

# A Method to Assess Sociocultural and Geopolitical Responses to Concurrent Infrastructure, Information & Economic Attacks

## DYMATICA

Dynamic Multi-scale Assessment Tool for Integrated Cognitive-behavioral Actions

Modeling, Assessment, and Training

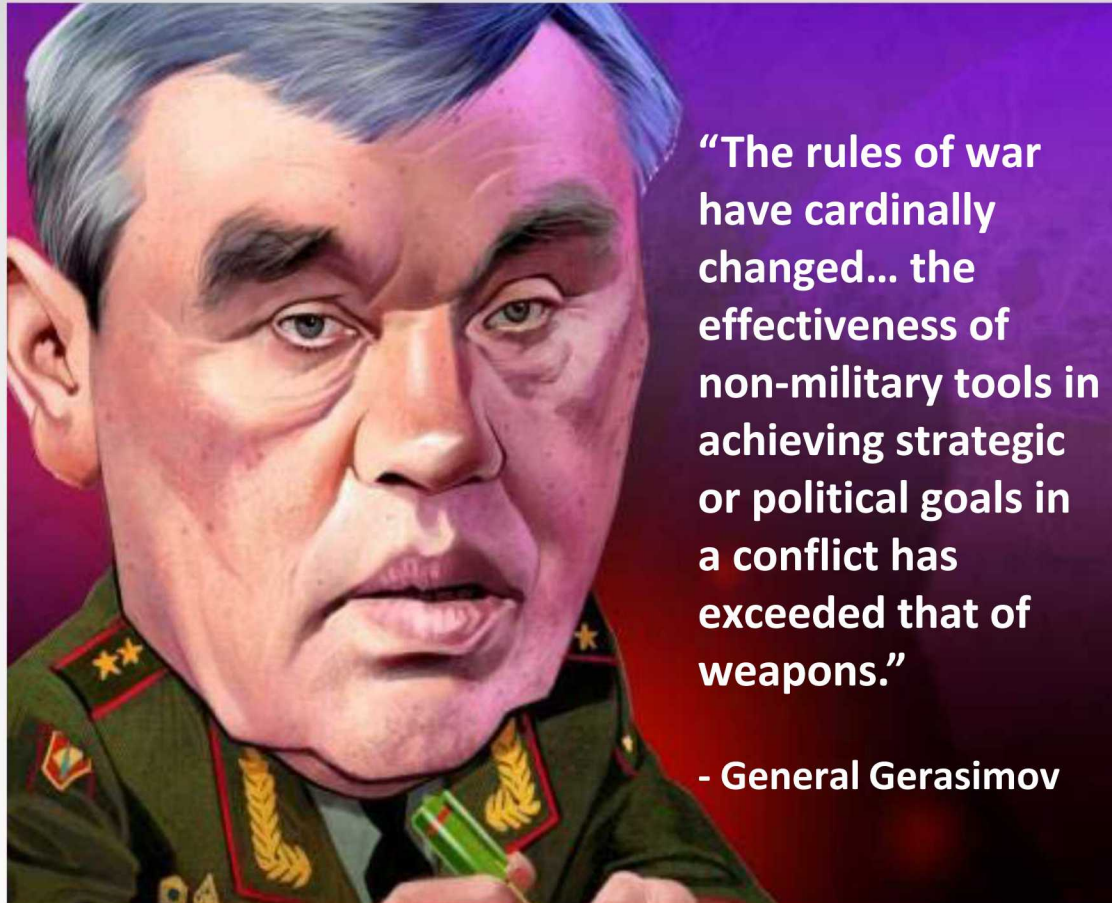
Sandia National Laboratories  
Department of Energy

PRESENTED BY

Casey Doyle, PhD  
Systems Research and Analysis



## Geopolitical Gamesmanship, Social & State Stability, Extremist Movements...



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**"TERRORISM IS A PSYCHOLOGICAL WARFARE. TERRORISTS TRY TO MANIPULATE US AND CHANGE OUR BEHAVIOR BY CREATING FEAR, UNCERTAINTY, AND DIVISION IN SOCIETY."**

**- PATRICK J. KENNEDY**



## Common Practices

- At least one expert with a specific domain expertise
- Group discussions, role playing, brain storming techniques

## Current Limitations

- Not reproducible
- Typically focus on 1<sup>st</sup>-ordered interaction effects
- Typical ability to understand dynamic structure and behavior is very limited
- Typically does not consider decision/social theories
- Typically incorporates limited range of information/data
- Often personality driven

*Yet...*

In this area **human behavior** is important to consider

If we ignore human behavior, we are assuming it does not affect the system (setting it to zero)



