MODELING AND SIMULATION ANALYSIS for *Conflict Crisis Disorder*

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MODELING and SIMULATION ANALYSIS for Conflict, Crisis, Disorder

Purpose of Presentation . . .

Part 1 discuss **why and how** we can engage M&S as an analytical tool to:

- ❑REPRESENT through model development
- ❑CHARACTERIZE through soft data inputs to the model
- ❑ANALYZE through simulation outputs
- ❑ANTICIPATE or forecast / predict through simulation iterations

. . . of real world events

Part 2 and suggest ways to utilize M&S for interagency war gaming and tabletop exercises via case studies addressing illicit power

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Part 1 - M&S a tool for understand·ing and solving diverse problems

Models may be real
case study **or contrived** ***use case***

Simulation is an applied methodology

This allows for opportunity to retest the hypothesis

hypothesis → test
hypothesis → simulation → test

Model –
approximation for the real-world

Simulation –
a methodology that can describe the behavior of a system

Visualization –
a means to communicate (digital computer)

Analysis –
findings, conclusions, recommendations

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2 types of systems

discrete - variables change instantaneously at separate points in time

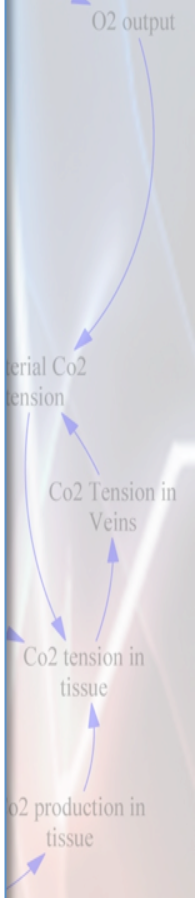
continuous - state variables change continuously with respect to time

3 types modeling paradigms

System Dynamics

Game Theory

Agent-based Modeling and Social Networks



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System Dynamics . . . understanding cause and effect

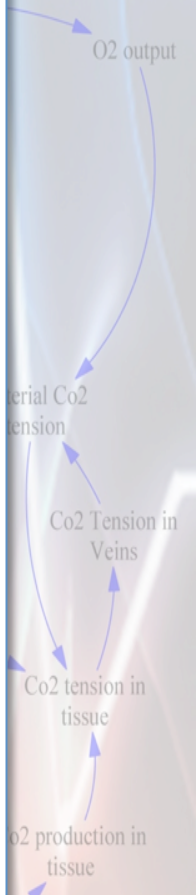
Causal thinking is the key concept behind constructing model

Logic of Causal Links (read as cause, affects, or influences)

1. Food intake → Weight
2. Money → Happiness

– an approach to studying complex systems
– feedback results as interaction of one system variable with another

Positive feedback - reinforces what is happening in system
Negative feedback - opposes what is happening / limits growth



