Modeling Potentially Hostile Crowds to Explore Effects of IFCs and ROEs

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The Crowd Dynamics Modeling Group,
https://nps.edu/web/crowdmodeling

IFCs and Crowds

- Effectiveness of IFCs in support of the mission varies with crowd behavior
- Responses of crowds to the use of IFCs is complex and difficult to predict
- Aspects of identity and group membership influence crowd response, often unexpectedly
- Existing IFC effects models generally focus on effects of IFCs on individuals
- Crowd modeling research usually focuses on individuals or assumes the crowd behaves as a unified mob

The Social in Crowds

In Reality:

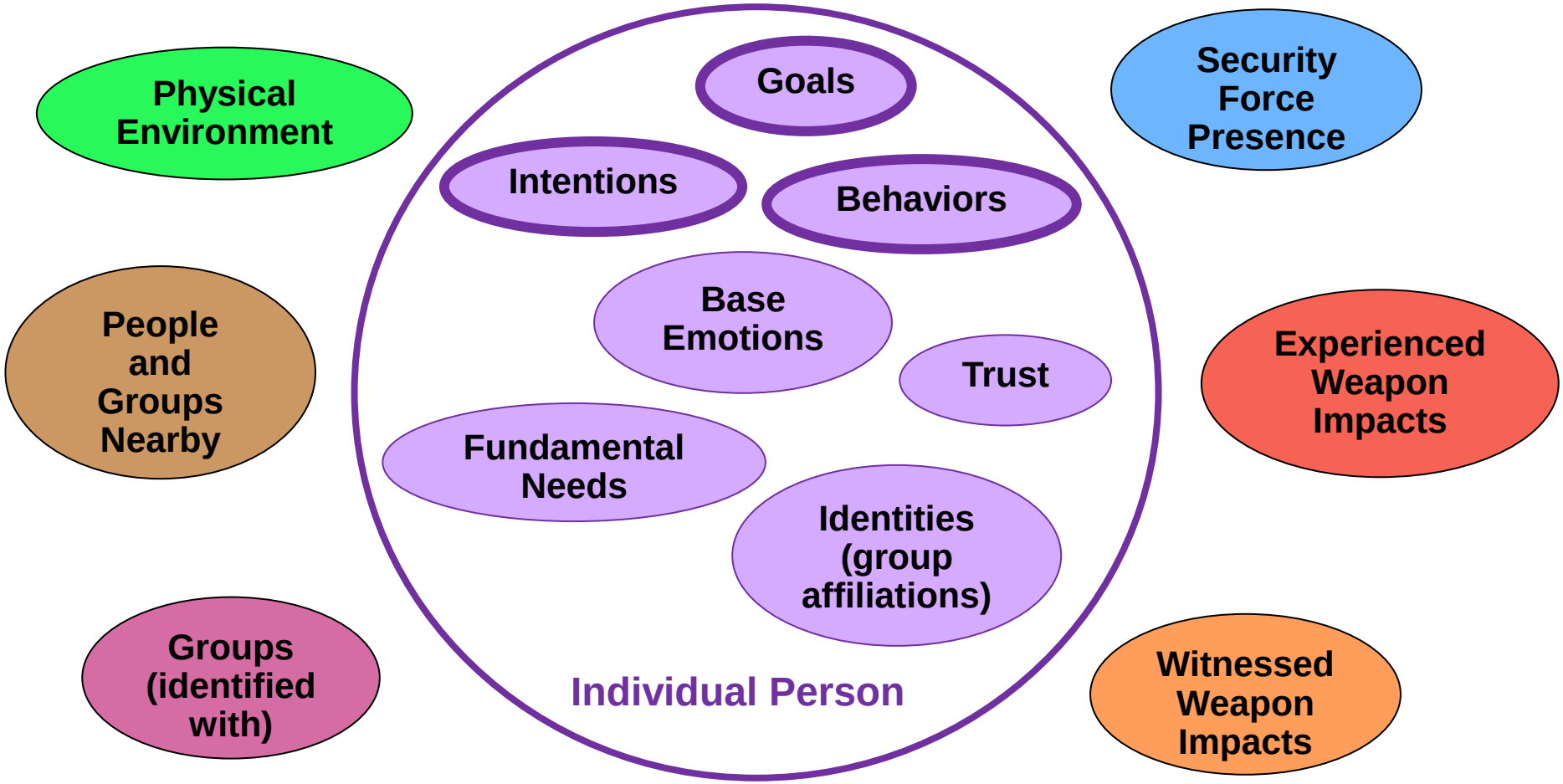
- Crowds composed of sub-groups or smaller social identity groups (SIGs)
- Individuals remain individuals in crowds but are influenced by others in their group as well as others nearby
- SIGs, can emerge in the crowd anew
- Group members stay together, live/die together in the crowd unless very compelling reasons arise to leave the group
- People's actions affected by SIG and attitude toward forces
- IFCs affect not just the individual directly impacted, but also those who witness the impact
- Individual assessment of IFC impact depends on who is hit and their perceptions of that individual

Social Dynamics in Crowds

To understand and model crowds, need to:

- Use a multi-agent model; including both individual & SIG behavior
- Break down by different types participants – gender, ageNeed to model SIGs as dynamic agents
- Include effects of SIG on member individual as well as social effects of nearby individuals and groups
- Include intentional and unintentional weapons effects
- Track attitudes/beliefs toward authority & security forces
- Represent a variety of beliefs and objectives of individuals within crowd that change dynamically

Factors Influencing Human Behavior



Agent-Based Simulation Modeling

- ‘Bottom-up’ modeling method:
  - decision-makers are individual agents
  - agents act independently of each other
  - agents are influenced by interactions with other agents
- Crowd behavior emerges as a result of individual agent actions and interactions
- Can include random, stochastic elements to more accurately simulate reality
- Best simulation method for modeling human behavior

WRENCH

Workbench for refining Rules of Engagement against Crowd Hostiles:

- Is the agent-based simulation model we have developed and coded in NetLogo (a top agent-based modeling platform);
- Explicitly models:
  - individual people, social identity groups, and security force members as independent agents,
  - who interact in a physical environment designed using GIS data,
  - where security forces can use intermediate force capabilities according to specified rules of engagement in response to hostile crowds.

