Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

Multi-source Signatures of Nuclear Programs

This project develops, validates, and demonstrates contextual, model-based data signatures in a variety of nuclear proliferation analytic challenges. The signatures utilize models to integrate across data types and technical communities.

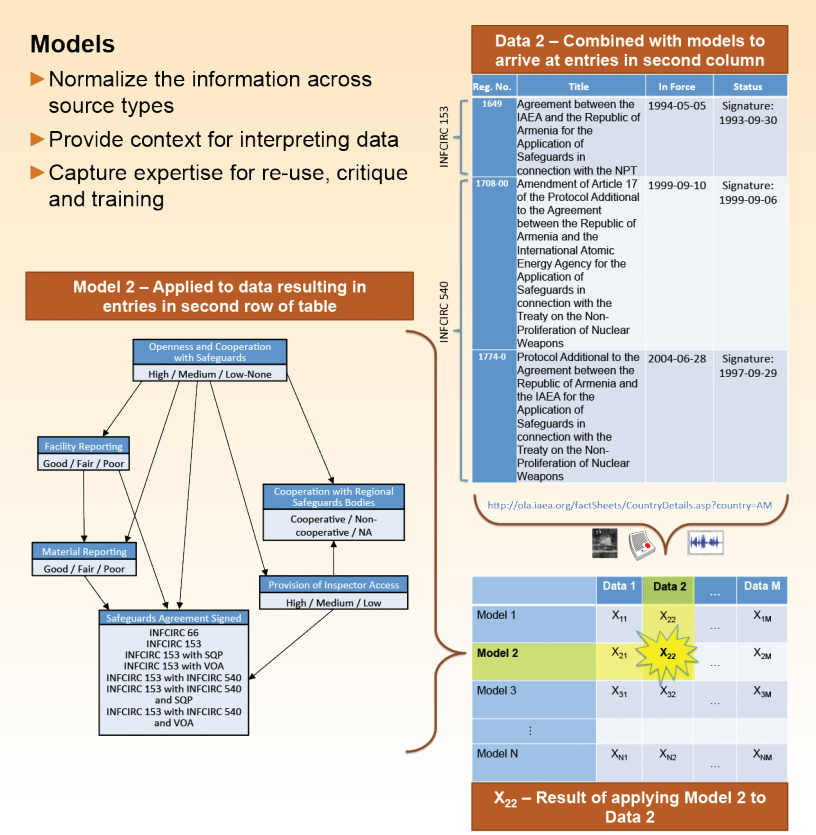
CHALLENGE

PNNL supports numerous U.S. government missions that require expertise in multiple disciplines, reach across technical communities, and incorporate multiple data types and sources. Developing the domain experts that can integrate information at this level is time consuming, and such experts are rare. This project is developing general capabilities for the identification of multi-source data signatures that extend the reach of these experts and allow their expertise to be "replayed" in new settings.

APPROACH

This project develops, validates, and demonstrates the use of model-based data signatures in a variety of nuclear intent analytic challenges. Detecting and identifying the intent to develop (or further) a nuclear weapons program requires inputs from diverse sets of expertise, and requires understanding of diverse types of information and data. Currently, this analytic activity is executed by teams of analysts. While an analyst's expertise typically crosses multiple disciplines, the entire set of required capabilities does not reside within any single analyst. This project develops and demonstrates the use of cross-cutting models to develop signatures based on multiple data types.