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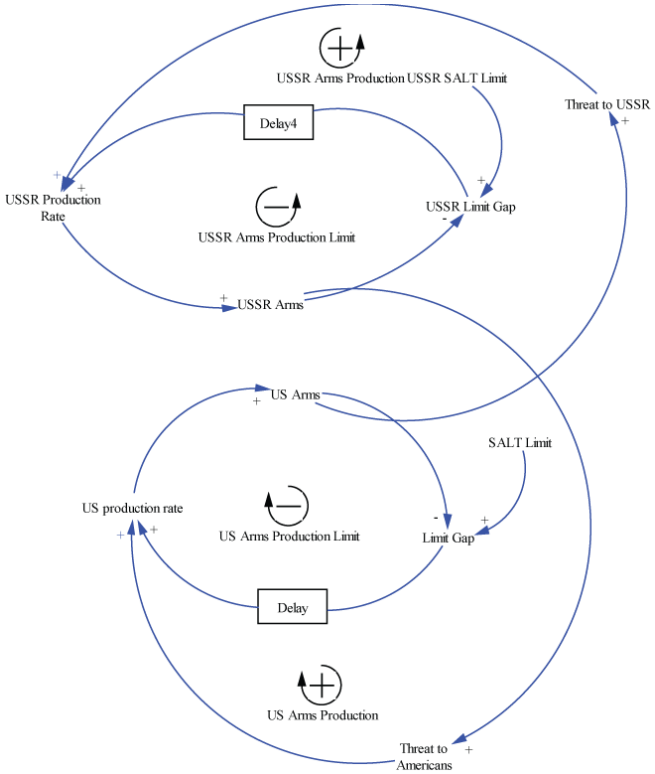
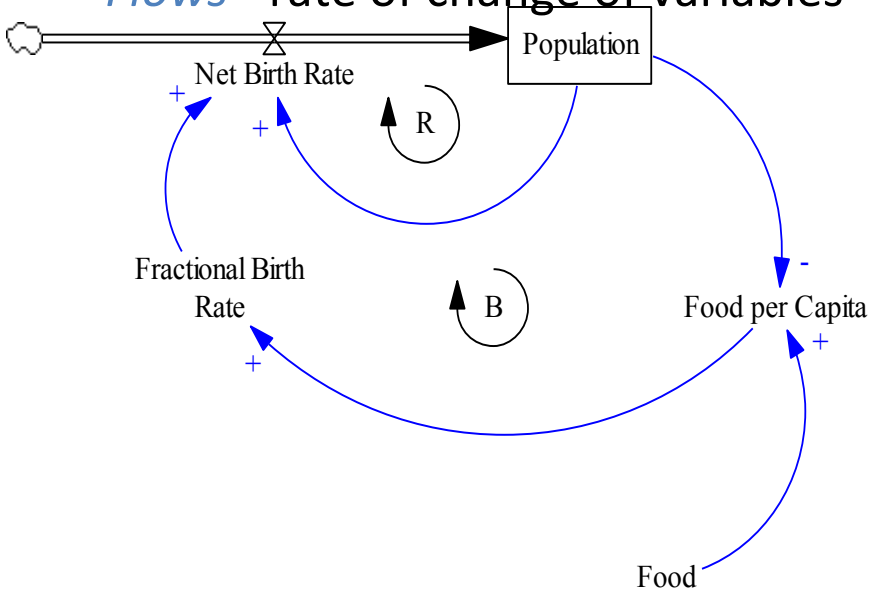
Causal Loop Relationships



Stock and Flow Diagram

Stocks - accumulators of the systems

Flows - rate of change of variables



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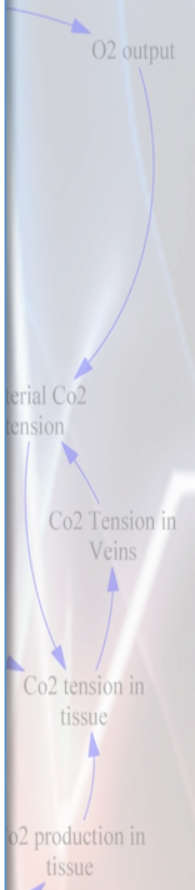
Case Study Colombia

TASK characterize the marginal and long-term changes in population numbers and insurgency strength due to modifications in governmental policy and military strategy for the counter-insurgency

ASSESSMENT effects or outcome of executing new government policy in waging a deeply entrenched and seemingly unending insurgency

RESEARCH QUESTION *How can governmental policy changes in Colombia's war against drugs be measured, then represented in a qualitatively developed and quantifiably supported model that can predict insurgency strength and prescribe counter-insurgency strategy?*