## Dynamic Multi-Scale Assessment Tool for Integrated Cognitive-Behavioral Actions

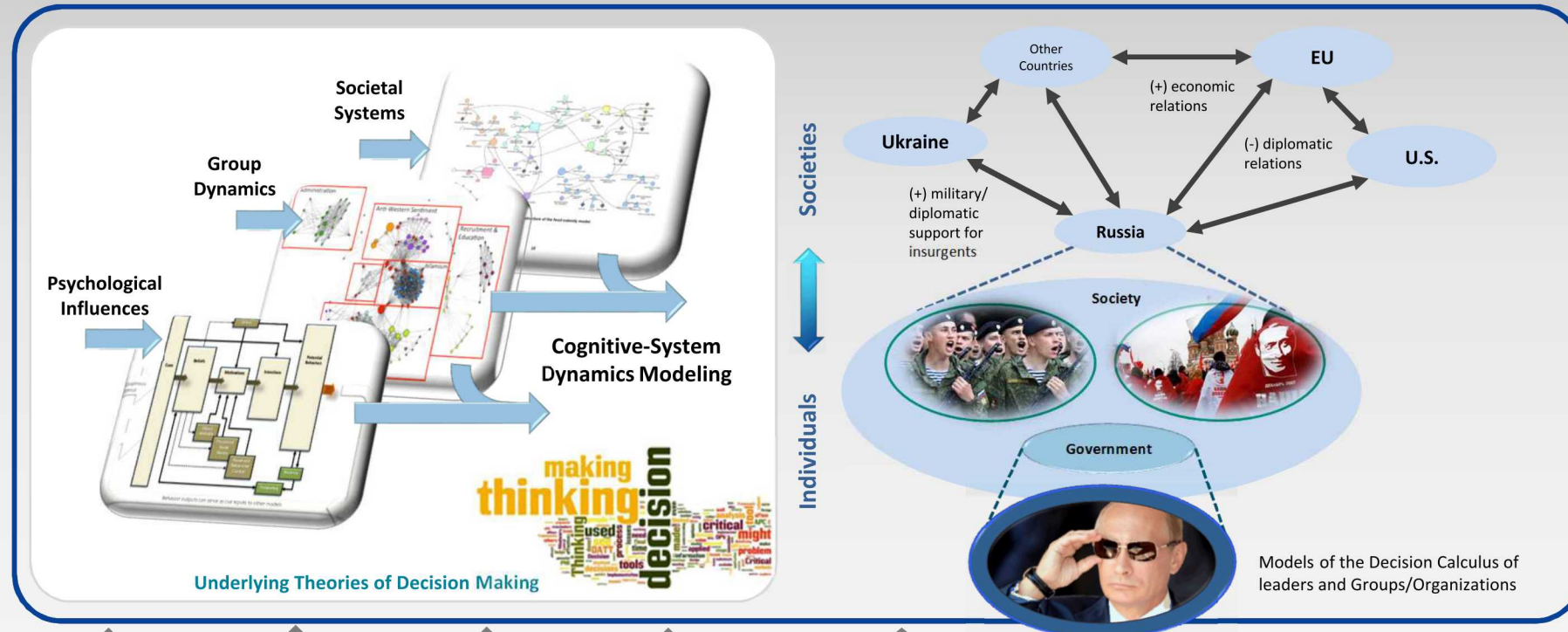
### Informs High Consequence Decisions

- Minimize the likelihood of decisions that lead to undesirable consequences by providing a more systematic analysis of group and individual decisions within state and non-state entities

### Impact

- Enable analysts to assess higher-order (cascading) influences and reactions to events, as well as determine the uncertainty that the event will produce the desired results over time





## Multi-INT Data/Info

Current data to update model outputs

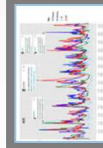
GDP



Military



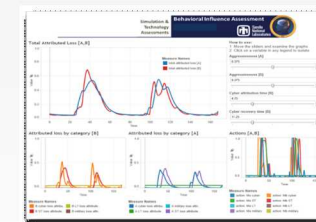
Sentiment



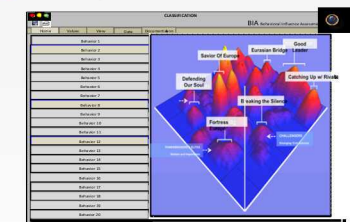
Reports



SME



Descriptive & Prescriptive Analytics



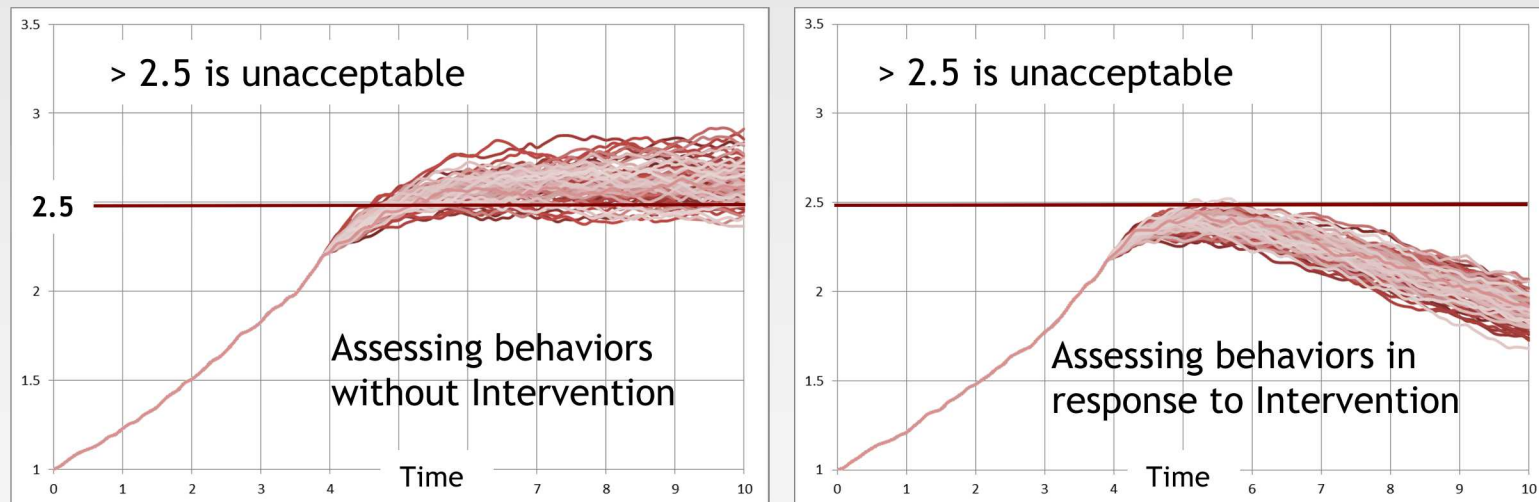
Hybrid Warfare Exercises and Future Operations