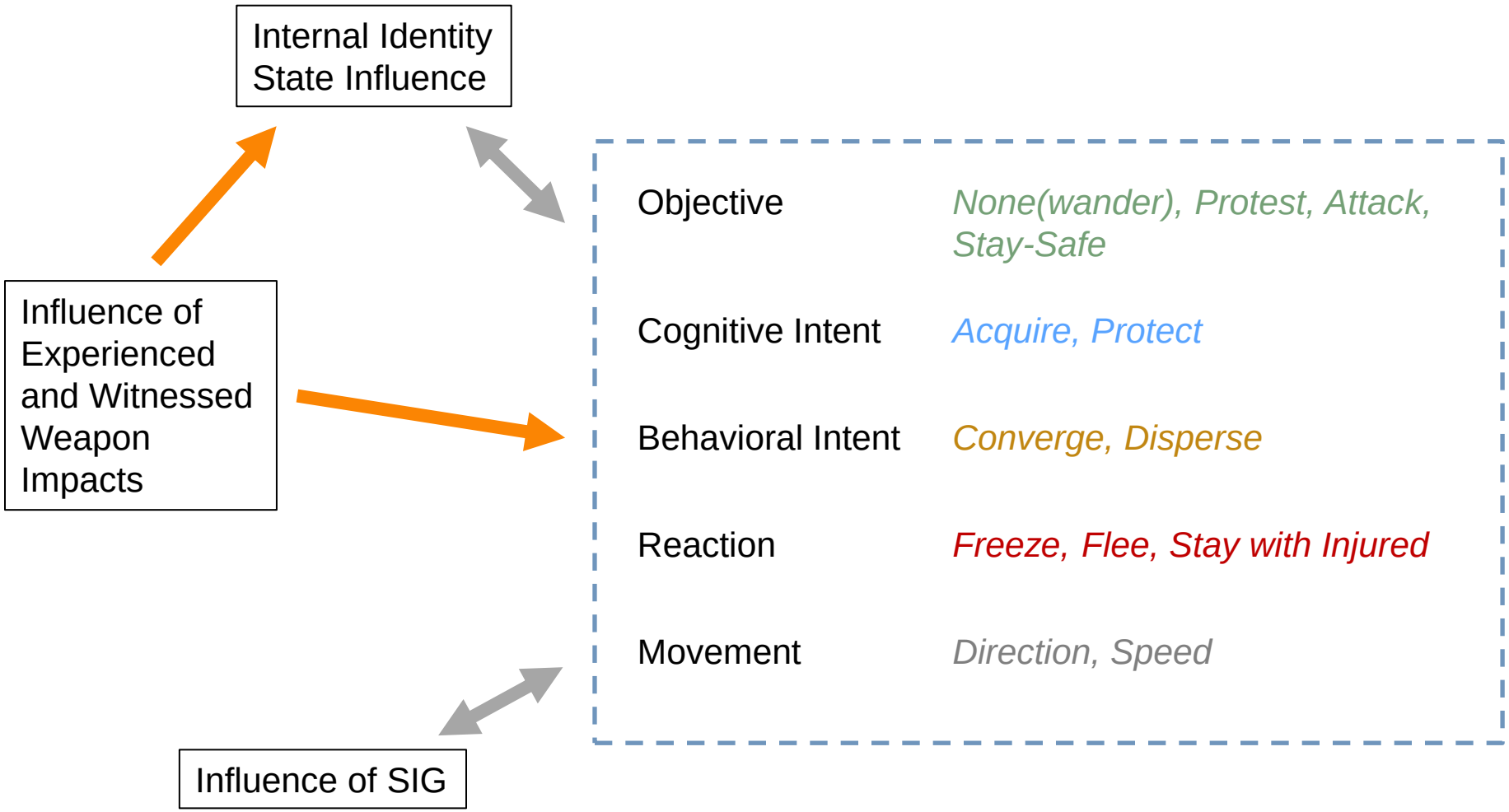
WRENCH

- Incorporates multiple aspects of PMESII-PT

  (Political, Military, Economic, Social, Information, Infrastructure, Physical environment, and Time)

- WRENCH explicitly models:
  - Military force structure, activities, ROEs and use of IFCs
  - Social needs and desires of individuals, dynamic SIG membership, emotional contagion, etc.
  - Information communicated among SIG members and within Security Force structure
  - Physical environment designed using GIS data, person and vehicle movement influenced by other people and buildings/roads, consideration of line-of-sight, etc.
  - Time with one second time-steps, communication and decision delays, movement happening over time, etc.

Individual Cognition and Behavior



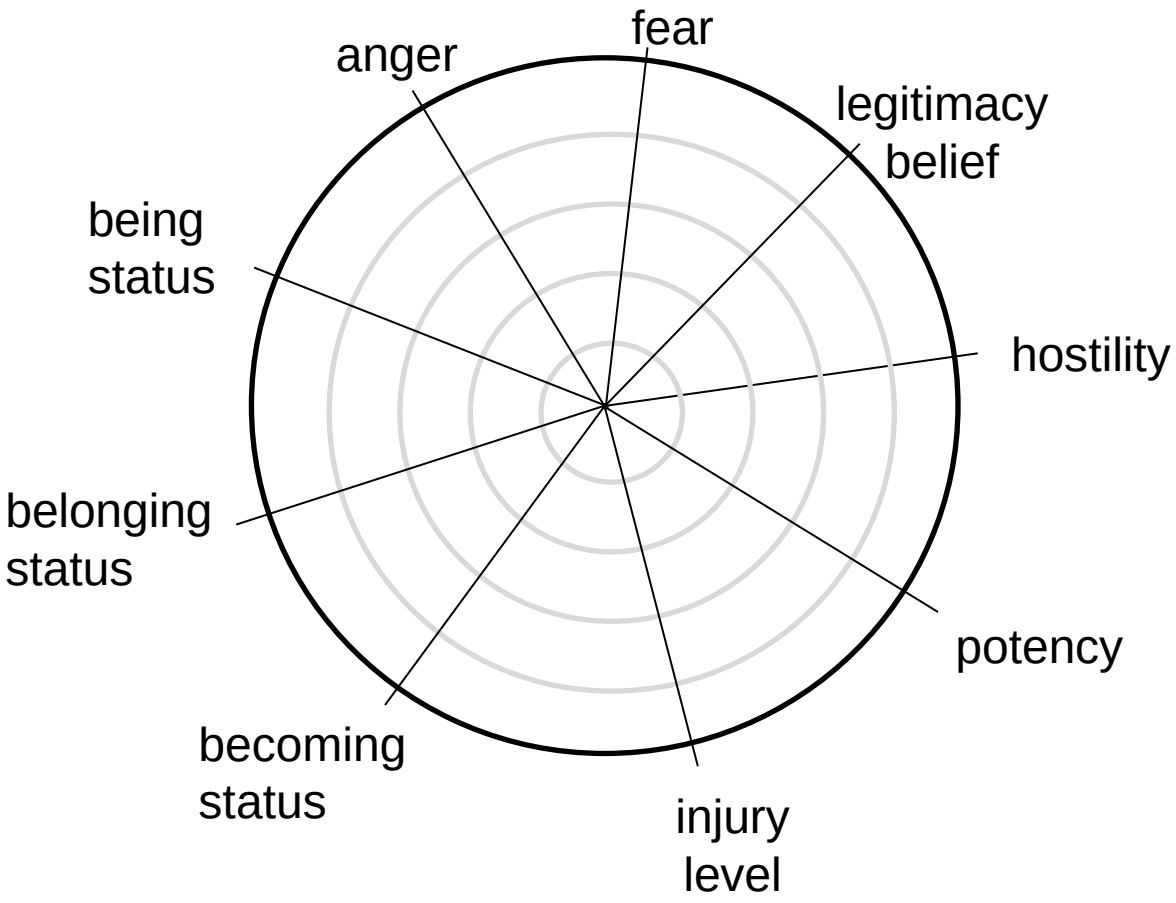
Individual People

Objective:

- None (wander)
- Protest
- Attack
- Stay safe

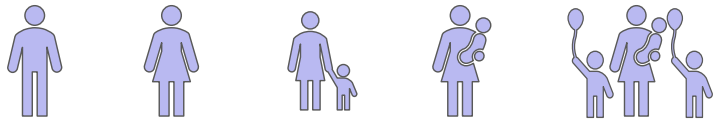
Intentional State

Behavioral State



Individuals and SIGs

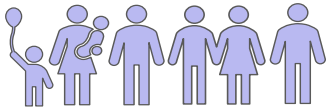
Individual (person with level 0 identity): man, woman, or mother with kid(s)



Family SIGs (level 1):

Nuclear Family: man and mother with kid(s)

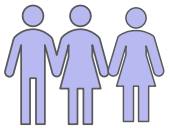
Mid Family: mother with kid(s) and 1-4 other Mid or young adults



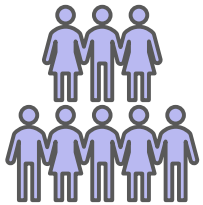
(Inter)generational Family: mother with kid(s) and 5-9 other adults of any age

Social SIGs (level 1):