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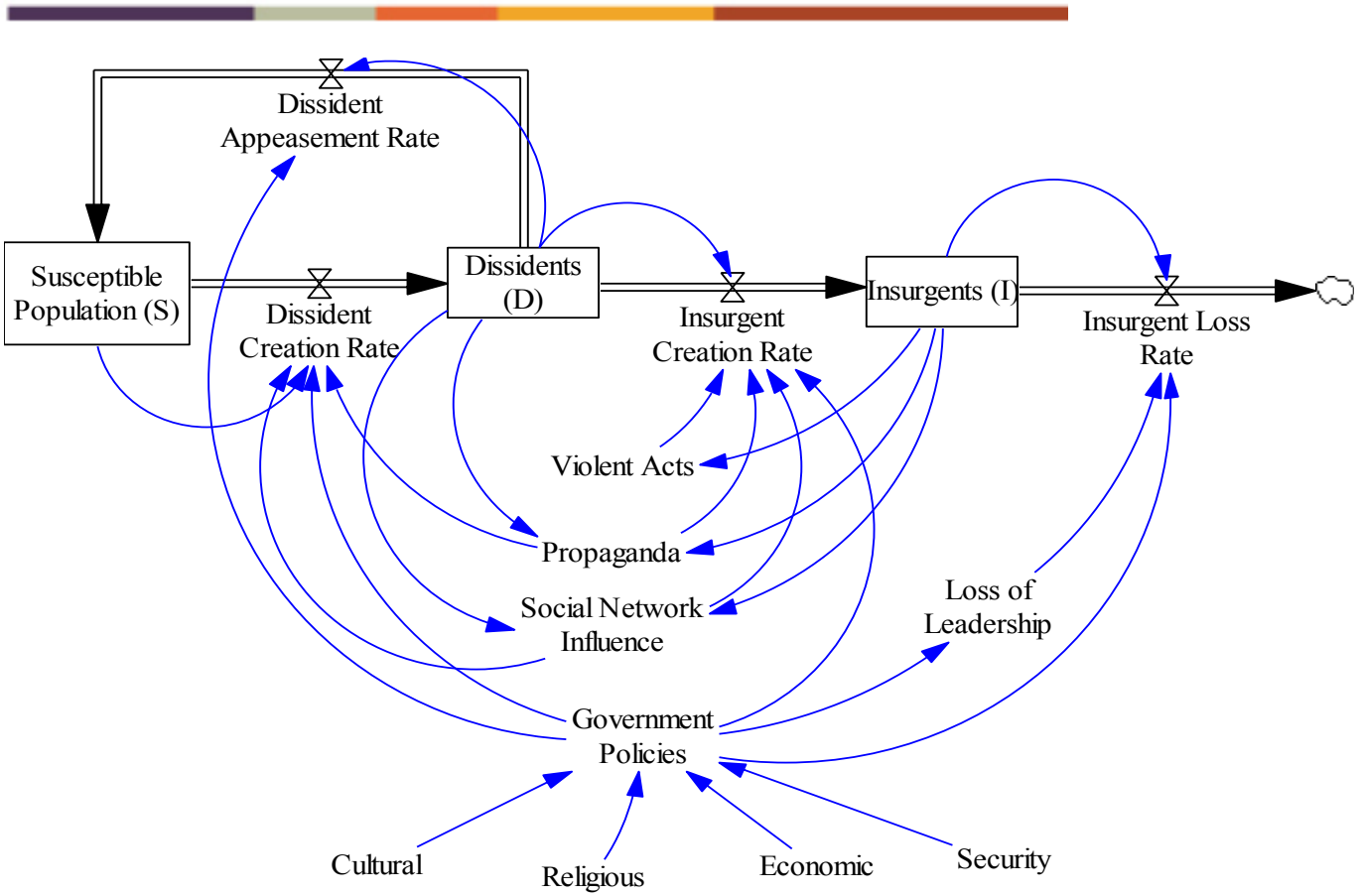