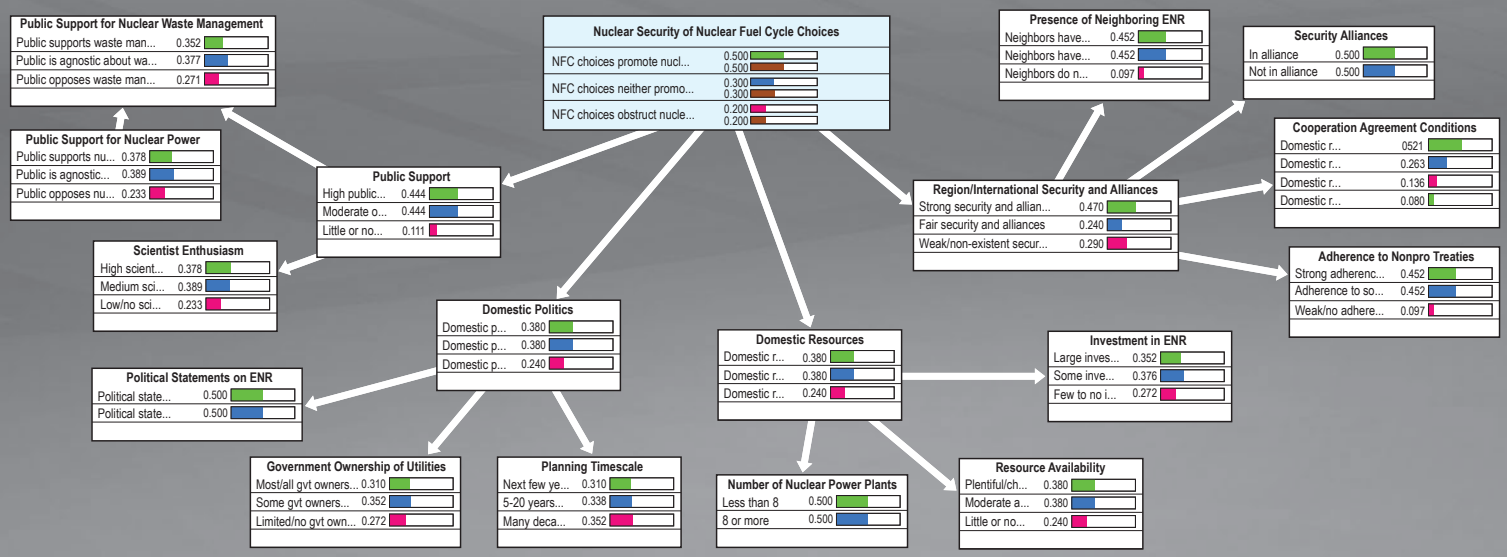
This project addresses both the heterogeneities in data and expertise to develop normalized, context-informed, summaries of the data used to assess nuclear intent. These issues are addressed by representing analytic expertise and known relationships as Bayesian networks. Normalization of the heterogeneous data is accomplished by the application of these models



The Multi-model Approach Uses Bayesian Network Models to Normalize Multiple Types of Data. The figure illustrates this normalization.

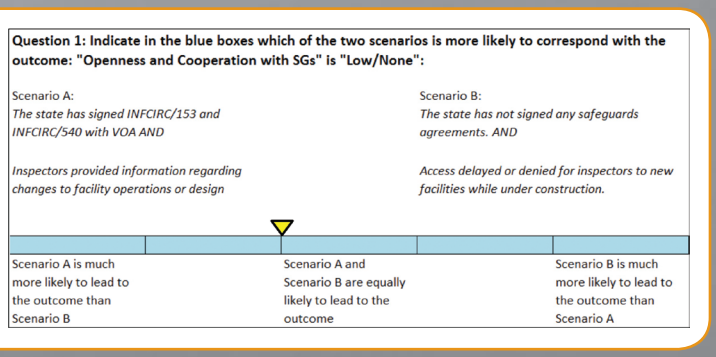
to the data. For each piece of data, the model produces a set of normalized features corresponding to some predetermined outcomes of the model. The feature vectors will be suitable for a variety of information analytic tasks, such as trending, anomaly detection, and summarization.

The model-based approach codifies expertise, and makes explicit various process models (for critique, revision, reuse). The project will demonstrate the signatures in the context of nuclear non-proliferation models and data. Models are built to represent technical processes, and also to represent social and political contexts. The use of the models to capture expertise is evaluated using a formal experiment comparing expert assessments with model-based assessments by non-expert users (where results are comparable).



The Model Relates Aspects of Nuclear Security Based on Fuel Cycle Choices from "Nuclear Fuel Cycle Choices and Security: A Decision Analysis Approach" (Ferguson 2010)

The author broadens the traditional definition of nuclear security as the prevention and detection of, and response to, theft, sabotage, unauthoirzed access, illegal transfer, or other malicious acts involving nuclear material to also include the concepts of deterrence against nuclear attack and improvement of the international nonprolfieration system in order to strengthen the norms against the spread of nuclear weapons and detonation of those weapons.
The high-level categories (public support, domestic politics, domestic resources, and regional/ international security alliances) have been created by the research team based on themes/trends in the nodes to simplify quantification.



The Elicitation as Presented to Experts That is Used to Calibrate the Models. The elicited information is generated from the model.

BENEFIT

The end user will be able to

- replay expertise
- reach across data types
- extend the reach of analysts and expertise

Nuclear intent demonstration analyses—demonstrate methodologies such as change detection, trending, summarization, or ranking for analysis of contextually enriched signatures of nuclear intent

Model-based descriptions of context and processes—demonstrate mathematical and computational representations for analyst decision logic and contextual processes associated with intent to develop a nuclear program (or some aspect of such a program)

Representation and linkage of heterogeneous, discrete data and information in context—develop and deliver mathematics and methodology for mapping text, image and other information streams against baseline contextual models for proliferation signatures

Paul Whitney
Pacific Northwest National Laboratory
paul.whitney@pnnl.gov | (509) 375-6737

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*

U.S. DEPARTMENT OF ENERGY

September 2013

PNNL-SA-96557