis of evidence in the area of focus (Illicit trafficking of nuclear material). Subject matter expertise is

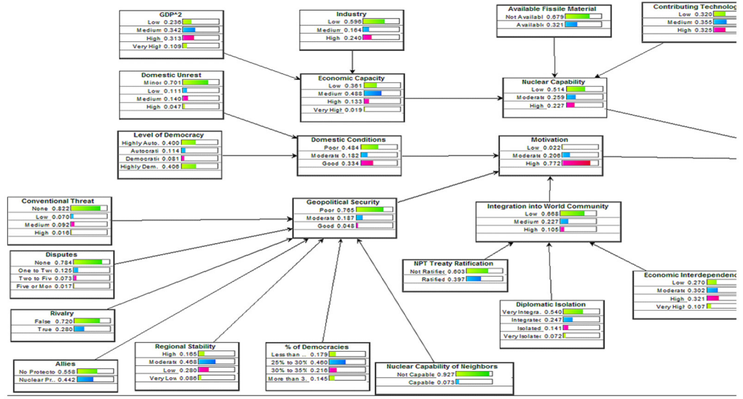


Harvesting evidence in the Knowledge Encapsulation Framework component of the TPAI platform.

aggregated using crowd-sourcing techniques. Evidence is collected from heterogeneous data sources, including newswires, scientific publications, specialized databases, and social media.

Technosocial Modeling

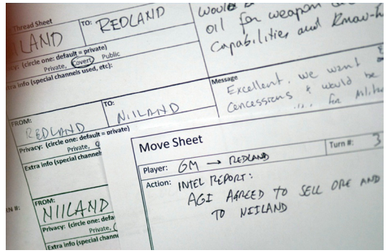
The team has developed Bayesian net models to assess the likelihood of a country acquiring nuclear weapons technology. Evidence may be linked to the models to assess its effect on the probabilities of various outcomes.



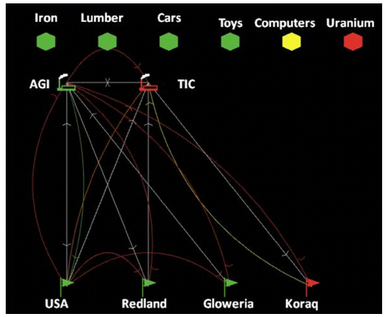
A graph representation of a Bayesian net of intent to proliferate.

Our technical approach to integrate predictive information has three unique and significant aspects: rigorous model validation, formal modeling of experts' assessments, and automatic support for model

behavioral data generated through role-playing in the analytical gaming exercise described above and will provide insights into possible futures that may ensue from such behavioral presuppositions. The ABM will then be integrated with the gaming environment so that players may interact with one another to rank-order the various possible future scenarios generated by the ABM via role-playing.

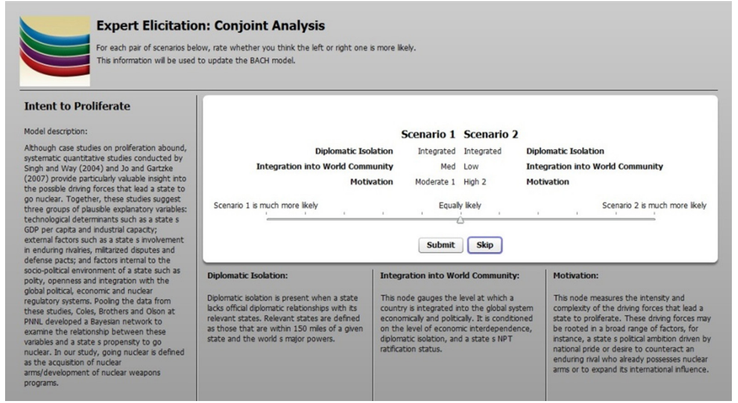


Players exchange records from a table-top game exercise.



Output of an ABM charting the evolution of exchange strategies between state and non-state actors within a nuclear trafficking context.

The integrated demonstration of TPAI capabilities responds to an often-articulated desire by TPAI stakeholders to see how the pieces of the initiative work together. By bringing together technology and social/behavioral modeling, analytical gaming, and the collaborative knowledge management framework of KEF, the demo illustrates how these tools can help analysts identify and evaluate a broad range of plausible scenarios quickly, efficiently, and with reduced bias.