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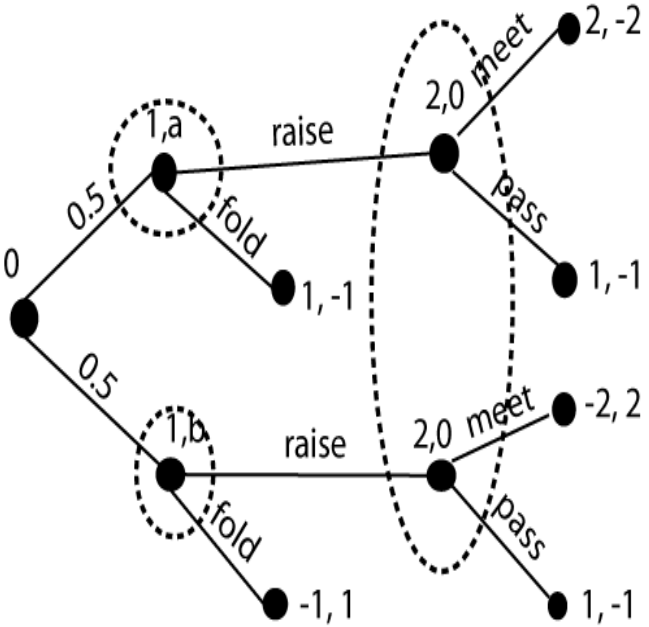
Game Theory . . . understanding interactions between players

Game – any social situation or interaction involving two or more people called players who are assumed to be rational and intelligent

Rational – players make consistent decisions advance their objectives or goals

Intelligent – a player's knowing everything about the game that the game designer does



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Game Characteristics

Cooperative vs. non-cooperative – cooperative games players form coalitions with each player bringing a particular talent or expertise to the group with the idea of maximizing the return for the coalition as a whole

Symmetric vs. asymmetric – symmetric games payoffs depend only on the strategies being played and not on the particular player playing them.

Zero sum vs. Non-zero sum – a zero sum game the total benefit to all players sums to zero

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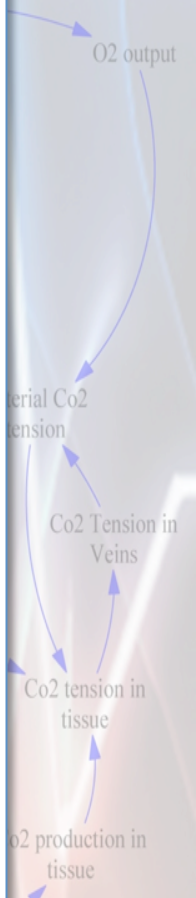
Case Study Cuban Missile Crisis

TASK Modeling national strategic decision-making using Game Theory to represent the effects of those decisions based on the concept of compellence

ASSESSMENT Theory of Moves

RESEARCH QUESTIONS

What was the relationship between the leaders of the two superpowers?
What was Khrushchev's objective in arming Cuba?
How did the U.S. respond diplomatically and militarily?
Can diplomacy work without compellence?



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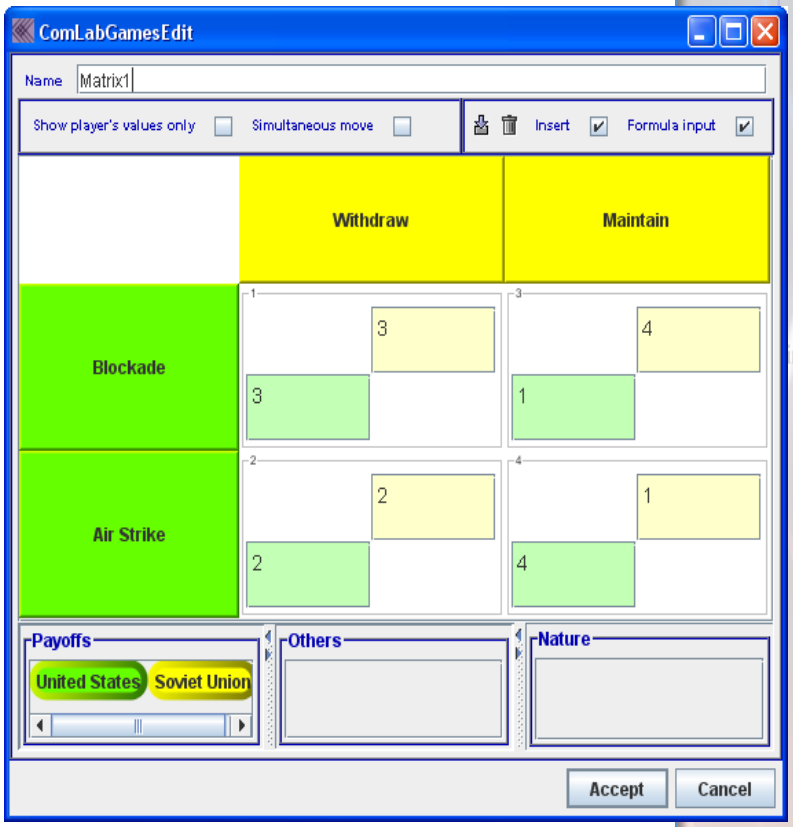
Theory of Moves Analysis (TOM)