## DYMATICA can assess the full range of behavioral patterns across time

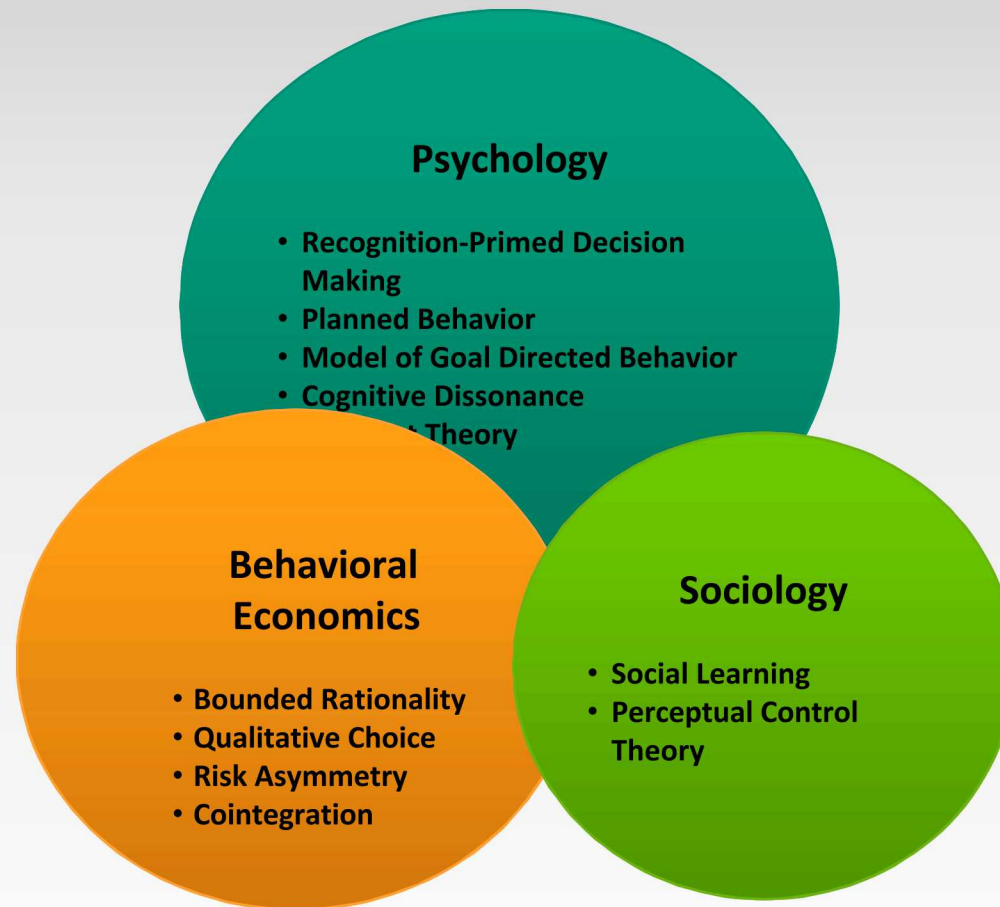
Given uncertainty, what interventions will most likely avoid unacceptable outcomes (including unintended consequences)?

- Example: Figures below shows likely behavioral paths across time. What is most important is to keep or move the range of behaviors to a level that is acceptable.



“River of Blood”: A now ‘formal’ term derived from the Bank of England Annual Report on economic forecasts and their uncertainty. Because of temporal volatility, DYMATICA extends the logic beyond the simplistic use of “variance” confidence intervals

## Incorporates a Set of Theories Across Domains



## Theory Descriptions (Examples)

### Perceptual control theory

- Model of behavior based on the principles of negative feedback, but differing in important respects from engineering control theory

### Prospect theory

- People make decisions based on the potential value of losses and gains rather than the final outcome, and that the losses and gains are evaluated using certain heuristics

### Recognition-primed decision making

- Model of how people make quick, effective decisions when faced with complex situations

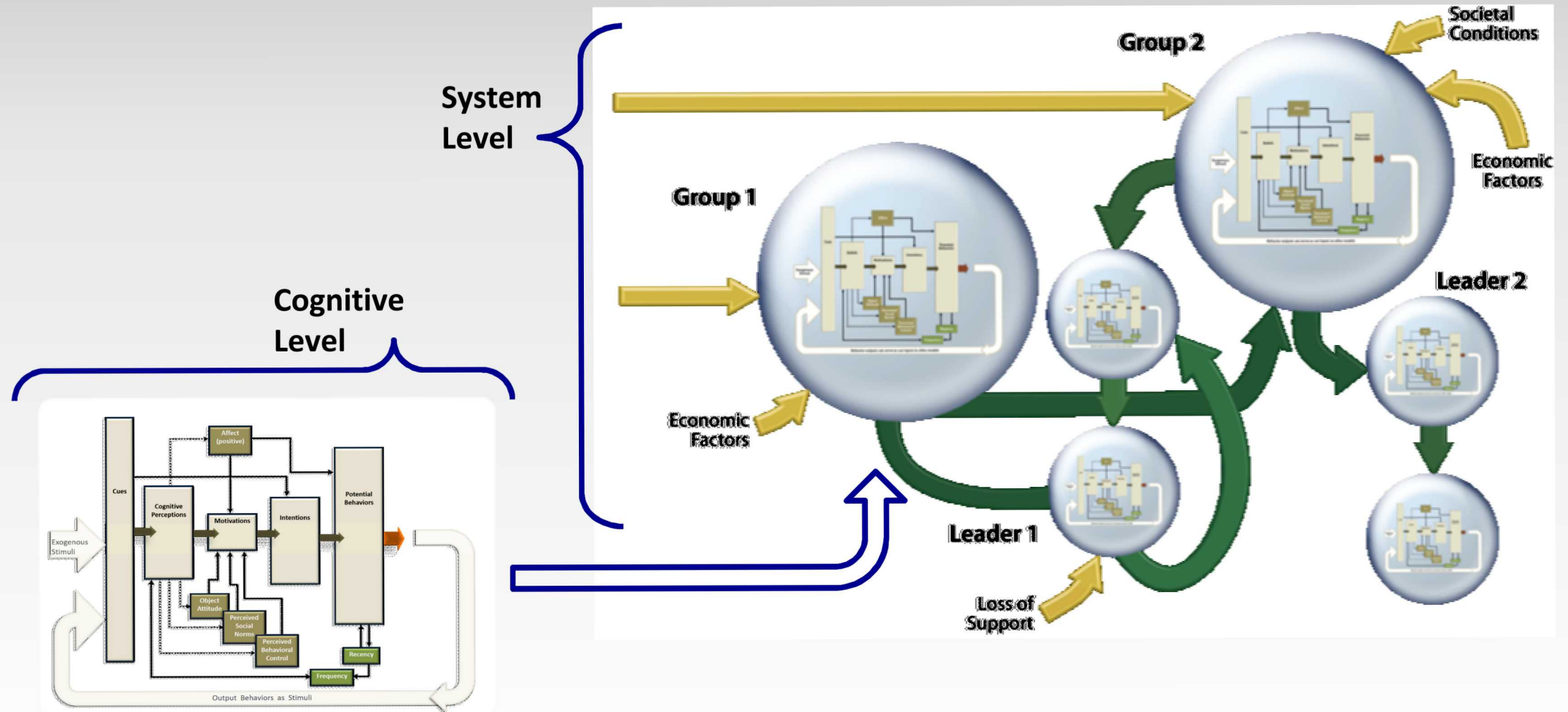
### Qualitative choice theory

- *Daniel McFadden: 2000 Nobel Prize*
- Social responses are dominated by uncertain decision logic, parameters, and information processing

