Sociocultural Modeling in the Social Identity Look-Ahead Simulation and the Green Country Model

Nathan D. Bos, Ariel M. Greenberg, Jonathon J. Kopecky, Alex G. Ihde, and Scott D. Simpkins

Models of human dynamics on a national scale are a current area of research interest. High-quality models could improve the nation's ability to manage social and political conflicts, win counterinsurgency struggles, conduct peacekeeping missions, and even prevent conflicts before they begin. Such models can potentially be used for research, policy, training, and prediction. However, validation is particularly difficult because of the complexity of the domain and nascent state of research. Types of validation include grounding, calibration, and verification. This article describes two current APL efforts: the Social Identity Look-Ahead Simulation (SILAS) and the Green Country Model (GCM). SILAS is a research tool focused on simulating social identity conflicts within a nation, with Nigeria used as a test case. GCM is a policy exercise (a "wargame") that simulates civilian (Green) effects in a Red-versus-Blue conflict. This article describes usage of these models and efforts at validation, including grounding, calibration, and verification, for each model.

INTRODUCTION

The emphasis on the role of human dynamics in warfare is increasing, as highlighted in a recent Defense Sciences Board report:

> Wars are won as much by creating alliances, leveraging nonmilitary advantages, reading intentions, building trust, converting opinions, and managing perceptions—all these tasks demand an exceptional ability to understand people, their culture, and their motivation.
>
> —Major General Robert H. Scales,[1] quoted in Defense Sciences Board report *Understanding Human Dynamics*[2]

Human dynamics is a broad term that draws on a wide range of academic disciplines, including psychology, sociology, anthropology, political science, and economics. In the past, the military's interest in the behavioral sciences was primarily internally focused on issues such as leadership, unit cohesion, command and control, etc. Recently, there has been a more external focus on understanding adversaries and civilian populations and a desire to improve how the military conducts operations in the areas of counterinsurgency, asymmetric warfare, and peacekeeping operations. Modeling is potentially one method by which this understanding can be expanded.

During the last 2 years, APL has done a cluster of research projects set in the country of Nigeria (as well as a number of projects in other settings). Nigeria was chosen for the two projects discussed in this article because of both its strategic importance and its interesting complexity. Nigeria is the most populous country in Africa and often takes a leadership role throughout that continent; it has been called the linchpin of West Africa. Nigeria is also a major oil exporter to the United States and an important emerging market for China and other international powers. In addition, Nigeria has significant internal conflicts, including an active insurgency in the southern oil-producing region as well as other ethnic and religious tensions that affect national politics. This article examines the Social Identity Look-Ahead Simulation (SILAS) project and the Green Country Model (GCM) as examples of work in the area of sociocultural modeling.

PURPOSES OF MODELS

Sociocultural models have a number of applications. Three examples are described in the following paragraphs: research and discovery models, policy and training exercises, and prediction models.

Research and Discovery Models

Models are sometimes developed because the process of development is also a process of scientific discovery. The end product of these models is increased theoretical understanding. Researchers in the behavioral sciences have for many years used theoretical models, often represented by concept maps or more formalized regression path models. Taking the next step of turning a concept map into a usable software model requires filling in a large number of assumptions and specifying relationships more precisely, actions that push theory and data collection forward. Models may also be particularly useful in connecting theories on different scales. Modelers such as Salzarulo[3] have had some success in programming agents to follow rules of individual behavior and observing larger-scale interactions that match prior observations.

Senge[4] advocated an interesting use of research and discovery models based on the observation that the people who learn the most from models are usually the builders, not the users. Senge proposed having decision makers, not just researchers, co-create models they will use. The process of model building forces people to make their tacit judgments explicit, requires divergent views to be reconciled, and helps to build shared understanding. Models can serve as "boundary objects" that help experts cross disciplinary boundaries.