- strategic analysis = moves / countermoves
- rules of play
  - play starts at an initial state
  - either player can unilaterally switch strategy and thereby move to a new state - player who switches is (P1)
  - Player 2 (P2) can respond by unilaterally switching its strategy, thereby moving the game to a new state
  - alternating responses continue until a player whose turn it is chooses ***not to switch*** its strategy



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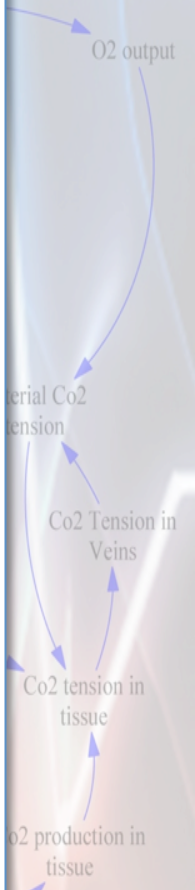
Agent-based Modeling . . . a power structure approach

- Determine the actors to be modeled
- Determine metric to be used to compare agents to one another
- Identify capital that each actor possesses
- Define the relationships among the actors
- Build social network structure linking actors via relationships
- Specify goals for each agent and their relative priorities
- Identify / incorporate external processes that affect the actors
- Define / build agent logic structure (behavior modeling)



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Agent-based Modeling . . .

Agent - autonomous software entity that interacts with its environment or other agents to achieve some goal or accomplish some task

Purely REACTIVE agents - agents that decide what to do without reference to history responding to some stimulus

Agents with state - agents whose decision making influenced by history; possessing internal data structure that captures information about environment / what happened in past

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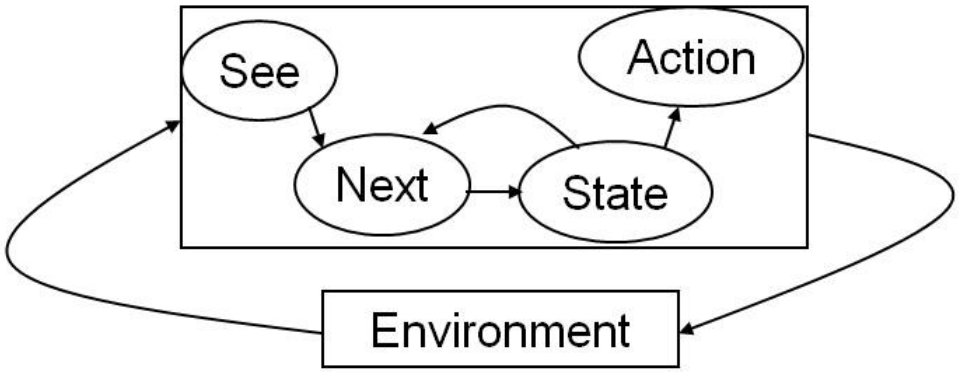
Agent Reasoning