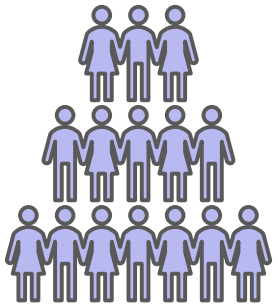
Small: 2-5 Adults of any age



Medium: 6-10 Adults of any age

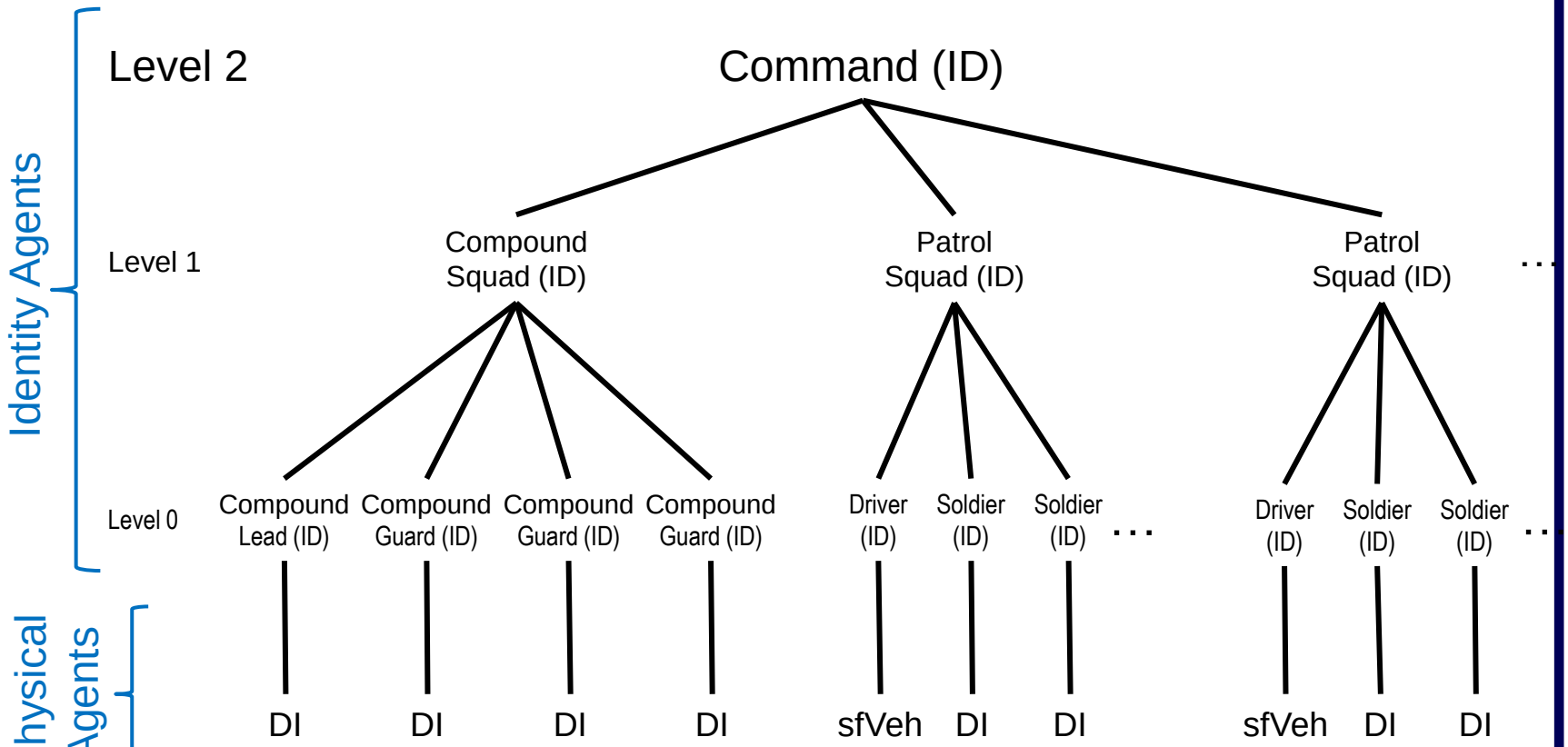


Large: 11-20 Adults of any age



Social SIGs may form based on age, gender, or ideology

Security Force

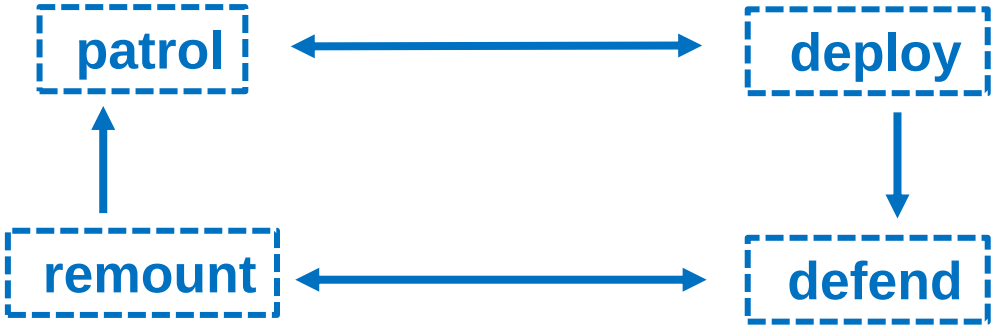


Key		
	ID:	Identity
	DI:	Dismounted Infantryman
	sfVeh:	Patrol Vehicle

Security Force

Compound Squad

Patrol Squads



Security Force

SF engagement decision-making:

- Discerning Hostile Intents -> Threat Assessment
- Deciding which threat to address -> Target selection
- Deciding method of engagement -> Weapon selection

Tactical ROEs specify target selection and weapon selection rules

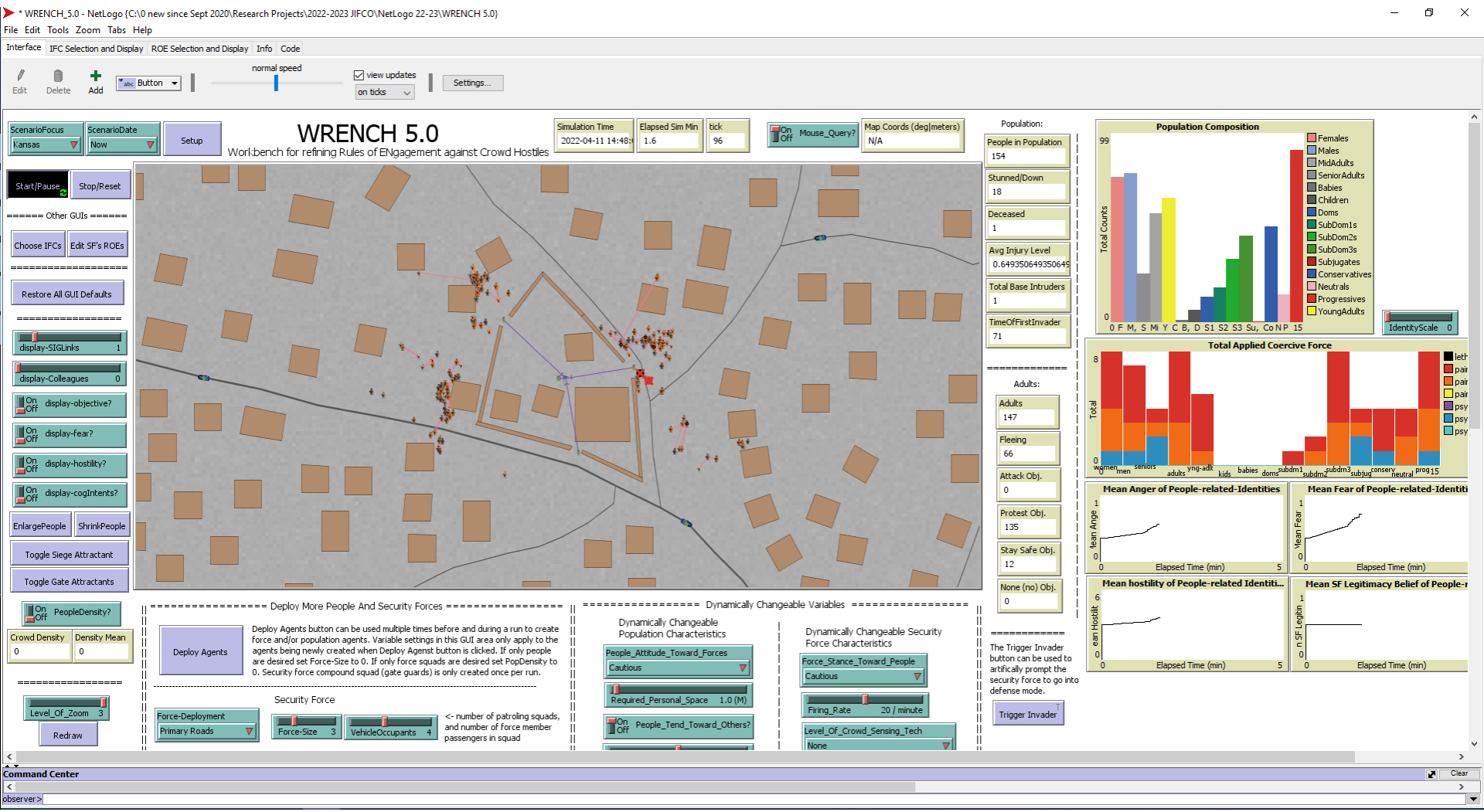
WRENCH User Interfaces

WRENCH has three user interfaces:

- Main interface:
  - animation screen
  - sliders, menus and switches to control aspects of:
    - security forces configuration and operating characteristics,
    - population demographics and attitudes, and
    - social identity group composition
- IFC selection interface allowing choice of which IFCs forces have, also provides information on each IFC
- Tactical ROE selection interface allowing design of custom ROEs

WRENCH Main Interface

Gate guards initiating defense during run



Experimentation with WRENCH

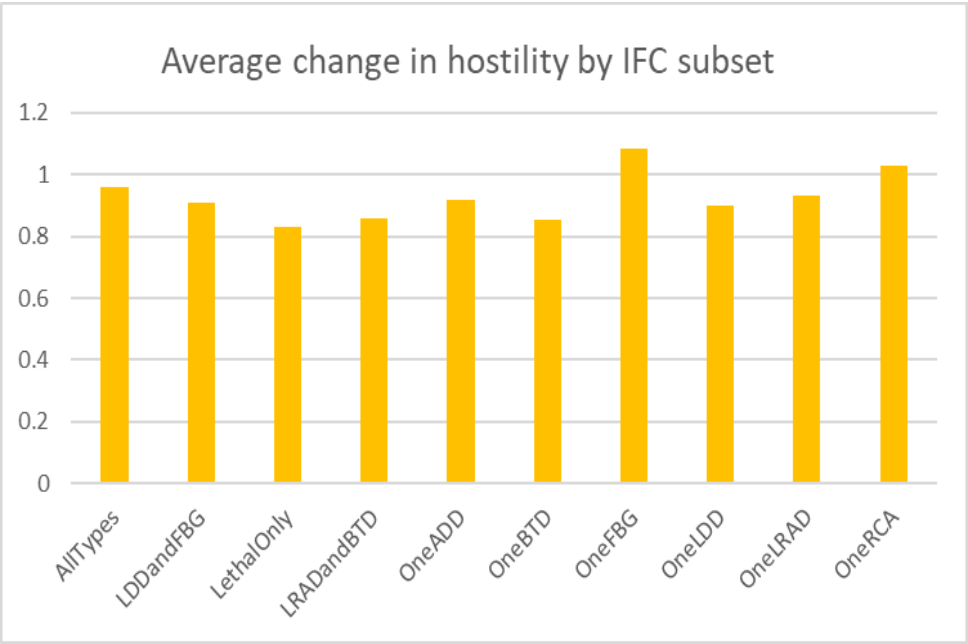
- WRENCH can also be run in a ‘headless’ mode to facilitate experimentation using data farming methods
- Efficient experimental designs test many input and software parameters, over many levels, to produce a wealth of data
- Some key output metrics for WRENCH include:
  - frequency of security force use of IFCs
  - severity levels of IFCs used
  - People’s current hostility
  - People’s objectives
  - People’s anger levels
  - People’s fear levels
  - Change in people’s beliefs about the legitimacy of the security forces

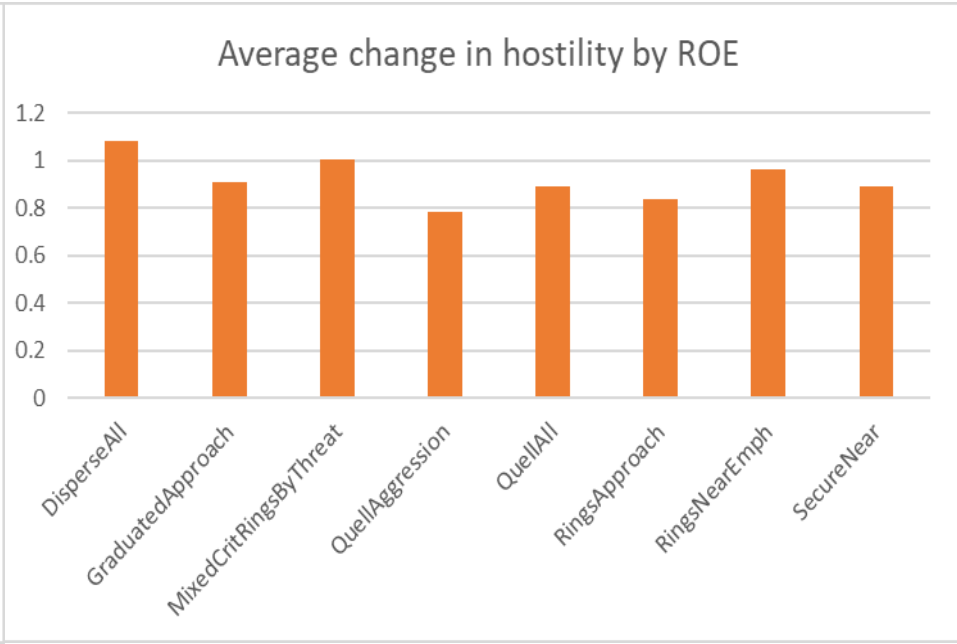
operational implications?

strategic implications?

Select Experiment 6 Results: change in hostility

- Average change in people's hostility depending on subset of IFCs used
- Average change in people's hostility depending on ROE used