Policy and Training Exercises

Simulations and wargames have a well-established place in the military, probably more so than in any other domain. Wargames help decision makers play out different courses of action, anticipate likely counteractions of opposing or neutral forces, and practice making rapid decisions when embedded in complex situations. Kinetic wargames are well established; nonkinetic wargames for counterinsurgency, asymmetric warfare, and peacekeeping are still evolving. Two good examples of projects in this area are the Institute for Creative Technologies' Cultural and Cognitive Combat Immersive Trainer[5] and UrbanSim.[6]

Prediction Models

Many model builders aspire to recreate the world with such fidelity that models can make accurate predictions about future states of the world. Some relatively simple prediction systems already exist. For example, pre-election political polling is somewhat reliable, although in this case the modeling is fairly simple, and the power of the prediction is in the breadth and accuracy of the data sample. Economic forecasting also generally does better than chance, although these models usually have a strong human-in-the-loop component (see Ref. 7 for a review). Recent economic events also remind would-be predictors of the power of unlikely but highly disruptive events, which Taleb[8] called "Black Swan" events, to quickly make obsolete even well-grounded predictions. There are some claimed successes in more difficult areas of prediction; currently, Mesquita's[9] models have been able to predict decisions, such as leader succession choices, of small oligarchies in limited situations where it is possible to estimate the preferences and influence of each stakeholder. However, the complexity of most sociocultural settings keeps prediction in the realm of aspiration for most current work.

MODEL VALIDATION

Because models have difficulty proving themselves by prediction, other means of assuring their quality, usefulness, and validity are needed. Carley[10] provides a useful framework for thinking broadly about types of data-based evidence that can be given for models.

Grounding

Grounding, as described by Carley, "is generally used for establishing the face validity of a model and sometimes its parameter or process validity." Face validity refers to how the model appears to users and nondevelopers; parameter and process validity mean what the names suggest. For our purposes, grounding often means finding starting values and reasonable ranges for variables that are taken from the real world in some form.

Calibration

Calibration is "the process of tuning a model to fit detailed real data."[10] Calibration is focused on testing the internal consistency of the model and adjusting parameters to achieve internal coherence. The more complex and ambitious the model, the more calibration will be needed to ensure that effects that may be well thought out and well grounded individually will also interact appropriately with each other. Poorly calibrated models tend to be unreasonably volatile, unstable realistically, or to move toward extreme states. Outside data sources may be used in calibration but are not the focus.

Verification

Verification is the process of testing a model against external data. At this stage models are usually asked to make "predictions." The word prediction here is used in the statistical sense: a model is run to produce a dataset that is then compared to known parameters. "Weak" predictions involve comparing to a dataset or data type that is close to the ones used for grounding. A "strong" prediction would be testing a model against a different dataset. And of course the strongest type of prediction, and an ultimate goal of the most ambitious sociocultural models, is to make predictions for things that have not yet occurred, such as a regime changes, social movements, or economic crises.

In the absence of quantitative data, verification is also sometimes done with subject-matter experts. Experts are asked to judge a model's output for plausibility. Verification by multiple experts is preferable to verification by single experts. Methods such as the analytical hierarchy process (AHP) are sometimes used to formalize the process of combining expertise on model judgments.[11] AHP breaks down judgments into a series of pairwise comparisons and then combines judgments within and across experts to derive ranked lists. AHP can also be used for grounding, because it is useful for transforming qualitative opinions into quantitative parameters.

Carley also discusses a fourth technique, harmonization, which is a multistep process that involves testing a model against both real data and other models, e.g., an agent-based model compared with a linear prediction model. In this article we do not differentiate harmonization from verification.

SOCIAL IDENTITY LOOK-AHEAD SIMULATION

SILAS is an attempt to model social identity conflicts and provide a mechanism to make statistical predictions about hypothetical conflicts that have not yet taken place.

In this context, "identity" refers to a person's collective identity. All individuals have a sense of belonging to multiple identity groups. Individuals can have many social identities along such dimensions as ethnicity, religion, politics, economics, and ideology, among others. Knowing an individual's identity affiliations can be the key to understanding attitudes and opinions, because individuals tend to adopt opinions compatible with their salient identity groups.[12–14] Identity can help explain the day-to-day behavior of individuals when rituals, mores, practices, or more subtle behavior patterns are associated with identity groups.[15] More important from the DoD's perspective, identity is a common and increasing source of post-Cold War political conflict. Tutsi versus Hutu violence in Rwanda, Sunni versus Shia violence in Baghdad, and Serb versus Bosniak violence in Bosnia and Herzegovina are a few recent examples of conflicts in which social identity (in addition to the usual political and economic factors) were critical causes of conflict. We developed SILAS because we believed that understanding the patterns of identity affiliations in a population is a key to understanding conflicts, both predicting where conflicts are most likely to occur and predicting how groups are likely to align in a conflict situation.