### Social learning theory

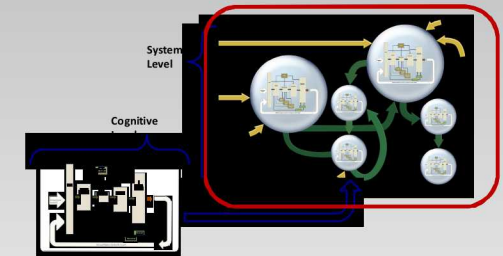
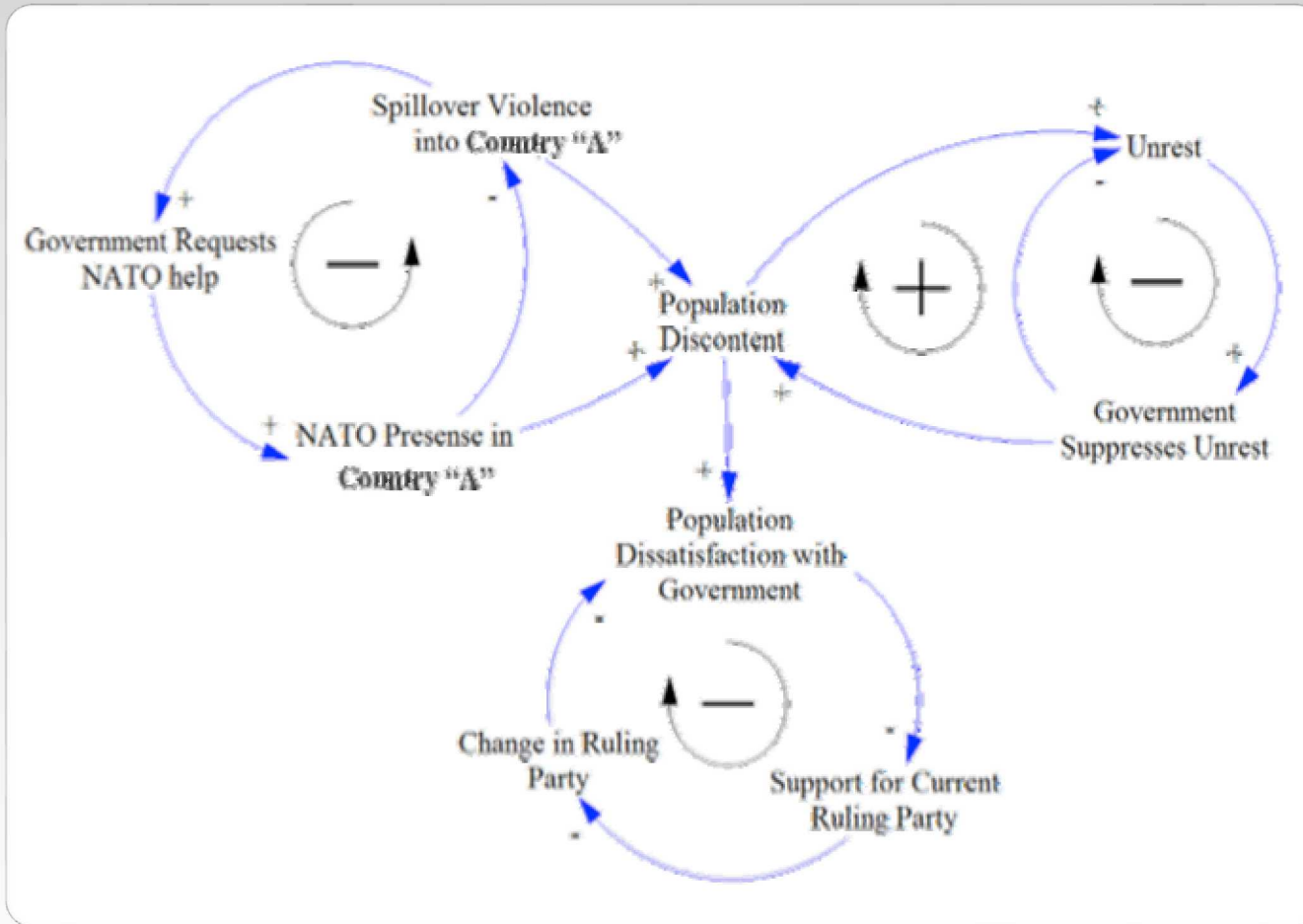
- Individual's behavior is influenced by the environment and characteristics of the person

