PROPOSAL WHITE PAPER

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Project Title:	Computational Framework for Assessing Absorptive Capacity
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Topic Title:	Sociopolitical (In)Stability, Resilience, and Recovery
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IDENTIFICATION OF THE RESEARCH AND ISSUES

Statement of Research: This research advances the innovative concept of *absorptive capacity* through modeling the interdependence between natural systems, infrastructure, and human population dynamics. Absorptive capacity is a community's ability to receive and manage mass migration influx. This project develops a computational framework for assessing absorptive capacity through simulation. Simulations would support evaluating a region's capacity to receive large populations (forced migrants, internally displaced people) due to environmental stressors, and to a-priori identify the tipping points at which mass migration engenders weakening governance and diminished resource capacity within the host region.

The characterization and measurement of absorptive capacity is inherently complex, touching upon the nexus of natural, social, and political systems. To study a community's absorptive capacity, we look into communities with displaced populations due to push factors, such as environmental stressors, and the infrastructure capacity and social and political climate to absorb such influx. Displaced populations destabilize host communities and the impact on infrastructures, like health and water resources, is measurable. We hypothesize *absorptive capacity thresholds* beyond which the receiving region can (or will) no longer adequately support the needs of both the local and arriving communities. Further, as capacity of a region reaches threshold levels, it has the potential to create social unrest, pushing its inhabitants out of the region or in conflict with newcomers. As the host system approaches capacity, resentment, racial, and xenophobic sentiments grow, internal political debates intensify, and indicators of weakening governance and internal dissent may appear.

Our approach develops a simulation framework that implements absorptive capacity and would allow for scenario evaluation under different stressors: natural disaster, conflict, and unemployment. The consideration of different stressors allows identification of novel courses of actions across situations. The framework will have two foundations: 1) empirical: by studying the cases of Puerto Rico (natural disaster), Lesbos, Greece (conflict) and Norfolk, Virginia, USA (flooding) and 2) technical: by considering the simulation infrastructure that implements the absorptive capacity concept and receives input data semi-automatically to provide valid outcomes.

Significance: The management of a mass population influx is often *ad hoc* and seen as a temporary challenge. However, displaced populations are spending longer times in host communities, fundamentally affecting the physical and social resources of those communities or not contributing to the communities from which they flee. These trends indicate the need to examine critically the capacity of host communities to receive and absorb displaced populations. Modeling and simulation allows us to systematically examine the interdependent relationships between the physical and social capacities and identify tipping points that lead to physical, social, and political instability.

Actionable Research: This research will contribute to the absorptive capacity body of knowledge by generating actionable information that may not only inform social/economic/political/environmental consequences that displaced populations generate in communities, but also support coordinated responses to rapid population movements and allocation of critical resources. For example, these models will assist in answering the fundamental questions: *How may the rapid inflow of populations impact the physical, natural, and social systems of their host regions*? *What predicts a region's turn away from initial receptivity to displaced populations? What is the impact that under-performing critical infrastructures have on the social fabric of a region?* For example, infrastructure was quickly overwhelmed in Lesbos, Greece during the height of Europe's forced migration crises. Despite the local community and volunteer support at the start of the crisis, resentment grew against migrants perceived as hurting tourism and other economic aspects of island life. Lesbos still suffers the destabilizing impact of the 2015-2016 rapid refugee influx. In some cases, local residents fled.

PROPOSED TECHNICAL APPROACHES

To explain regional absorptive capacity and predict its long-term impact, our approach includes the integration of two complementary modeling methodologies. Systems dynamics (SD) models that capture systems' macro connections and causal effects over time (e.g., drought or unemployment impact to support local populations) will be integrated with agent-based models (ABMs) to capture individuals' decision processes and reactions to resource constraints (e.g., xenophobia or political view shifting).

Case Selection: The strengths of selecting these cases for model building include the availability of quality data and the distinct condition of stressors, their impact on displacement, and ultimately of absorptive capacity of a region. Puerto Rico, affected by hurricane Maria, provides a case to study absorptive capacity and the impact of displaced populations on the island as well as those that left the island. Norfolk, VA, USA, affected by frequent flooding, provides an interesting case for evaluating potential population shifts, across socio-economic levels, due to projected flooded areas. Lastly, Lesbos, Greece, affected by the different conflicts from the Middle East and Africa, has received large numbers of people some remaining in the island after several years.