In Nigeria there are two key sources of identity conflict, religion and ethnicity; both are interrelated with each other and with political identities. (There are also important conflicts related to economics, particularly oil revenue, but these were not modeled because of lack of available data connecting Nigeria's oil-based conflict to social identity issues.) Although it is intended to be a general model, SILAS was developed with data from Nigeria.

A few factors make modeling social identity more difficult than simply tracking demographics. First, individuals tend to have multiple identity affiliations that interact with each other, and these identities overlap and conflict. In Nigeria, the three major ethnic groups have an imperfect alignment with religion. While most Hausas are Muslim, and most Igbo are Christian, the Yoruban ethnic group is split between Muslim and Christian. Yorubans and a number of smaller groups tend to form the swing votes in national politics, and understanding their changing patterns of political affiliations would be crucial for understanding political developments. Figure 1 shows the geographic distribution of Nigerian ethnic groups in our simulated population.

The second factor that makes identity modeling complex is that identities are flexible; they can be activated or not depending on circumstances. Conflict situations are often the triggers for identities to become activated (salient).

One of the provocative findings that motivated the model, shown in Fig. 2, is a change in ethnic identity salience among Nigerians at three points in time. This change was identified by using three Afrobarometer surveys of Nigeria,[16] which will be described in the *Validation* section. The figure is reproduced from a paper by Peter Lewis,[17] who is director of the Africa Studies pro-

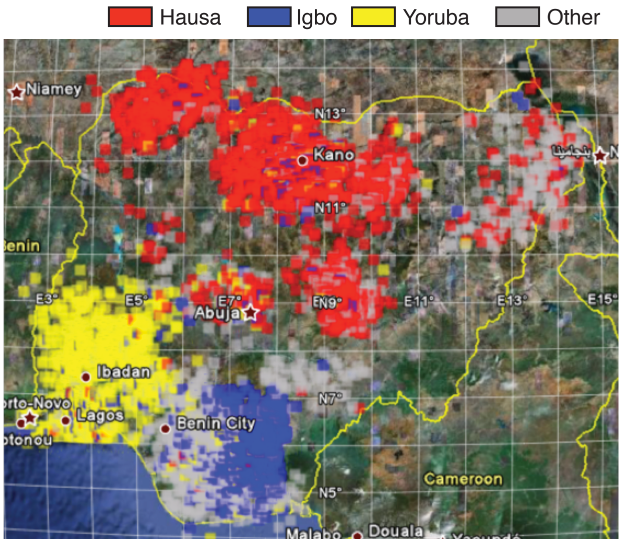


Figure 1. SILAS's simulated population of Nigeria, color-coded by ethnicity.

gram at the Johns Hopkins School of Advanced International Studies and who assisted with the SILAS project. The figure shows changes in answers to a question about social identity administered as part of the Afrobarometer surveys in 1999–2000, 2001, and 2003. The exact question is shown in the appendix to this article.

In Fig. 2, the percentages (y axis) refer to the number of respondents who listed an ethnic identity as their strongest identity group, ahead of other alternatives such as political, religious, or professional identities. The V-shaped patterns in each curve indicate relatively large fluctuations in the salience of ethnic identity between surveys.

What would lead to such a large-scale change in identity salience over a relatively short timescale? Lewis's hypothesis is that the national elections that took place in 1999 and 2003 served to "activate" ethnic identities to higher levels than in off-election years such as 2001. In Nigeria, national elections have often been framed as contests between major ethnic groups, leading to a strong association between ethnicity and politics.

The goal of SILAS was to make a model that would predict how agents in the model would align in such conflict situations. We developed a two-level model that included both individual agents and abstracted identity groups, with networks of associations between them. The human agents are a fairly typical agent-based model of 3300 simulated Nigerians (shown in Fig. 1), based on Afrobarometer[16] data for 2001.