Calibrating model parameters through the aggregation of subject matter expertise via conjoint analysis.

Having used these tools to focus attention on a specific state actor, the second half of the demo follows the team of analysts as they use analytical gaming to explore strategies and scenarios for how nuclear materials and expertise might be brought to the target country. Using both "table top" (board-style) games and their computerized counterparts (see picture in APPROACH section), the analyst team can identify different strategies that emerge from the game play, and evaluate how each of them might be countered.

The next version of this demo will include an agent-based model (ABM) of exchange strategies between state and non-state actors within an illicit nuclear trafficking context. The ABM will be calibrated using the integration. Each is an essential step to improving the forecasting of organizational behaviors.

We take an "engineering" approach to validating the integrated forecasting model — executing a detailed quantitative comparison of dynamic behavior models to observations.

We incorporate experts' assessments through a mathematical structure linking experts' input and the computational model. Our approach treats experts as "sensors," incorporating their opinions through sensor model component.

Finally, the diverse concepts and expertise to address these challenges drives developing automatic support for model integration. These three aspects involve significant traditional science and technology expertise, combined with detailed knowledge of extant social systems (e.g., banking, energy distribution, insurance...) and technical systems. Enabling and supporting integration of models, experts' opinions, and data is a critical step forward to address the challenge of illicit nuclear trafficking.

Analytical Gaming

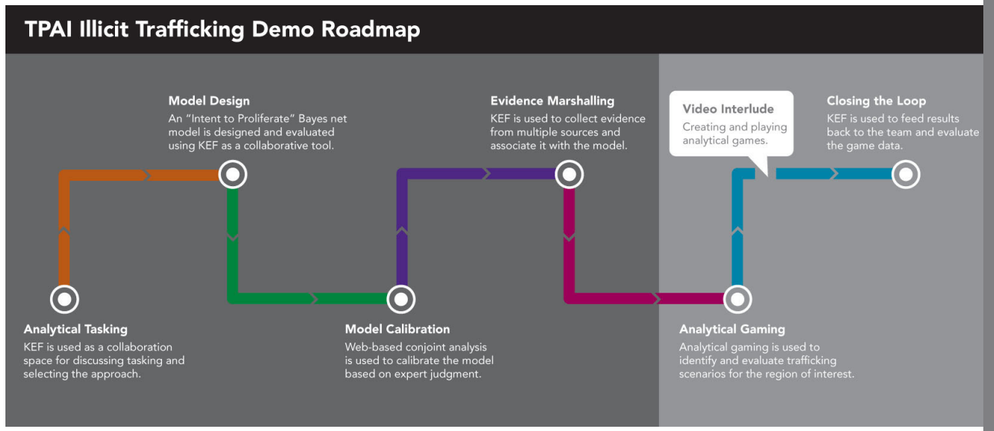
Analytical gaming harnesses role-playing to stimulate creative reasoning in the exploration and creation of plausible futures. In the integrated demo, the TPAI analytical gaming tools are used to examine the trading strategies used by state and non-state actors in trafficking in illicit and dual-use technologies and materials. We leverage role-playing to help stakeholders interact within a compelling collaborative/competitive environment to

- generate behavioral data for trading strategies
- explore trading strategy scenarios through model parameter setting.

In the generation of behavioral data for trading strategies, players interact without the mediation of a model and their game-play behavior is stored and used as evidence to perform model calibration. In the next version of the integrated demo, the game will be integrated with calibrated dynamic models of trading strategies to enable players to explore and rank trading strategy scenarios through model parameter setting in role-playing.

Using role-playing during a game session to generate behavioral data on trading strategies used by state and non-state actors in trafficking in illicit and dual-use technologies and materials.

TPAI ILLICIT TRAFFICKING SCENARIO

Focusing on the issue of illicit trafficking of nuclear materials and technologies, the ITD follows a team of analysts as they use the TPAI tools to shed light on a hypothetical scenario of suspected nuclear smuggling. The demo roadmap graph below provides a summary of such a process.

In the first half of the demo, the analysts work together via the collaborative environment of Knowledge Encapsulation Framework (KEF) to define and build a model that describes the likelihood of a nation to seek nuclear weapons. The Bayesian network model is calibrated using conjoint analysis before being loaded into KEF once again. This time, however, KEF is used as an evidence-marshalling tool to document the model parameters that make up each case study, and to automatically identify candidate evidence, which drives the model.