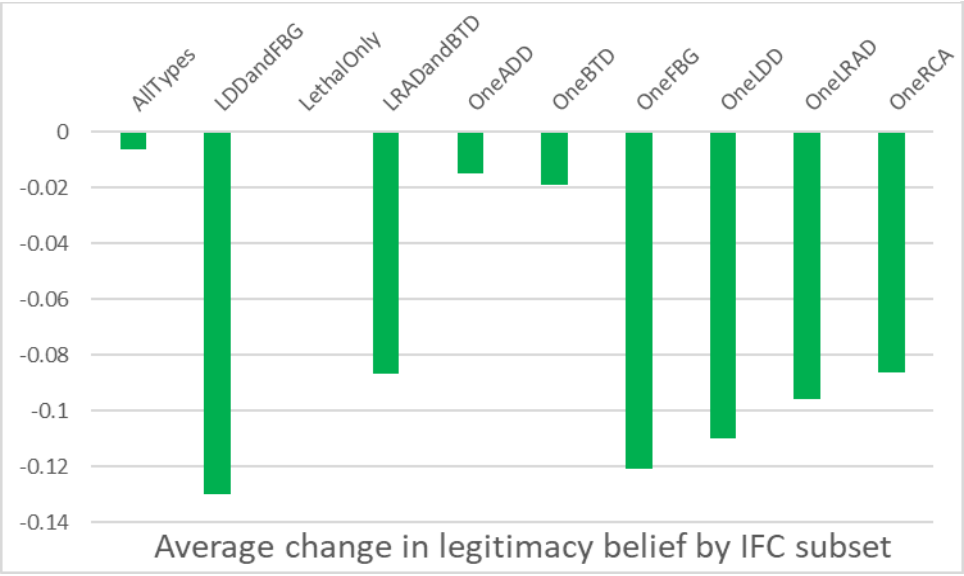


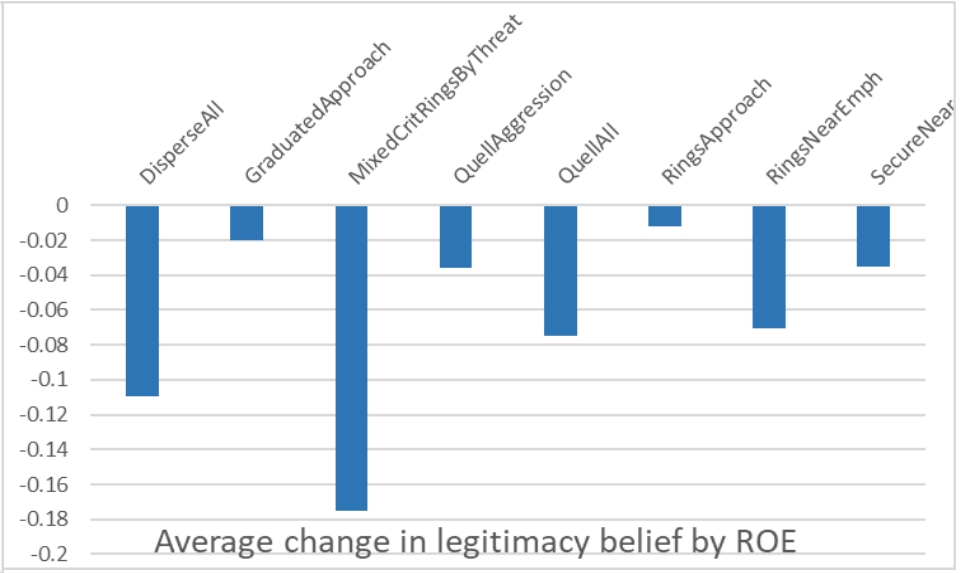


Time-series data shows larger hostility changes (rise then fall)

Select Experiment 6 Results: change in legitimacy beliefs

- Average change in people's legitimacy beliefs depending on subset of IFCs used
- Average change in people's legitimacy beliefs depending on ROE used

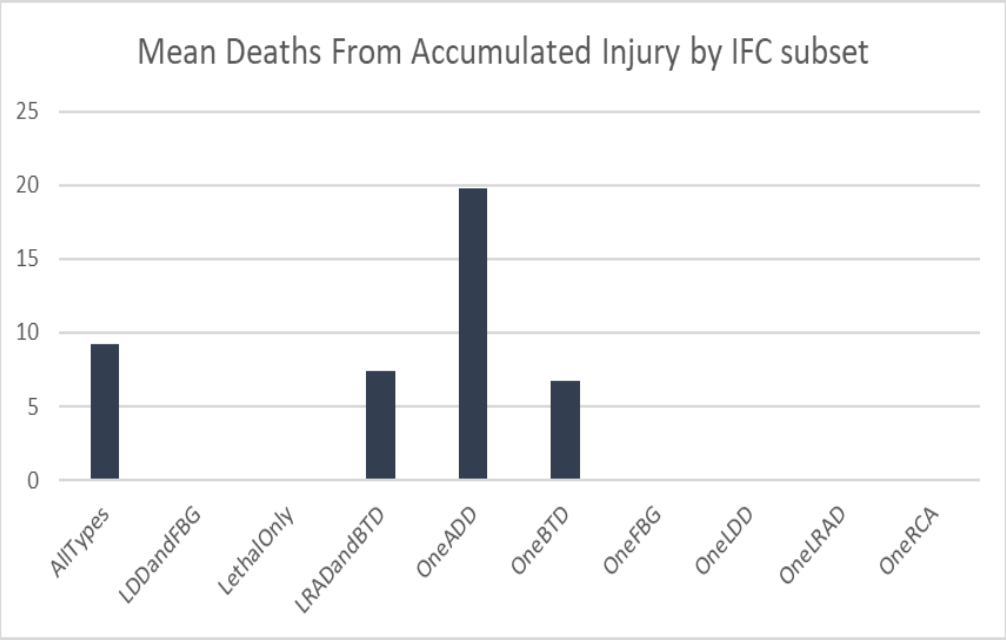


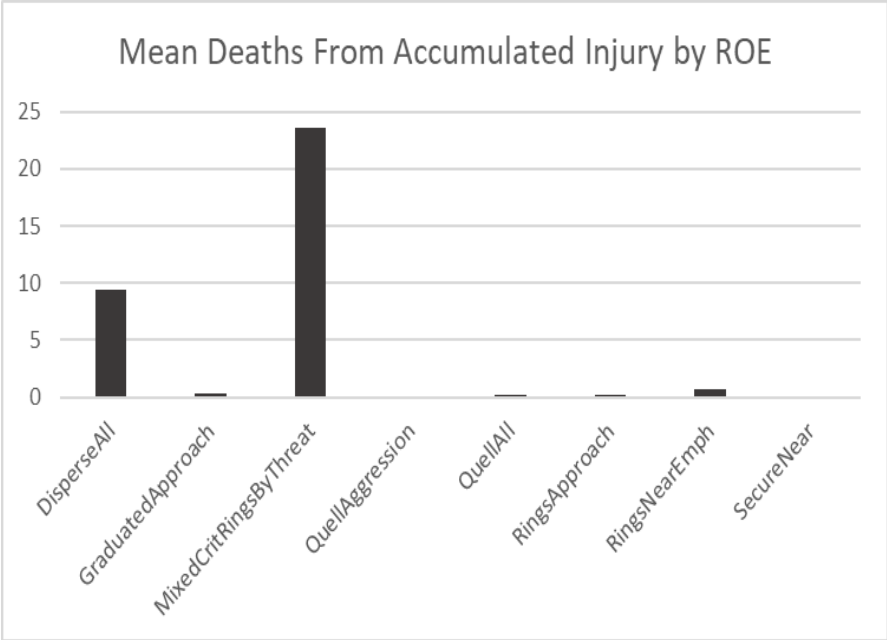


Legitimacy beliefs didn't decrease in all cases, just when averaged

Select Experiment 6 Results: number of unintended deaths

- Average number of deaths due to accumulated injury depending on subset of IFCs used
- Average number of deaths due to accumulated injury depending on ROE used