The second level, which is the most unique feature of SILAS compared with peer models, is an association of ethnic, political, and religious groups (Fig. 3). The third row of the model (unlabeled) includes the specific ethnic, political, and religious identity groups in the model. These groups are connected by links with a

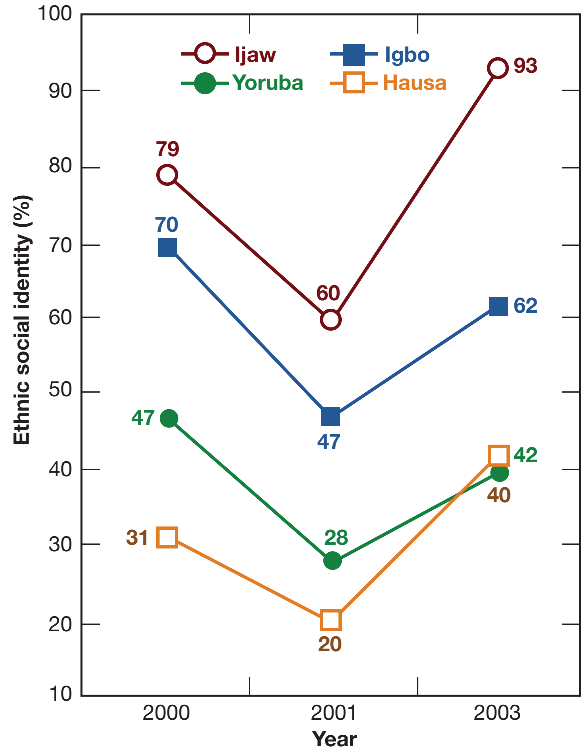


Figure 2. Changes in ethnic social identity salience (as indicated by language group) in Nigeria. (Reproduced with permission from Ref. 17.)

weight equal to the rate of co-membership between the groups in the Afrobarometer dataset above minimum thresholds for group size and co-membership percentage. So, for example, the "affinity" between the Hausa ethnic group identity and the Muslim religion was set to correspond to the percent of Hausa Afrobarometer respondents who were Muslim.

This was an asymmetric network, meaning that the strength of association from one group (e.g., from the Muslim religious identity to the Hausa ethnic identity) is separate from the strength of association in the other direction (from Hausa ethnic identity to the Muslim religious identity). This asymmetry was necessary because of the different group sizes; for example, a small ethnic group might be almost 100% affiliated with a certain religion (e.g., Catholic) but still make up only a small percentage of the nation's Catholics. Thus, that ethnic group would be expected to be strongly influenced by Catholic-relevant issues, but the nation's Catholics as a whole would not necessarily be strongly influenced by issues relevant to the small ethnic group.

Each individual in the model was affiliated with multiple identity groups, usually with one ethnic, one religious, and one political affiliation. Figure 4 shows one individual (at the far right) and the network of identities to which that individual is connected either directly (one "hop") or separated by one identity (two hops). As

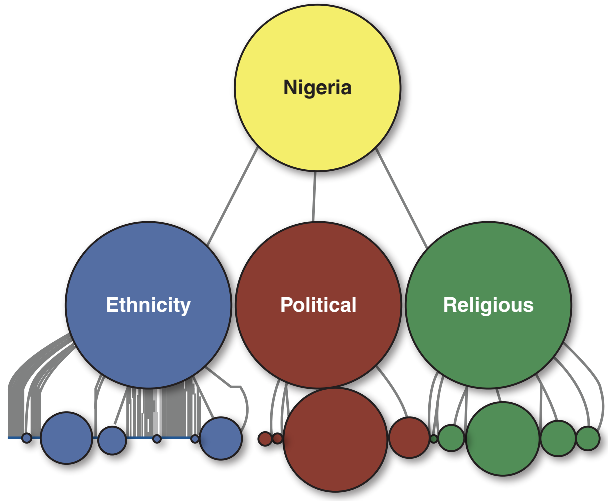


Figure 3. Abstracted identity objects in the SILAS Nigeria model.

and will weigh the level of each message to determine where they stand on the conflict. Some individuals will have received no sentiment messages, or equal positive and negative sentiment, and so will remain neutral. The temporary sentiment messages with varying levels of activation are how SILAS represents situational fit.