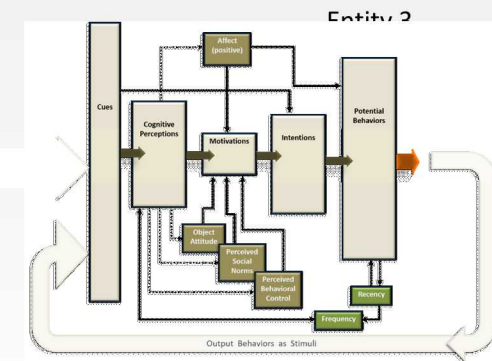
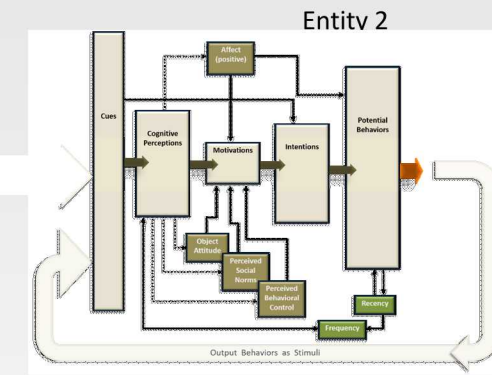
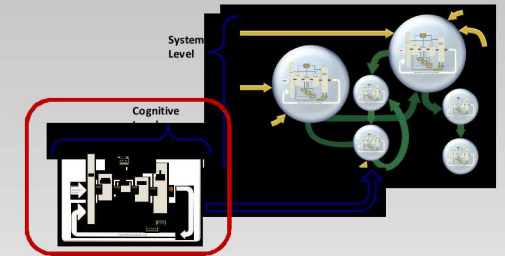
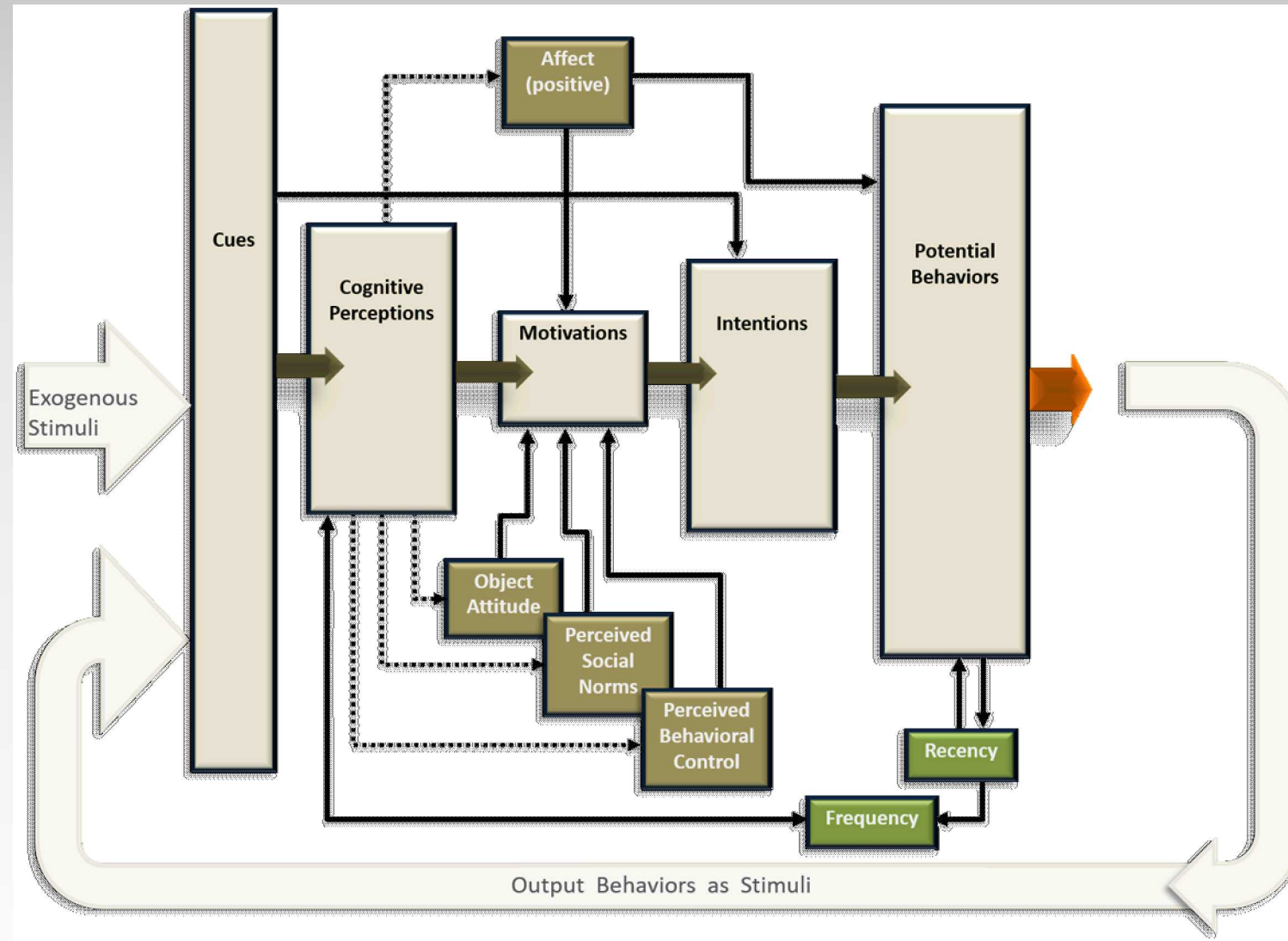
## Integration of Cognitive and System Models



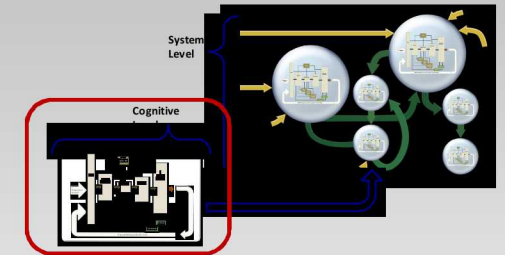


## Broad-Level Societal System (Example)

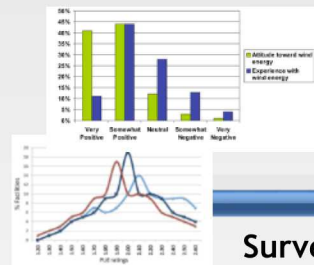




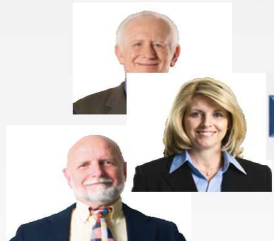
Examples of SME information, data, and report information that populate DYMATICA models



## Cues



Surveys,  
etc Data



### CUES

SC1 global VEG seeks presence in country  
SC2 promote culture and traditions  
SC3 legitimize government  
SC4 suggest G1 factionalism  
SC5 suggest G1 leadership disloyalty  
SC6 suggest conflict between G1 and G2  
SC7 suggest G1 corruption  
SC8 suggest G1 losing funding and military ground  
SC9 suggest G2 losing funding and military ground  
Territory held by G1  
Territory held by G2  
Security provided by government  
Services provided by government  
Success of recent attacks by global VEGs  
Success of recent attacks by G1  
Success of recent attacks by G2  
Global VEG courtship of G1  
Global VEG courtship of G2  
Societal stability  
Foreign funding to anti G activities  
G1 size  
G2 size  
G1 funding  
G2 funding