- Finite State Machines and Markov Chains
- Rule Based
- Case based reasoning (expert systems)
- Neural Networks
- Fuzzy Logic / Fuzzy Inference systems



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Case Study Nigeria

TASK Nigeria is an example of an ongoing insurgency that affects the global economy of which international community and the state itself endeavors to understand and mitigate insurgency

ASSESSMENT agent-based model is capable of depicting the complex interactions among the groups and capturing the evolution of the system as these agents (actors) interact over time

RESEARCH QUESTIONS *What sustains the insurgent groups? What is causing an increase in recruits.? What policy changes can be implemented to control or eliminate the insurgents and thrust behind the insurgency?*

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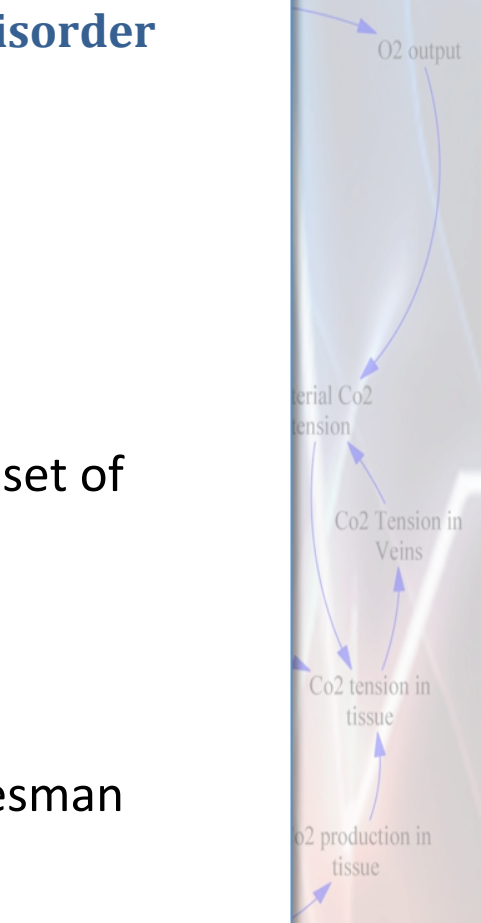
THE MODEL . . . agents represent the
1) tribesmen
2) the national police
3) the oil assets

- the tribesmen –most complex of the agents governed by a set of variables that include:

  ✓level of anger against the government
  ✓a measure of their well being
  ✓their violence threshold, which determines when a tribesman becomes an insurgent

- a tribesman transitions into an insurgent when his anger exceeds both his well being and his violence threshold



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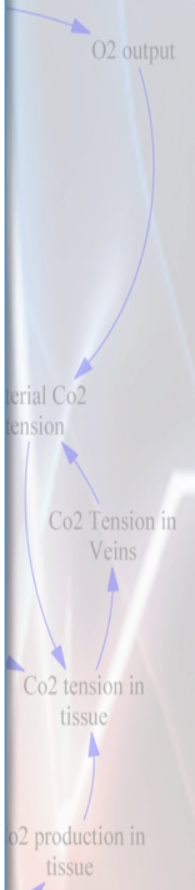
- values randomly set for each agent at the beginning of the simulation based on data / indices

- tribesmen are randomly distributed on a square cellular grid representative of an area in the Niger Delta

- population density of this region is 265 people per square kilometer so the agents are dispersed with this density

- also dispersed on this grid are a fixed number of oil assets and national police with a police to tribesman ratio of 1:400 (which is representative of the total police force strength compared to the total Nigeria population)