Validation

The Afrobarometer[16] datasets allowed us to partially validate the SILAS model.

Grounding

Grounding, as described, came in several forms. The demographics of the simulated Nigerian population were adapted directly from the (anonymous) 2001 survey respondents. Affinities between the identity groups were based on observed co-membership. The identity a default, the weight (accessibility) of each affiliation link was set to 1 to indicate membership with a group. We used the Afrobarometer data on most-favored identities to increase this weight to 2 when such a response was given (recall that each individual in the model is based on an actual Afrobarometer respondent).

Running the SILAS model begins with a conflict event between any two identity groups (e.g., Muslim versus Christian, Igbo versus Ijaw, or Igbo versus People's Democratic Party). The groups do not have to be of the same type. The two groups in the conflict spread positive sentiment about themselves and negative sentiment about their opponent in the conflict. These sentiments spread through the abstracted identity model along affinity links. The strength of the affinity links was used as a multiplier of the strength of the sentiment. Sentiment, both positive and negative, spreads between identities and down to individuals. Spreading activation is limited to two hops to minimize feedback loops among identities. When the model is finished running, many individuals will have received positive and negative sentiment about the identities involved in the conflict. Some will have received both messages through separate channels

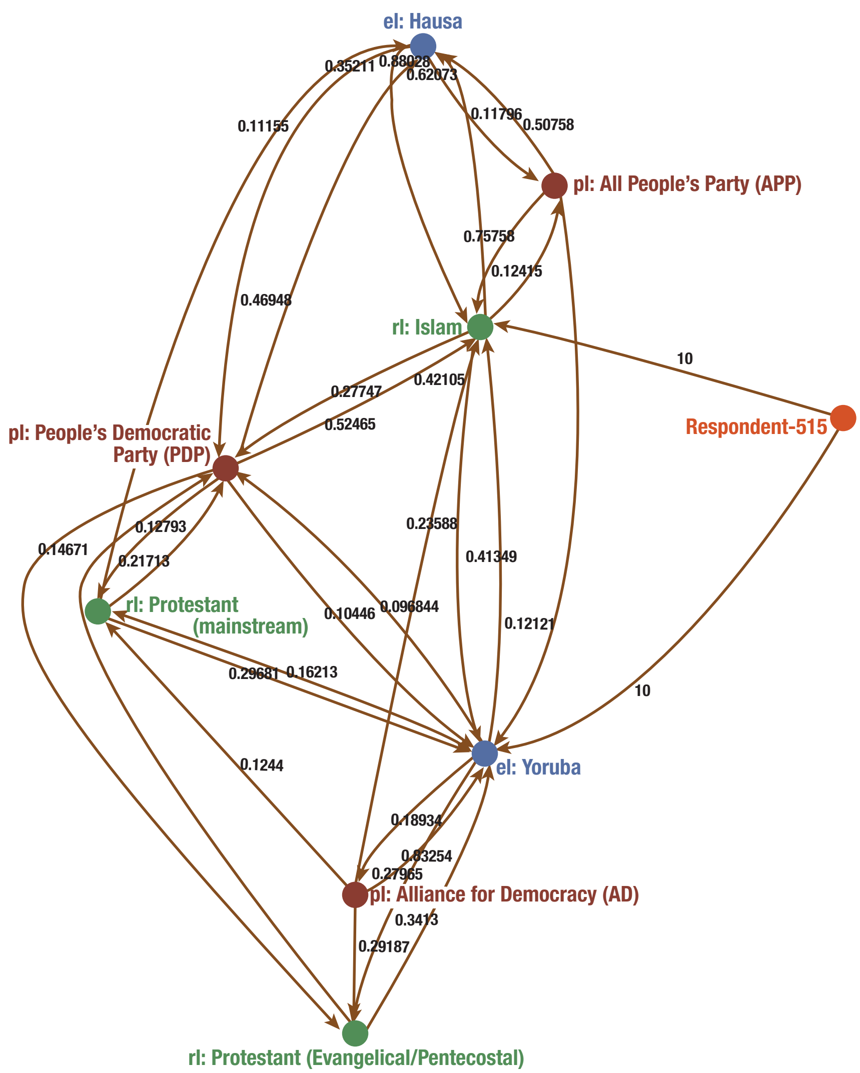


Figure 4. One individual (far right) in the Nigeria SILAS model with the network of identities linked to that individual. el, ethnicity; pl, political party; rl, religion.

categories (ethnic, political, and religious) were based on that survey's question structure. Some parameters had to be grounded with other data. The simulated person-to-person social network between SILAS agents was synthetic, based on realistic assumptions about social networks but not on real data.