## Decision Factors

### Perceptions

Perception that global VEG seeks presence in country  
Perceived importance of culture and traditions  
Perceived government legitimacy  
Perceived G1 factionalism  
Perceived G1 leadership disloyalty  
Perceived conflict between G1 and G2

### Expectations

Expectation of importance of culture and traditions  
Expectation of government legitimacy  
Expectation of G1 factionalism  
Expectation of G1 leadership disloyalty

### Discordance

Discordance that global VEG seeks presence in country  
Discordance of importance of culture and traditions  
Discordance of government legitimacy  
Discordance of G1 factionalism  
Discordance of G1 leadership disloyalty  
Discordance of conflict between G1 and G2  
Discordance of G1 military strength  
Discordance of G2 military strength  
Discordance of benefit of leaving G1  
Discordance of cost of leaving G1  
Discordance of benefit of leaving G2  
Discordance of cost of leaving G2  
Discordance of status of G1  
Discordance of status of G2  
Discordance of strength of G1  
Discordance of strength of G2

### POTENTIAL BEHAVIORS

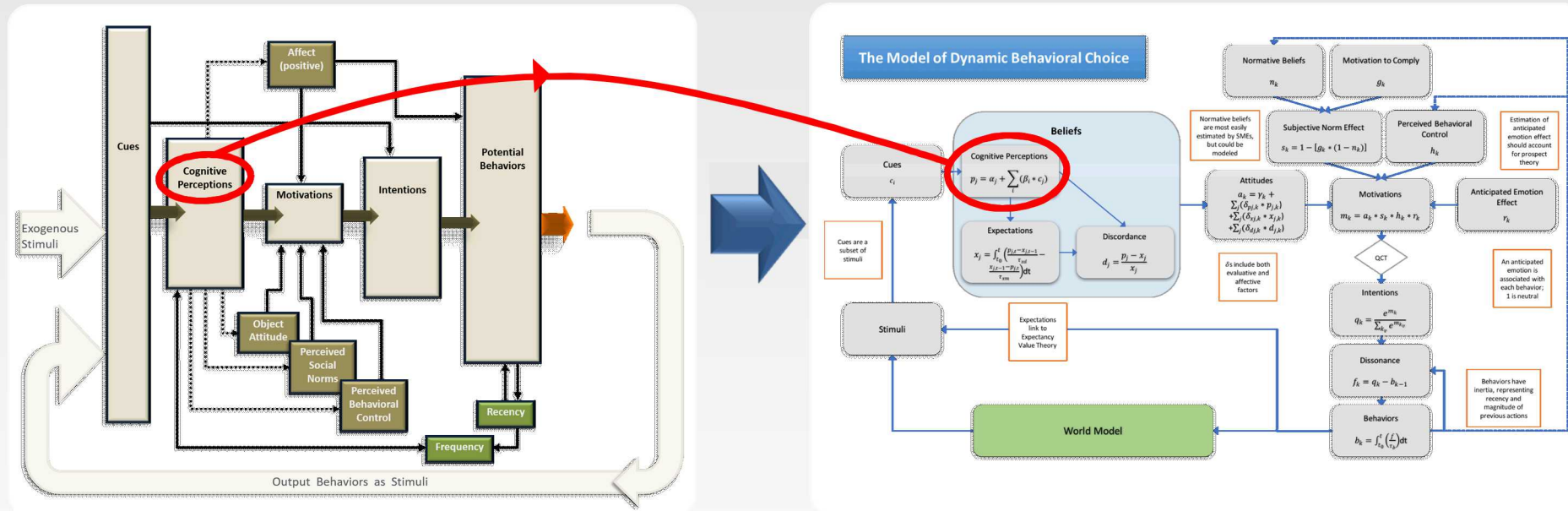
G members choose G1  
G members choose G2  
G1 leaders choose global focus  
G1 leaders choose local focus  
G1 leaders push G1 narrative  
G1 leaders do not push G1 narrative  
G members favor G1 ideology  
G members favor G2 ideology  
G1 members leave G  
G1 members move to G2  
G1 members stay in G1  
G1 removes members  
G1 does not remove members  
G1 members infight  
G1 members do not infight  
G1 provides services to society  
G1 does not provide services to society  
G1 provides security to society  
G1 does not provide security to society  
G1 invests in logistical network  
G1 does not invest in logistical network  
G1 attacks G2  
G1 does not attack G2