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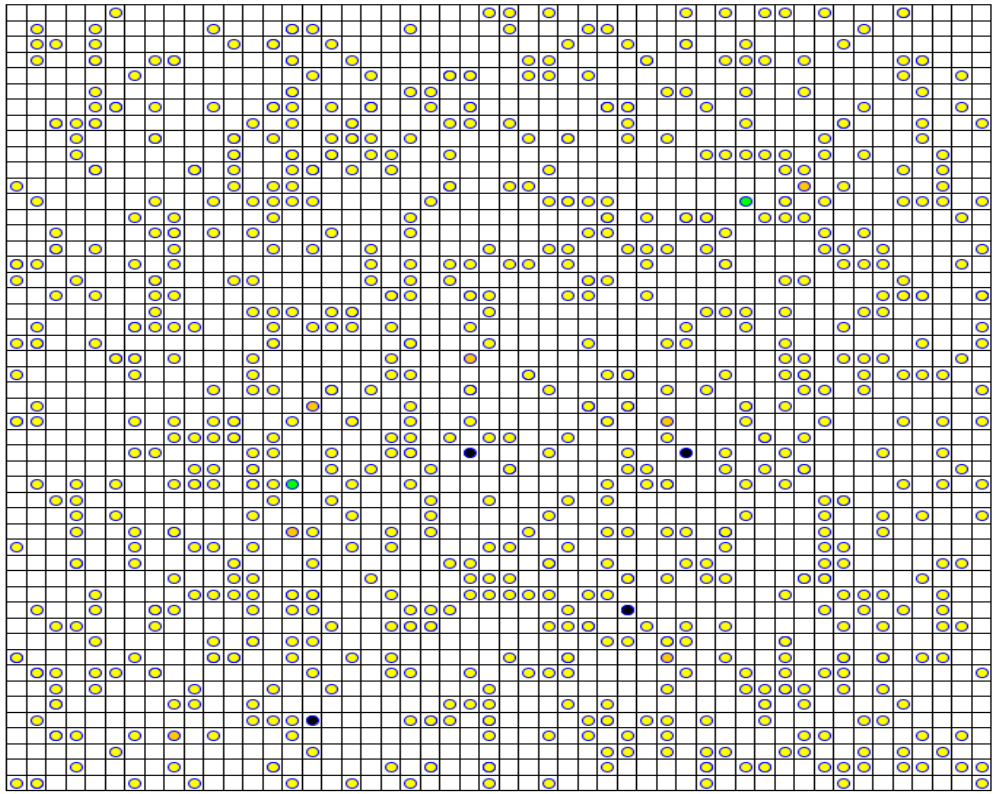
black circles represent the oil assets

green represents the police forces

yellow the tribesmen

orange for insurgents



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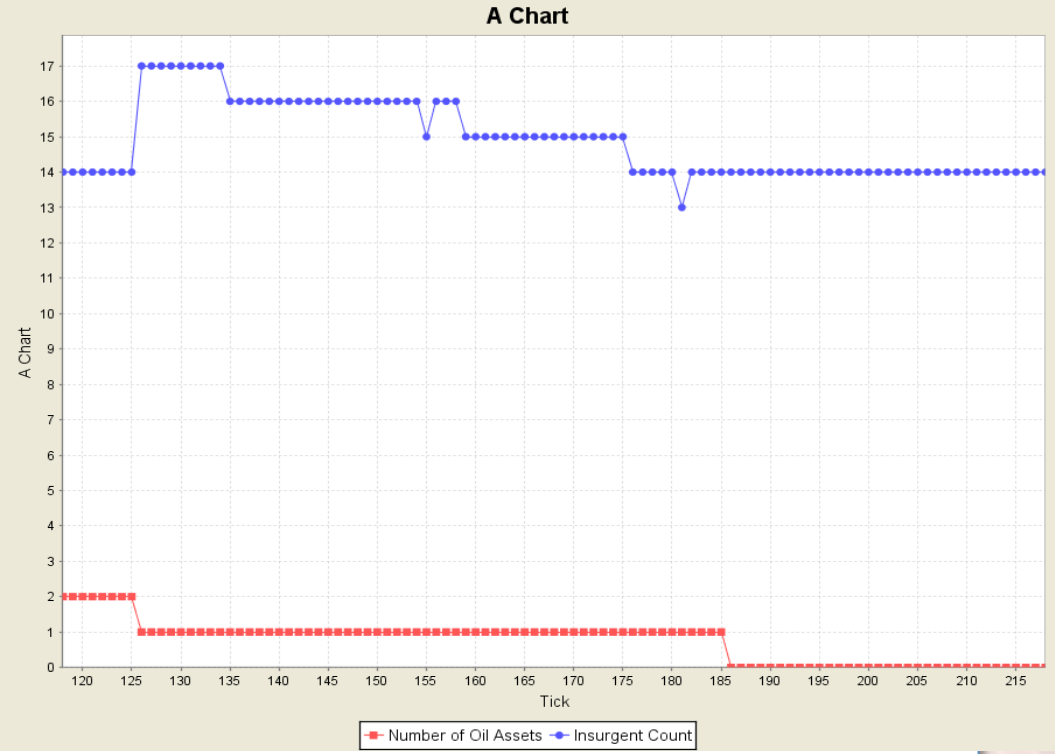
MODEL OUTPUT ANALYSIS