Calibration

Calibration of this model mostly involved adjusting the mechanisms of the spreading activation. We experimented with different numbers of allowable hops, with using both positive (affinity) and negative (rivalry) links, and with different algorithms for spreading activation. Design of this system was more craft than science, with no strong theoretical model of the exact mechanisms by which identities interact and without similar prior models on which to base new work.

Verification

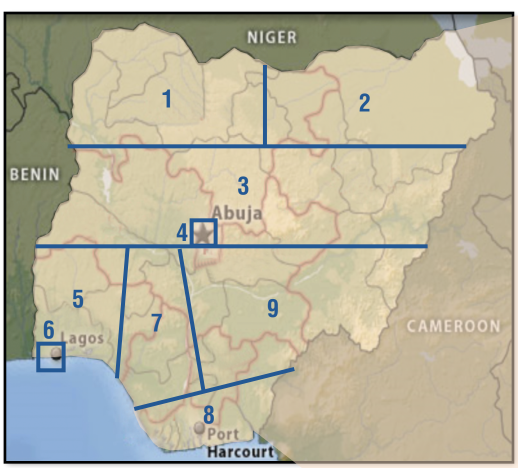
We performed one small-scale validation study, trying to "predict" agents' political party affiliation on the basis of an individual's identity links. The model was constructed using known co-memberships, and then it was run on the same dataset with political affiliation links removed. (We chose to train on the entire set rather than reserve part for validation because of the small cell size of some affinities.) The conflict event was a simulated election between the three major political parties in Nigeria at the time of the 2001 Afrobarometer survey. The SILAS model correctly predicted 72% of known party affiliations. We compared this with a more conventional multinomial logistic regression analysis whose predictions were 76% correct. We were disappointed that SILAS did not outperform conventional regression but were pleased to be close. We hope to be able to improve the model with more highly localized data.

The Green Country Model

GCM (Fig. 5) was a second APL sociocultural modeling project focused on Nigeria. GCM is an interagency collaboration application designed to support policy exercises. It was developed by Alex Ihde and Scott Simpkins of the APL National Security Analysis Department. The scope of GCM was much broader than that of SILAS, encompassing political, military, economic, social, infrastructure, and information (PMESII) variables. Nigeria was modeled as a set of nine regions that roughly correspond to major ethnic or economic boundaries. Each region had a set of PMESII scores that were affected by game actions. GCM was developed in parallel with the SILAS Nigeria model and used SILAS data about social identity relationships to ground affinities between regions of Nigeria. As the game progressed, these social identity relationships were used in adjudication of game actions.

Is is not surprising, given the GCM's broad scope, that calibration was a key phase of model development. When the model was first run, the differences in regional

Nigeria ⇒ 9 regions



PMESII meter (one per region)

Political	• Affinity • Corruption • Effectiveness • Popularity	–100 to 100	• Computed separately • Degree of corruption • Political ability to get things done • Popular opinion
Military/law enforcement	• Effectiveness • Conflict	–100 to 100	• Military readiness, training, and equipment • Presence of unrest in area (*Both pertain to region only.*)
Economic	• Business climate • Individual climate	–100 to 100	• Taxes, available labor, gross domestic product • Per capita earning, mean vs. median
Social	• Cohesiveness • Contentedness • Public health • Crime	–100 to 100	• Cultural identity • Population happiness • Reflects disease outbreaks • Local crime rate
Information	• Connectivity • Openness	–100 to 100	• Reflects access to media: literacy rate, print, radio, TV, Internet, cell phone • Susceptibility to propaganda
Infrastructure	• Transportation • Public services • Urban development	–100 to 100	• Quality of roads, electrical service, buildings, airports, rail, seaports

Figure 5. Each region of a country has separate PMESII scores that affect each other.

scores combined with the strong interregional influence mechanisms led to a system with strong oscillations (Fig. 6), which eventually converged into a homogeneous society, neither of which was realistic. The model parameters were tuned to damp down oscillations and converge more quickly to an equilibrium state consistent with grounding data (Fig. 7).