Simulation Framework Development[1]: We leverage the US Department of Homeland Security's Critical Infrastructure and Key Resources (CIKR)[2] sectors to characterize the SD. Maslow's Hierarchy of Needs will be used to characterize the SD and ABM and their interconnection. The CIKR captures a representation of assets considered vital to a community that can support the absorption of new inhabitants. We will model five sectors: Commercial Facilities; Emergency Services; Healthcare and Public Health; Food and Agriculture; and Water and Water Treatment. These are selected as they are commonly found across regions regardless of size and are some of the most impacted under different stressors. We propose to include Transportation and Energy in a funding extension. Maslow's Hierarchy of Needs, Integrated Threat Theory[3], and Berry's four-fold model of acculturation strategies[4] provide a starting point to capture the interconnected impacts between infrastructure and human dynamics. We hypothesize that decline or perceived decline in infrastructure services generates discontent and less social absorptive capacity leading to dissent or political unrest.

The approach will be iterative, developing small and increasingly complex models. It builds on previous work conducted by the researchers in terms of method[5] and scope[6]. The final simulation set will capture the three cases and allow for generalizability to other regions. The SD and ABM models will be integrated so input from one informs the other, allowing social and physical interconnections to be captured at different scales (macro and micro). Validation of the simulation framework will include its applicability to other cases, namely Cape Town, South Africa (drought).

Figure 1 shows preliminary simulation specifications of portions of the framework using an activity diagram for agents and a stock and flow model for the Water system infrastructure. The activity diagram captures an agent decision rule where agents check for desirable living and investment conditions leading

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[1] Simulation Framework is defined here as a simulation that allows rapid adjustment to new data sets.
[2] https://www.dhs.gov/critical-infrastructure-sectors
[3] Stephan, W., Ybarra, O., Martinez, C., Schwarzwald, J., and Tur-Kaspa, M. (1998). Prejudice toward immigrant to Spain and Israel. *Journal of Cross Cultural Psychology, 29*(4): 559-576
[4] Berry, J.W. (1997). Immigration, Acculturation, and Adaptation. *Applied Psychology*, *46*(1): 5-34.
[5] Tolk, A., Diallo, S., Padilla, J., and Herencia-Zapana, H. (2013). Reference modeling in support of M&S – Foundations and Applications, *Journal of Simulation*, *7*(2): 69-82.
[6] Padilla, J., Diallo, S., Kavak, H., Sahin, O., Sokolowski, J., and Gore, R. (2016). Semi-automated initialization of simulations: an application to healthcare, *Journal of Defense Modeling and Simulation*, *13*(2): 171-182.

to staying or living an area. The stock and flow diagram captures some of the factors and interconnections between factors for the water system based on the DHS CIKR taxonomy.

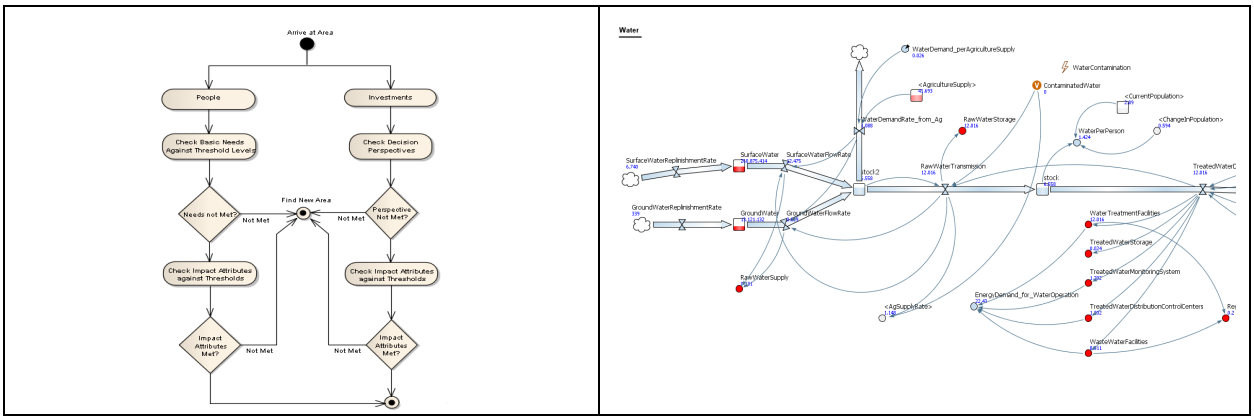

Figure 1. Preliminary Simulation Specifications – Agent and System Dynamics

Data Collection: Data collection is divided in two stages: stage one to inform the simulation framework and stage two to validate the framework. Stage one leverages 1) local news data captured through automated web scraping from web archives of at least two local news agencies from each case region. We will systematically retrieve timestamped news webpages in HTML format; and 2) fieldwork relying on interviews and survey instruments based on the CIKR, Integrated Threat Theory and Four-fold Model to assess sentiments and perceptions towards infrastructure use and arriving populations. These interviews/surveys will be conducted in each of the case regions and used for exploratory analysis. 3) we will acquire census data to describe community demographics. Date ranges for historical data collection are 2014 to early 2018, where available. 4) Regional critical infrastructure stability data are garnered through statistics reported by the host governments and related agencies. Stage two leverages all data sources in Cape Town. We understand the limitations of validating a framework with one case. We propose a funding extension to validate the framework in Cucuta, Colombia due to large migration from Venezuela due to lack of employment and basic goods.

