Enhancing C4I Systems with Actionable Human Terrain Knowledge*

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"Human reactions cannot be reduced to an exact science, but there are certain principles which should guide our conduct. These principles are deduced by studying the history of the people and are mastered only by experience in their practical application."

- US Marine Corps, Small Wars Manual, 1940

***Abstract* – Warfighters have long recognized the importance of understanding and shaping the human elements of their operating environment. Now termed the 'human terrain', these elements include the psycho-social, ethnographic, cultural, economic, and political aspects of the people among whom a force operates [1, 2]. Modern war and peace-time operations require such actionable knowledge to inform commander's situational awareness and decision-making processes. This makes integrating actionable human-terrain knowledge into C4I systems increasingly critical. Developing such integrated capabilities, however, presents a formidable challenge. Useful human-terrain data is difficult not only to collect – often requiring physical presence in hostile areas – but also to effectively quantify and digitize for C4I use. We highlight some approaches – including potential scientific, technological, and operational challenges as well as solutions – towards enhancing C4I systems with actionable human-terrain knowledge. Specifically, we discuss some of the quantitative social science and computational modeling approaches for generating quantifiable insights into notoriously difficult-to-quantify social phenomena. This includes conceptual and analytical tools for systematically representing diverse sets of social phenomena – e.g., using a multi-scaled human-networks paradigm – as well as the development of operational metrics and indicators for establishing and maintaining high-fidelity links between real-world conditions and their computational representations within C4I systems. Potential R&D topics are also identified – all towards ultimately generating accurate and useful insights to support complex US operations in unfamiliar and hostile settings.**

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I. Introduction

Warfighters have long recognized the importance of understanding and shaping the human elements of operational environment. A pre-World War II US Marine Corps manual [3], for instance, instructs that using psychological operations to undermine enemy's resolve may be as effective as battle casualties. Yet a failure to use tact, or lack of firmness, with relevant populations at opportune moments may precipitate problems that could have been avoided had the commander been familiar with local customs [3]. The military today terms such issues the 'human terrain' – including the psycho-social, ethnographic, cultural, economic, and political elements of the people among whom a force operates [1, 2].

Traditionally, human terrain knowledge has been derived through study, experience, and intelligence—and disseminated through professional military writings, doctrine and training [4]. Some of these features persist over time and remain amenable to such traditional, doctrinal methods involving in-depth scholarly study to develop a coherent understanding.

For other, more dynamic aspects, however, traditional methods alone no longer suffice. Specific situations on the ground evolve rapidly shaped by today's dynamic global economy and Information Age society as well as adversary efforts to influence the local populations – requiring more direct channels into commander's situational awareness and decision-making processes.

This makes integrating actionable human-terrain knowledge into C4I systems increasingly critical. In doing so, it is also critical to maintain links with in-depth understanding of the underlying social principles and enduring socio-cultural and historical factors. These principles and factors should guide and inform the collections and interpretation of real-time data to facilitate resulting understandings and decisions well-grounded in local realities.

II. An Approach for Integrating Actionable Human-Terrain Knowledge Into C4I Systems

There are many diverse C4I systems [5, 6]. A comprehensive approach for synthesizing and linking into C4I architectures the various relevant and situationally-appropriate human terrain aspects can be summarized as follows:

1. Inputting and processing selected types of raw open-source and/or intelligence data to formulate representations of enemy as well as regular local population roles, behavior patterns, and processes.

2. Hypothesizing models of local factions and organizations that could result in these observations based on available social scientific theories pertaining to the locale and phenomena being evaluated.

3. Rapidly generating performance models of hypothesized human-terrain networks and elements.

4. Recommending to the warfighters a range of "probes" to distinguish among competing models and representations, and refine the confidence measures in the most likely models and states of the world. Probes may be non-kinetic (e.g., informational, involving visits with the locals or distribution of fliers, etc.) or kinetic (involving attacks), depending on specific circumstances, missions, and commander's intent.

5. Recommending to the warfighter optimal courses of action and intervention strategies per most likely states and propensities of human networks estimated in #4, under given mission objectives and operational constraints.

6. Generating confidence values on each representation, model, recommendation, and expected outcome so that the measures of accuracy can be refined through feedback from real-world results.

III. Potential Challenges & Solutions

A. *Scientific*

Scientific challenges include developing systematic and accurate representations of the complex underlying social phenomena that are also compatible with C4I architectures. Figure 1 provides one approach for systematizing such representations based on viewing the various social phenomena in terms of the social agents involved and the links and social (human) networks at different levels of analysis.