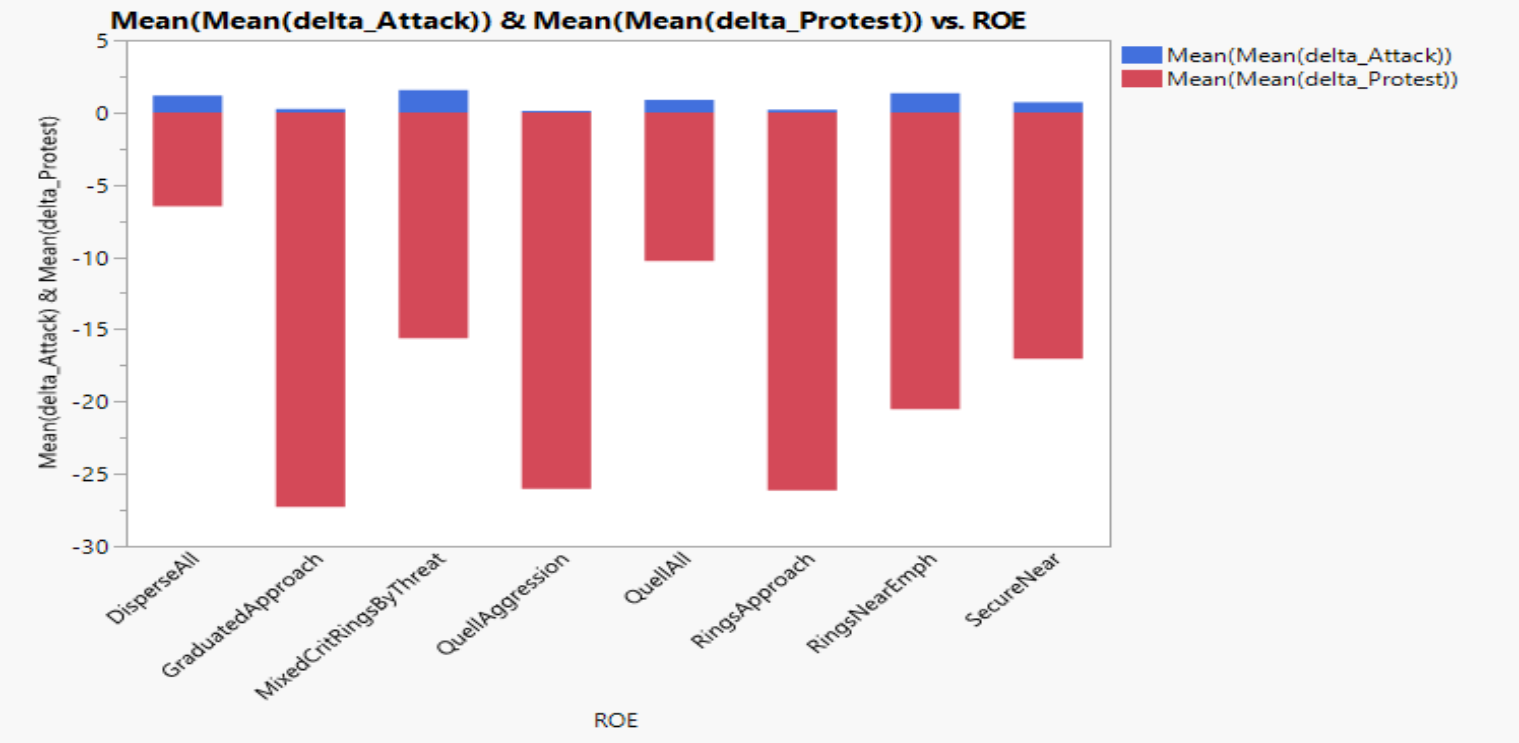




In WRENCH code only the more severe IFCs can cause an accumulated death (i.e. tip a Person from injured to dead)

Select Experiment 6 Results: change in objectives

- Average change in the number of people with an Attack objective (blue) depending on ROE used
- Average change in the number of people with a Protest objective (red) depending on ROE used



Select Experiment 6 Results: change in objectives

- Average change in the number of people with an Attack objective (blue) depending on subset of IFCs used
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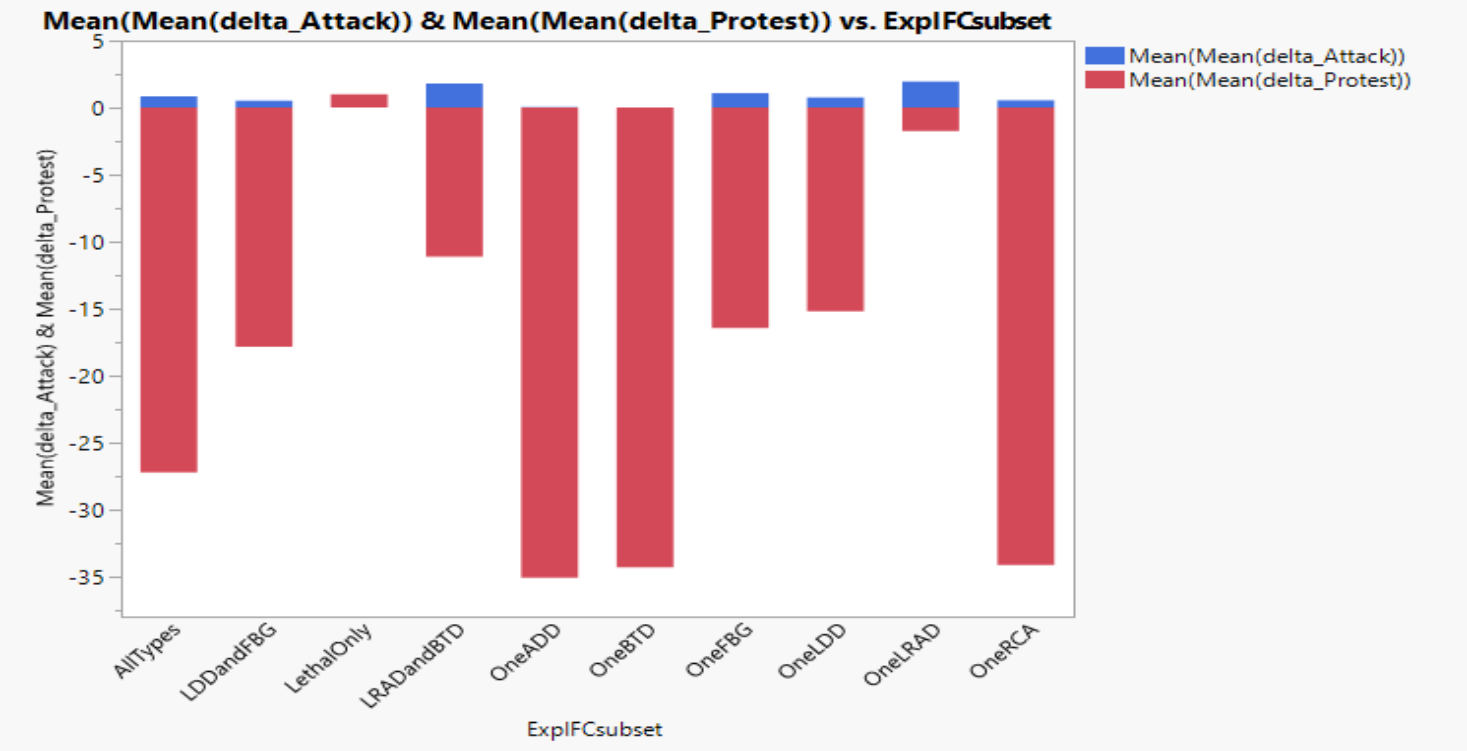


Future Plans

- Continue researching, testing, and experimentation to improve validity
- Ongoing research into IFC and ROE effects
- Enhance various aspects of model
  - force member psychological drivers, identity dynamics and will to fight
  - enhance needs modeling of people and resource acquisition behaviors
  - incorporate latest social research on crowd adaptation, e.g. post-traumatic growth
- Inform combat models such as COMBATXXI (NRP proposal)
- Assist other research organizations per sponsor's request
- Acquire new sponsors to explore additional use cases

Interdisciplinary Research Team

Dr. Susan K. Aros, DDM (co-lead)
Operations research, agent-based simulation, psychology