Cue Inputs to other entities

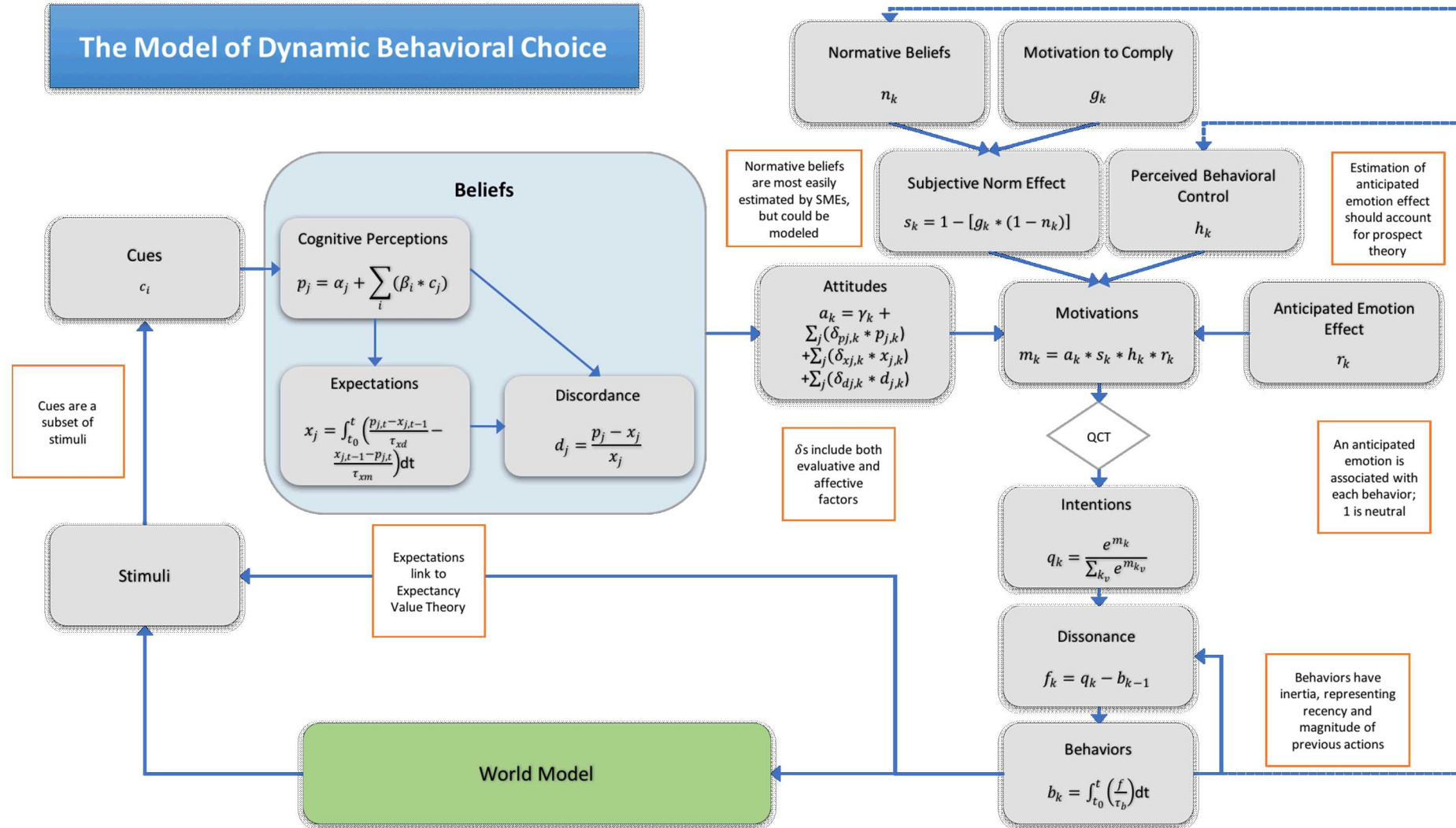


## One-to-one Mapping of Conceptual Model to Mathematical Implementation

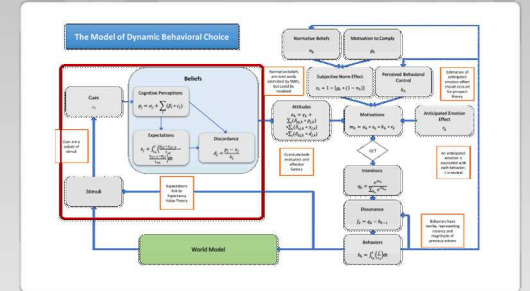
*How to translate and incorporate SME opinion into computational, decision models of specific groups/individuals?*



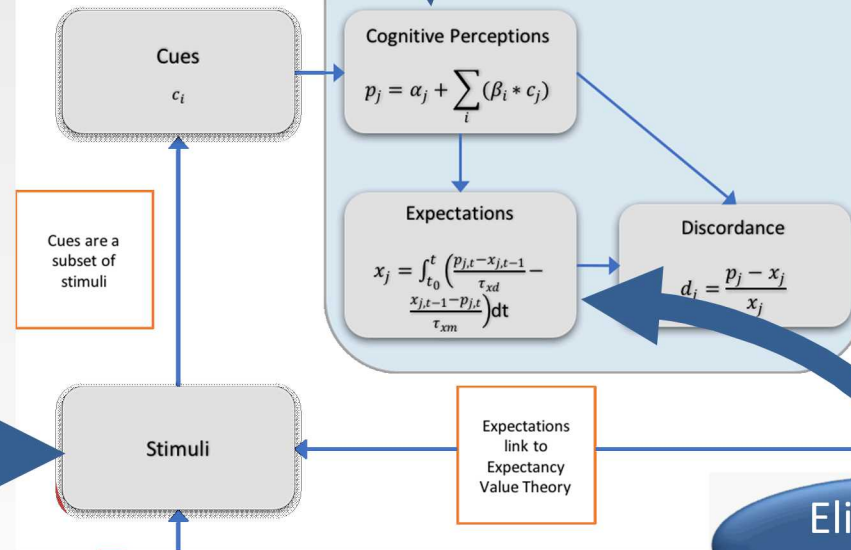
## The Model of Dynamic Behavioral Choice



	PERCEPTIONS													
	A		B		Population				Govt					
CUES	A's power	A's membership	A's resources	B's power	B's membership	B's resources	A's power	A's resources	Terrorist attacks by A	Population support for A	B's power	B's resources	Terrorist attacks by B	Population support for B
A's membership	0.50	1.00												
A's resources			1.00				0.50	0.50						
Terrorist attacks coordinated by A	1.00			-0.25	1.00		1.00	-0.50						1.00
B's membership				0.50	1.00								0.50	
B's resources						1.00		0.50					0.50	
Terrorist attacks coordinated by B	-0.25			1.00		-0.50		1.00	1.00					1.00
Effectiveness of local government										1.00				
Acts of prejudice toward pop associated with EGs											1.00			
Population support for extremist group agenda												1.00		