- various parameters tracked in simulation

1) assess how an insurgency will grow

2) determine vulnerability of oil assets to the insurgency by tracking number of insurgents over time and number of oil assets remaining



- top line = number of insurgents
- bottom line = number oil assets

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Case Studies

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Balaban, M., Banks, C. M., Sokolowski, J. A. **Vietnam 1969-1973**: Engaging M&S to Characterize Cause and Effect Patterns of US Withdrawal. In *Proceedings of the 2012 Spring Simulation Conference.* March 26-29, 2012. Orlando, Fl.

Sokolowski, J. A., Banks, C. M. Investigating **Social Dynamics and Global Connectivity**: An Agent-based Modeling Approach. In *Proceedings of the 2010 Winter Simulation Conference*. December 5-8, 2010. Baltimore, MD., pp. 773-740.

Sokolowski, J. A., **Banks, C. M.** Unequal Protagonists: Modeling the **Irish Insurgency** 1916-1921. *International Journal of System of Systems Engineering.* Vol. 1 No. 4 (2009), pp. 445-471.

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Case Studies

Sokolowski, J. A., **Banks, C. M**. Modeling **Complex Social Behavior**: A System Dynamics Approach. In *Proceedings of the 19th Conference on Behavior Representation in Modeling and Simulation.* March 22-25, 2010. Charleston, SC.

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Banks, C. M., Sokolowski, J. A. Advancing **Cognitive Agent-Based Modeling**: Personifying the Agents. In *Proceedings of the 2009 Summer Simulation Multiconference*. July 13-16, 2009. Istanbul, Turkey, pp. 54-60.

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Case Studies

Adam, J. A., Sokolowski, J. A., Banks, C. M**.** A Two-Population Insurgency in **Colombia**: Quasi-Predator-Prey Models – A Trend Towards Simplicity. *Mathematical and Computer Modeling*. Vol. 49 (2009), pp. 1115-1126.

Sokolowski, J. A., Banks, C. M. Investigating Social Dynamics and Global Connectivity: An Agent-based Modeling Approach. In *Proceedings of the 2010 Winter Simulation Conference*. December 5-8, 2010. Baltimore, MD., pp. 773-740. (**Iran)**

Student Advising

Jan Nalaskowski - *Dynamics of Chain Revolution Processes (**Arab Spring**)*
Brent Morrrow – *Assessing Impact of Surge in **Afghanistan*** MS
Brent Morrrow – *Assessing Sharia Law in **Afghanistan*** PhD
Alessandro Casapietra *– Hostage Intervention Strategy: Case Study **Lebanon***
Christopher Hartline – *US-Russian Response to Islamic Safe-haven in **Caucasus Region***

Questions?