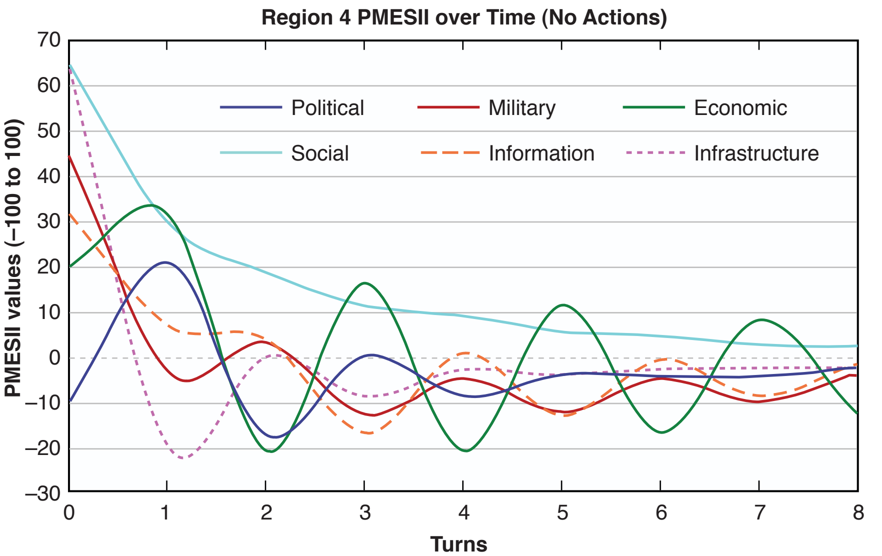


Figure 6. Game trials using original PMESII weights resulted in unrealistic oscillations and changes. The figure shows model results for Region 4 over time, with no actions taken.

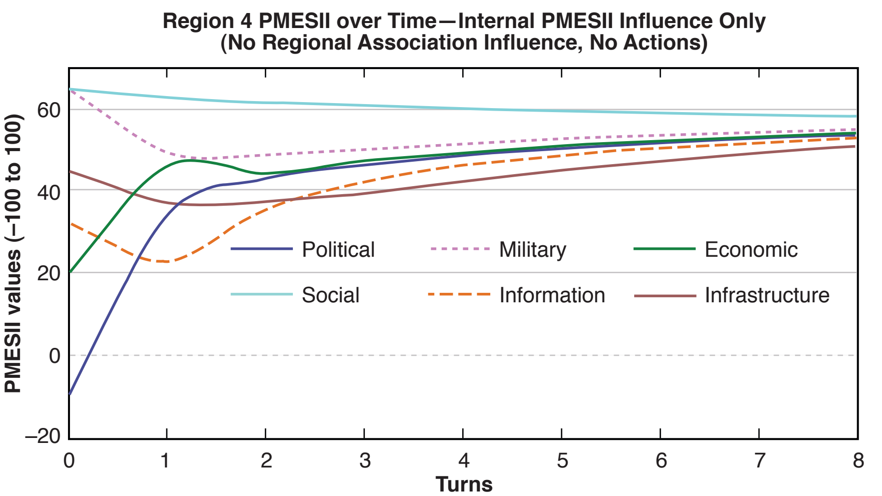


Figure 7. Calibration of PMESII weights allowed for better accuracy within the model; changes reflect more probable results of actions. The figure again shows results for Region 4 over time, with internal PMESII influence only (no regional association influence and no actions taken).

GCM was designed not as a standalone simulation but as a playable exercise. Human players filled the roles of Blue, representing the United States, and Red, representing entities in opposition to regional U.S. interests, in a hypothetical asymmetric contest for influence in that country. Unlike many previous wargames, however, the civilian population was not represented as monolithic but as a realistic network of interests and influences. Blue and Red actions also spanned a wide range of kinetic and nonkinetic options.