Data Processing & Analysis: Official statistics and survey data will be cleaned and analyzed using statistical approaches. Qualitative data will be analyzed using content analysis and coding techniques. To process and analyze HTML formatted news data, we will parse the HTML, confirm news related to stressors and arriving populations, filter data that describes tensions and analyzed the data for sentiment using NLTK[7] as it is more appropriate than SentiStrength on formal texts.

PROJECT OUTPUTS

1) An *explanation* of the concept of absorptive capacity across stressors. 2) *a database* (PostgreSQL) will store structured official statistics and survey data. The goal here is to provide a well-defined interface for the simulation models to access data in a standardized way so that new use case regions can be added with minimal effort. 3) *a simulation framework* that facilitates the evaluation of current and future cases. We will provide model iterations as support material. 4) *Publications*: newspapers, scholarly journal and conference papers. 5) *Dissemination platform*: a cloud-based platform to disseminate data, models, and publications. The platform will provide the ability to execute and reuse models from a web browser. This will be based on the PIs previous cloud-based simulation work.

[7] http://www.nltk.org/api/nltk.html

POTENTIAL IMPACT ON DoD CAPABILITIES

Understanding the absorptive capacity of a region allows insight about the factors and dynamics leading to tipping points beyond which communities experience dangerous levels of tension or resentment toward their leaders or migrant populations. This has implications for regional stability and recoverability and global emergency sustainability. Puerto Rico and Norfolk are of crucial importance to DoD as both have military infrastructures. The Naval base in Norfolk is weaved to the social and economic fabric of the Hampton Roads area and environmental stressors could have a lasting impact in the stability of the region. Of the selected cases, Greece is a NATO ally and its stability, especially in relation to neighboring Turkey, are of importance to US interests.

POTENTIAL TEAM AND MANAGEMENT PLAN

Jose J. Padilla (VMASC, ODU), an expert in simulation modeling, will serve as administrative and technical lead of the design and development of the simulation framework. Erika F. Frydenlund (VMASC, ODU), a forced migration expert with experience in Rwanda, Africa and Lesbos, Greece, will oversee the fieldwork and data analysis. Joshua Behr (VMASC, ODU), an expert in resilience and vulnerable populations with research in the Hampton Roads area, will lead the characterization of interaction between population and infrastructure. Saikou Y. Diallo (VMASC, ODU), an expert in interoperability and simulation hybridization, will lead data analysis and simulation interoperation efforts. Michael Allen (Political Science & Geography, ODU), a climate scientist, will lead the study of environmental stressors and regional vulnerability due to extreme conditions. Apostolos Spanos (University of Agder, Norway), a historian and Lesbos native, will lead placing the displacement of people in a historical context. The project will require a software engineer to develop the simulation framework, one postdocs to support the research efforts and facilitate coordination and three Ph.D. students.

To *socialize* research efforts, obtain *local input*, and distribute/collect surveys, we will conduct workshops in each of the selected regions between years one and three. Material collected from the workshop will be part of the data collection effort and shared in the project deliverables.

DATA MANAGEMENT

Data collected during the project will be managed in accordance with ODU's Research and Scholarly Digital Management Policy. We will get IRB approval from both ODU and the DOD sponsor identified by the Minerva Research Initiative. Research data which documents, supports, and validates findings will be made available, after disassociation with personal identifiers (PII) and review by the Minerva Research Initiative POC, for educational, research, and non-profit purposes using web-based applications.

SUMMARY OF ESTIMATED COSTS

The total cost will be approximately $1,459,042 over 3 years (1/1/2019-12/31/2021), with estimates broken down as follows. Model development, data analysis, database & dissemination platform development (labor for 5 faculties, 1 software developer, and 2 graduate students): $656,520. Modeling software license: $15,000. Computer (1): $8,000. 2 workshops (each including 6 invited international participants): $45,000. International travel to case regions: $36,000. Local travel (project review meetings and conferences): $15,000. Student tuitions: $48,384. Subcontract to University of Agder $120,000. University indirect costs: $515,138.