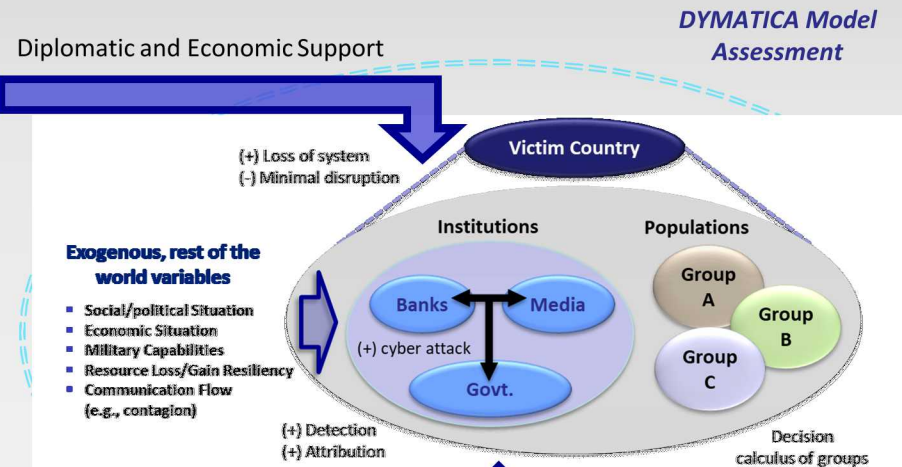
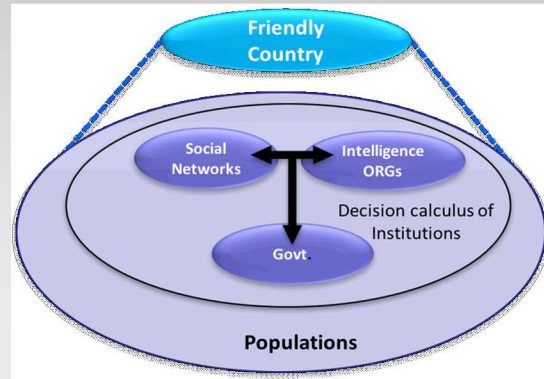
World model and previous behaviors



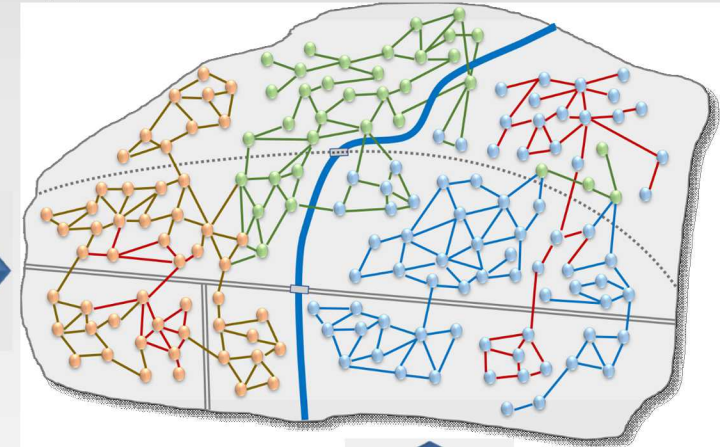
Elicited lag times



## Hybrid Warfare Simulations for Assessment Tools

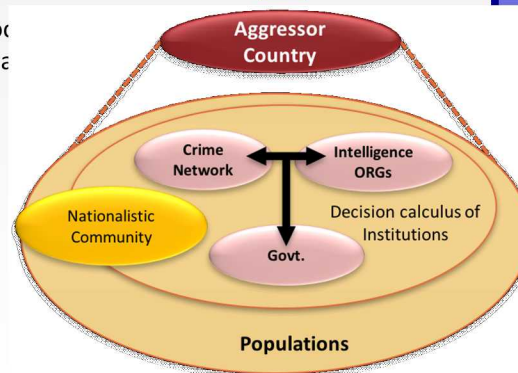


Agent network of populations within a

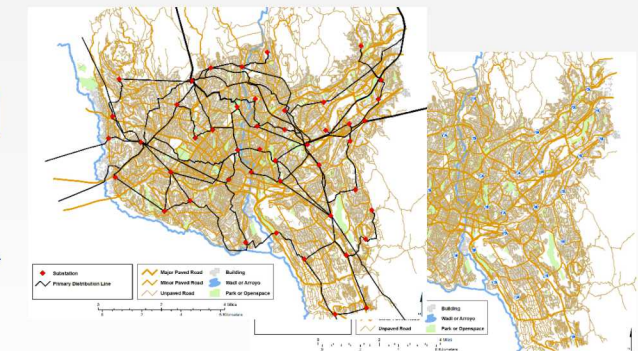


Electric, Food, Fuel, & Transport Models

Current Real-world Soc Economic, Political Data



Infrastructure Stability



National Infrastructure Simulation and Analysis Center models

## Projected Developments

### *Year One (FY18-19)*

- The ability to model and simulate how certain infrastructure disruptions and co-occurring geopolitical, economic, and sociocultural events affect the resiliency of governments, as well as various aspects of society.
  - *Coupling of DYMATICA with Infrastructure and economic models*

### *Year Two (FY19-20)*

- The modeling and simulation of multiple adversary messaging/propaganda, economic warfare, infrastructure disruptions/special operations, along with friendly country assistance as it affects the behaviors of multiple government institutions, societal groups and non-governmental organizations across time.
  - *Coupling of DYMATICA with Infrastructure and economic models*
- The ability to ingest government data and social media information to update and calibrate the model over time.

## Assessing Data Within Models

- ***Quantifying uncertainty:***

- Assess how uncertainty in model inputs propagates through the model to affect results
- Characterize uncertainty in model inputs
- Helps the analyst to understand potential outcomes given that some assumptions and conditions are uncertain
- Run the model with different combinations of inputs to characterize uncertainty in outputs
- Likely to use Dakota software - Sandia-developed, Publicly available

- ***Sensitivity analysis:***

- Assess which COAs have the largest effects, i.e., where intervention would be most effective
- Can use to learn
- Best places to focus data collection resources
- Whether the model can be simplified

- ***Verification:***

- Extreme value tests - to assess implausible behavior caused by certain ranges of values
- Benchmark problems - to test the accuracy of the code used for numerical integration

- ***Validation (Confidence Management):***

- Face validation - assess model for reasonableness; Diagrams of model structure
- Cross validation - assess a subset of historical data, compare results to remaining data



# DYMATICA Modeling & Assessment

## Current Work and Capabilities

# DYMATICA

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Integrated Cognitive-behavioral Actions

Modeling, Assessment, and Training

**Sandia National Laboratories**  
**Department of Energy**

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