GCM held a validation exercise in July of 2009 with knowledgeable Blue and Red role players, and feedback from these subject-matter experts provided the first validation data. The GCM team subsequently transitioned the model to sponsored work and received funding to examine a different region and to continue enhancing the game mechanics, focusing on nonmilitary operations for a government sponsor.

Table 1 is an overview of the validation efforts for the two models described in this article.

FOLLOW-UP RESEARCH

SILAS and GCM were both internal research projects. Several sponsored follow-up proj-

Table 1. Types of validation used in SILAS and GCM.

Type	SILAS (Research and Discovery Tool)	GCM (Policy Wargame)
Grounding	Afrobarometer[16] survey series supplemented with some non-open-source polling data	Background research on political, economic, and military conditions; SILAS input on regional affinities
Calibration	Tuning of parameters for model stability	Model sensitivity analysis
Verification	Small-scale study to test predictions about political affiliation	Feedback from subject-matter experts as game players

ects later built on these frameworks. The U.S. Army Asymmetric Warfare Group has funded an expansion and adaptation of GCM. The Air Force Research Laboratory has sponsored a modeling task based on SILAS to recreate dynamics that led to the Anbar Awakening in Iraq. The Office of Naval Research has funded a data collection project that focuses on Nigeria and also builds on the SILAS work. The Office of Naval Research project, called "Evaluating Online Social Media as a Source for Understanding Regional, Political, and Cultural Sentiment," is collecting open-text data from blogs, discussion forums, and Twitter and then performing sentiment analysis on postings related to Nigerian politics. Sentiment derived from social media will be compared with "ground truth" from polling data, including Afrobarometer and other Nigerian sources. If successful, this effort should help establish a new, faster, and more detailed source of data for grounding and verifying sociopolitical models.

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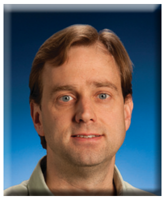
APPENDIX: AFROBAROMETER ITEMS RELATED TO SOCIAL IDENTITY

- Survey questions on basic demographics:
  - What language do you speak at home?
  - What is your religion?
  - What is your occupation?
  - What is your monthly income?
- **Question 54:** *We have spoken to many Nigerians and they have all described themselves in different ways. Some people describe themselves in terms of their language, ethnic group, race, religion, or gender and others describe themselves in economic terms, such as working class, middle class, or a farmer. Besides being Nigerian, which specific group do you feel you belong to first and foremost?*
- Value Labels:
  - 0 = Can't explain
  - 1 = Language/tribe/ethnic group
  - 2 = Race
  - 3 = Region
  - 4 = Religion
  - 5 = Occupation
  - 6 = Class
  - 7 = Gender
  - 8 = Individual/personal
  - 10 = Won't differentiate/National identity
  - 12 = Traditional leader
  - 13 = Political party identity
  - 14 = Age-related
  - 15 = African/West African/Pan African
  - 89 = Other
  - 97 = Refused to Answer
  - 98 = Missing Data
  - 99 = Don't Know
- **Question 55:** *Let us suppose that you had to choose between being a Nigerian and being an Ijaw. Which of these two groups do you feel most strongly attached to?*

The Authors



Nathan D. Bos

Ariel M. Greenberg

Jonathon J. Kopecky

Alex G. Ihde

Scott D. Simpkins

Nathan D. Bos, **Ariel M. Greenberg**, and **Jonathon J. Kopecky** are in the System and Information Sciences Group of APL's Milton S. Eisenhower Research Center and have worked together on a number of simulation and gaming applications in the sociocultural domain, including projects on text analysis of social media and use of virtual environments for simulating coordinated human activity. **Alex G. Ihde** and **Scott D. Simpkins** work together in the National Security Analysis Department collaborating on research into competitive gaming and advanced concepts for understanding the application of soft power. Both are currently involved in projects related to asymmetric and irregular warfare. Mr. Simpkins is the section supervisor for the Gaming Technologies and Engineering section in the Modeling, Simulation, and Gaming Group. For further information on the work reported here, contact Nathan Bos. His e-mail address is nathan.bos@jhuapl.edu.

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