Dr. Anne Marie Baylouny, NSA (co-lead)
Social movement theory, crowd dynamics

Dr. Anshu Chatterjee, NSA
Social movements, case studies

Dr. Deborah Gibbons, DDM
Psychology, cross-cultural social influences

Mr. Chris Ketponglard, NSA
Research associate, weapons effects research

Ms. Mary McDonald, SEED Center
Data farming, data analysis

Mr. Terry Norbraten, MOVES
Simulation, computer science

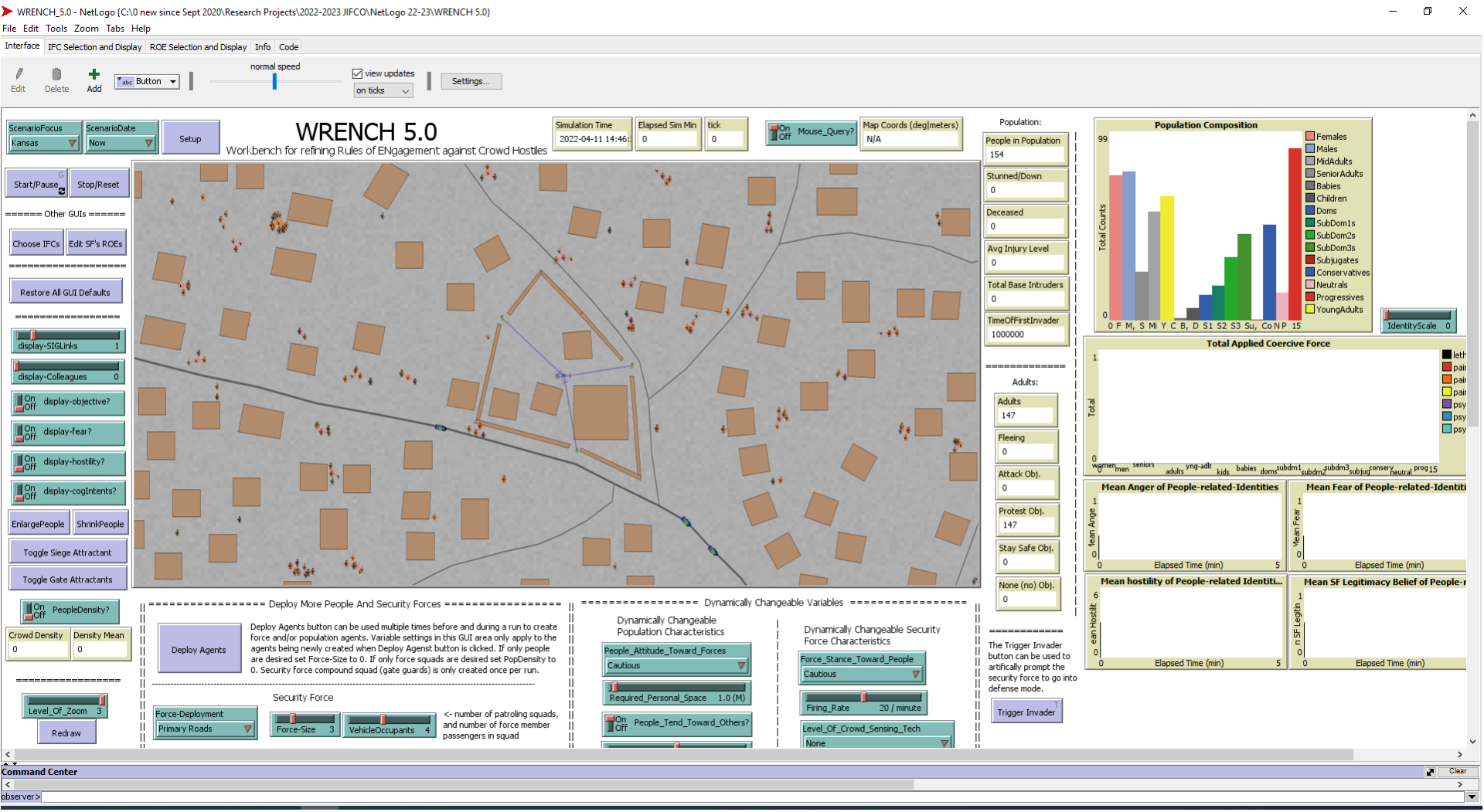
Dr. Susan Sanchez, SEED Center
Statistics, design of experiments (Co-Director of NPS SEED Center)

Mr. Steve Upton, SEED Center
Simulation, data farming

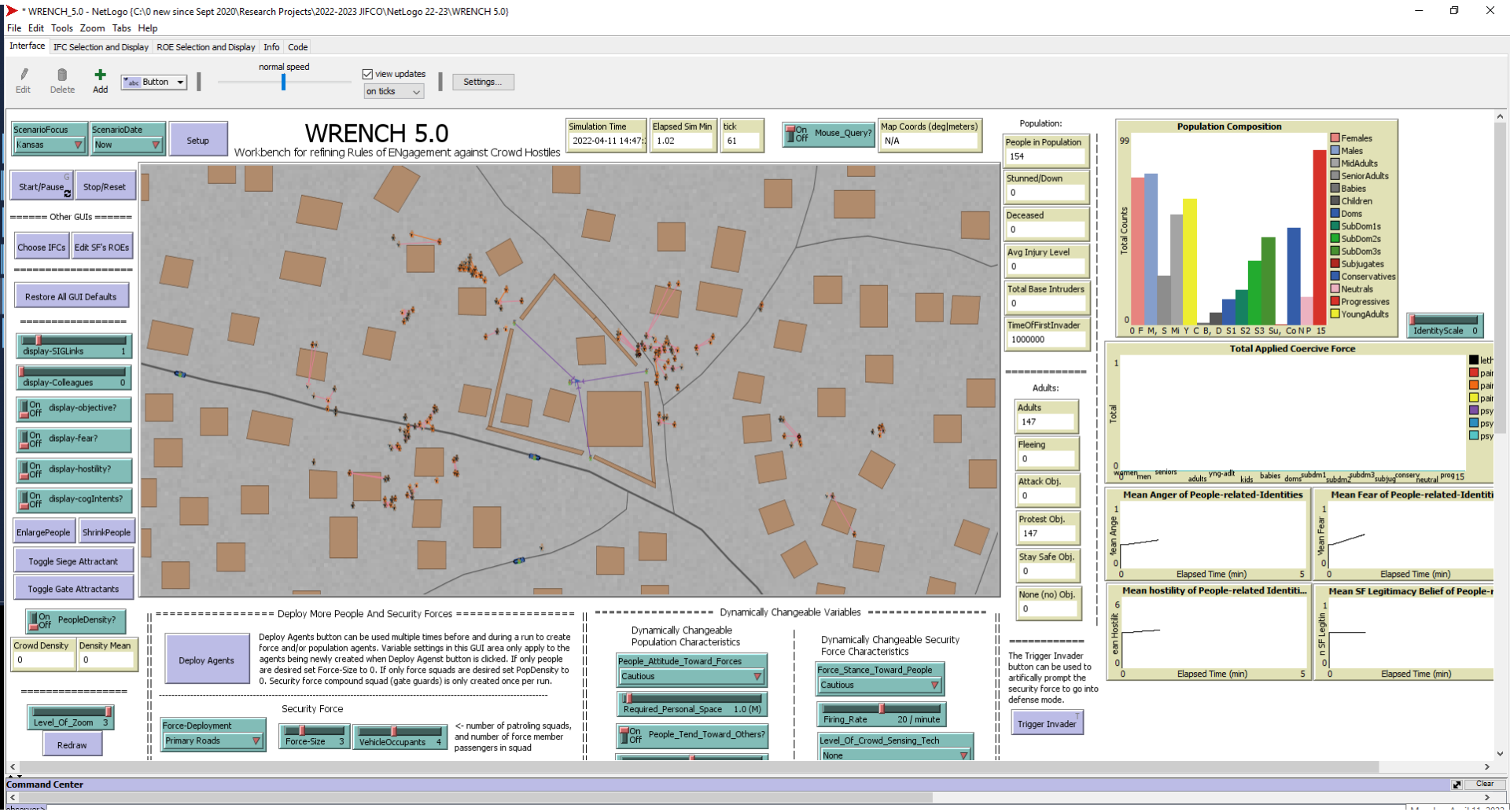
Dr. Matt Zefferman, DA
human culture, cooperation, and conflict, math modeling

Questions?

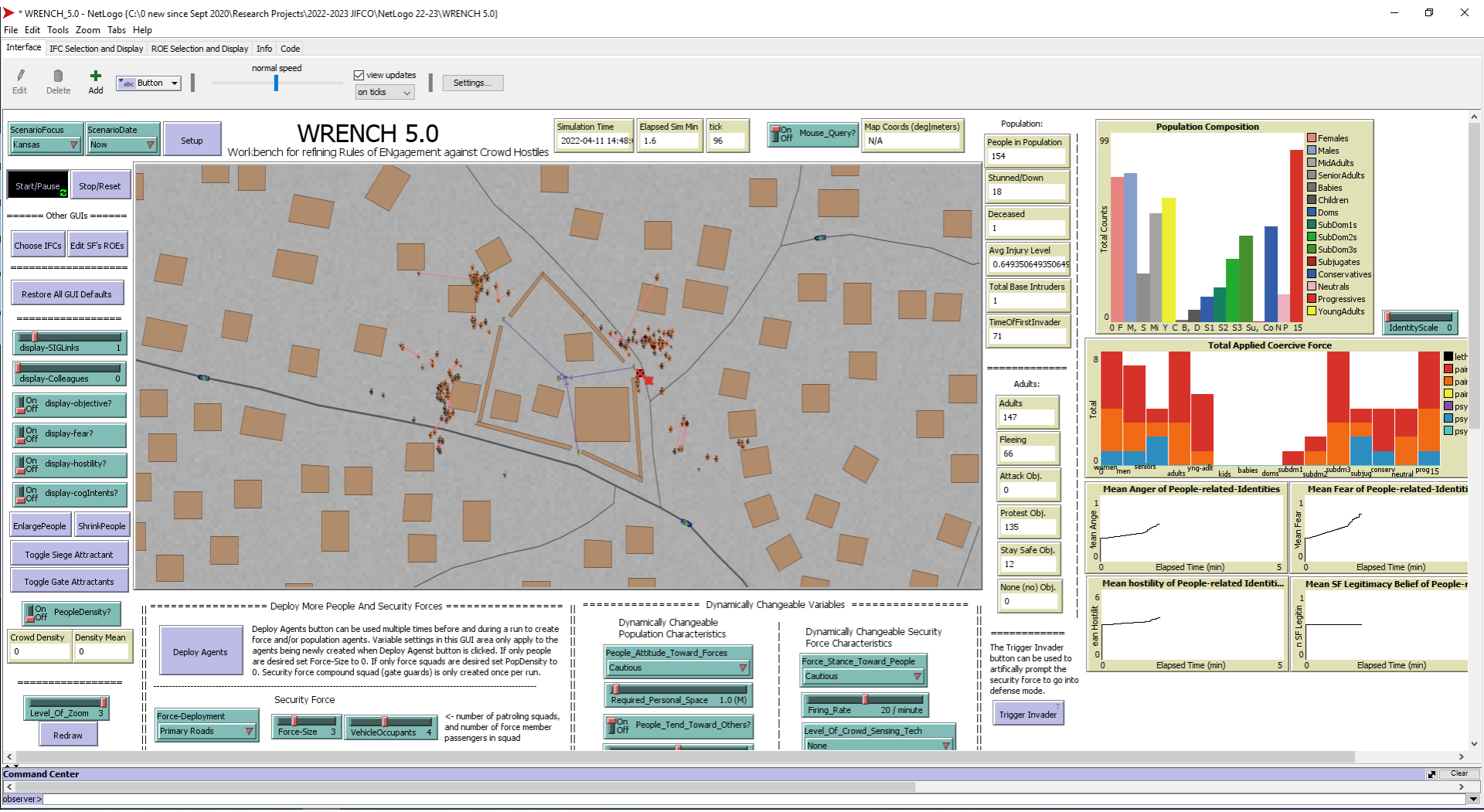
WRENCH Main Interface



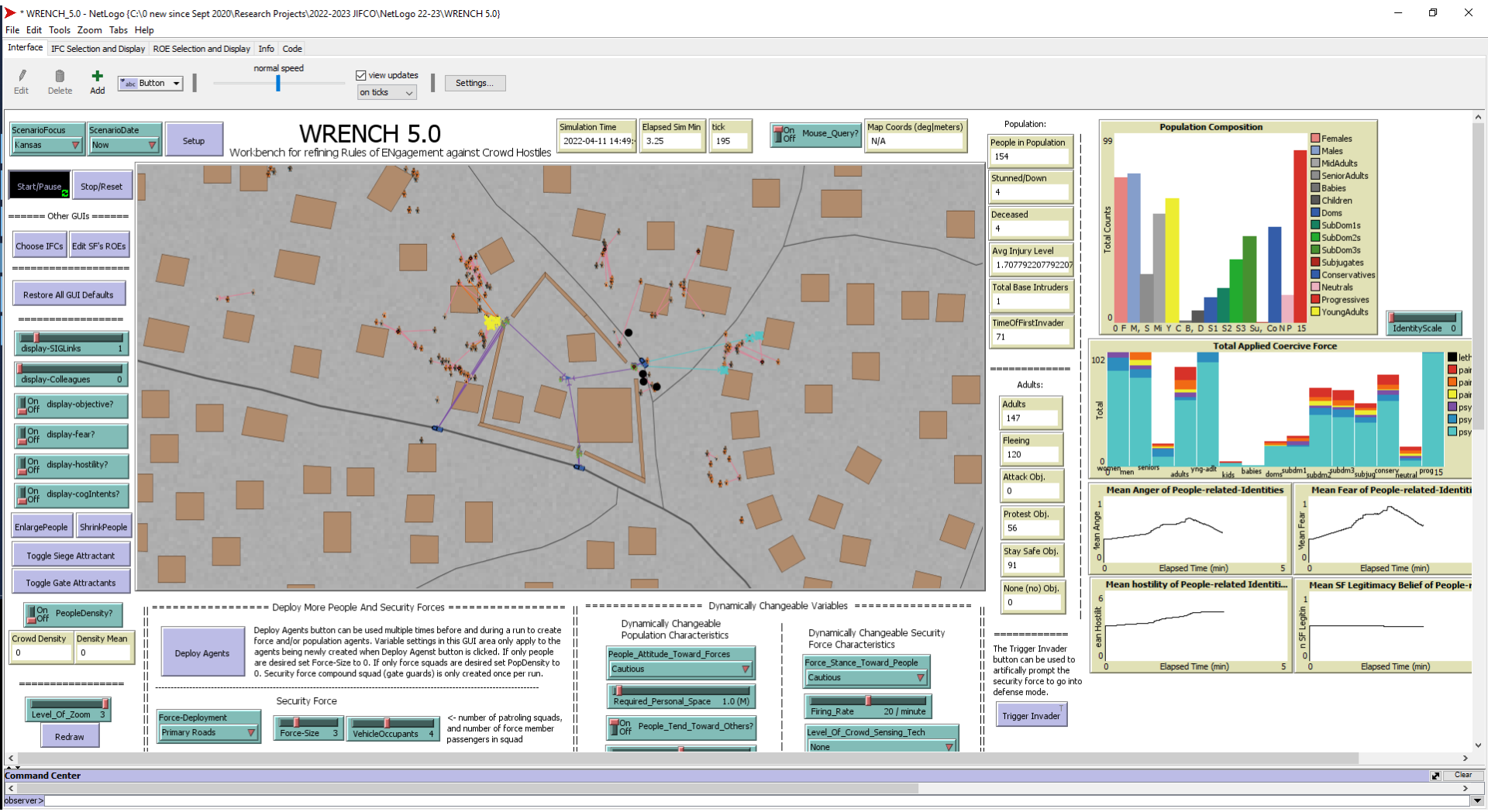
Interface During Run: People gathering to protest



Interface During Run: Gate guards begin defense



Interface During Run: Defense with patrolling squads at gates



Recent Publications

- Aros, Susan, Anne Marie Baylouny, Deborah E. Gibbons, and Mary McDonald, "Toward Better Management of Potentially Hostile Crowds," Winter Simulation Conference, December 14, 2021. *Peer-reviewed conference proceeding*.
- Baylouny, Anne Marie and Anshu Chatterjee, "The mob made me do it? Collective identity, agency, and crowd theories in the Capitol siege and Black Lives Matter protests," American Political Science Association conference, October 1, 2021. *Conference paper.*
- Baylouny and Aros, "Modeling protest-security forces dynamics: Agency, collective identities, and sub-groups in the Capitol Siege and BLM." presentation to International Studies Association conference, April 2, 2022, Nashville, TN. *Conference paper.*
- *Upcoming*: Baylouny, Anne Marie and Susan Aros. "Advances in Modeling Conflict Interaction Using Social Psychology," American Political Science Association Conference, Montreal, Canada, September 2022. *Conference paper.*

Recent Presentations

- Aros, “Complex Agent Based Simulation for Management of Potentially Hostile
  Crowds using IFCs,” presentation to the Military Operations Research Society Emerging Techniques Forum, December 7, 2021.
- Aros, “Workbench for refining Rules of Engagement against Crowd Hostiles”, presentation to the NATO Modeling and Simulation Group MSG-198, December 22, 2021.
- *Upcoming*: Aros, Susan. “Modeling Potentially Hostile Crowds” presentation to the 90th Military Operations Research Society Symposium, as part of the Human Behavior and Performance Community of Practice Session. conference, June, 2022.