Figure 2 summarizes an iterative analysis approach to then modeling the available data based on modeling abstractions and social-science theories available and appropriate to the respective levels of analysis identified in Figure 1.

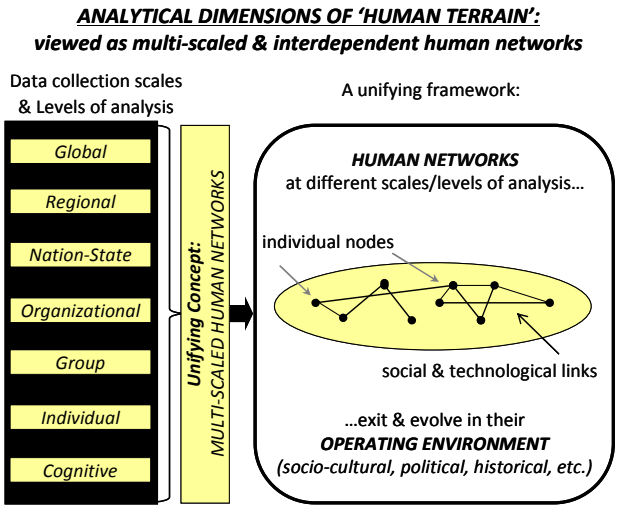

Figure 1: A conceptual framework for analyzing human-terrain elements in terms of their enabling multi-level human networks that exist and operate in relevant social and geo-political contexts comprising the human terrain. Network analysis techniques can be used to quantify, systematize and model diverse elements of human-terrain – towards integrating relevant processes and results into C4I systems.

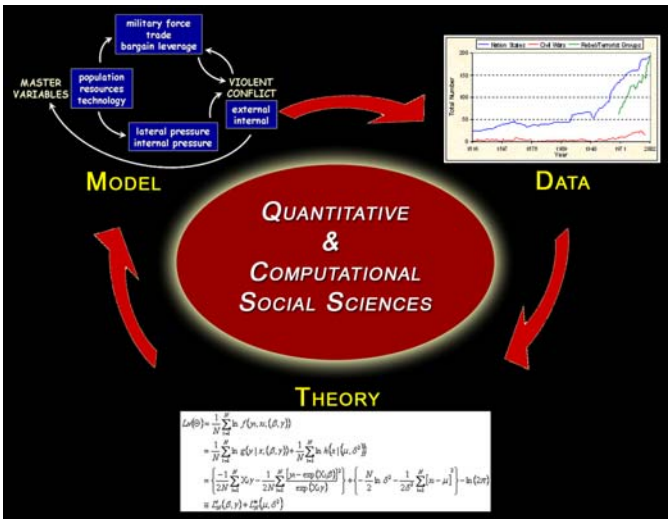

Figure 2: An example Quantitative & Computational Social Sciences Approach to rigorous analysis of social phenomena, including human-terrain issues, among others. The approach is based on integrating real-world data, theory, and modeling techniques in an iterative process aimed at incorporating the scientific method into the production of robust as well as actionable results for national security applications.

B. *Technical*

Technical challenges include achieving interoperability with existing C4I architectures as well as supporting decision-making processes with current and accurate information. The challenge may be compounded when dealing with streaming, incomplete, noisy, and adversarial networked data that is not

readily supported by traditional statistical methodologies and knowledge-discovery algorithms (see e.g., [7, 8]).

Figure 3 provides an approach for dealing with such data toward estimating covert enemy activity against the backdrop of (complex and noisy, etc.) urban life.

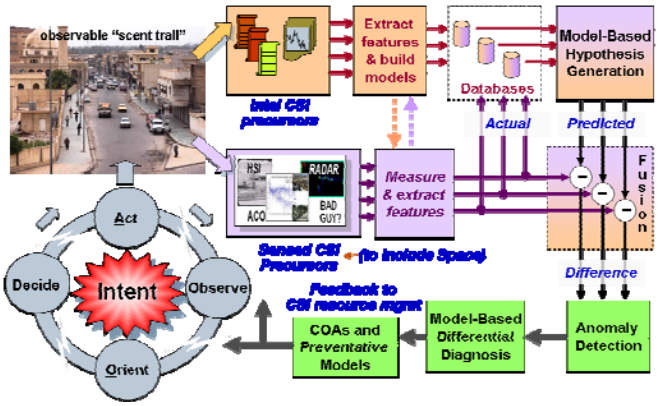

Figure 3: A conceptual approach to estimating covert enemy activity against the backdrop of typical urban life, using anomaly detection algorithms and behavior diagnostics models to identify and effect an adversary's decision process.

C. *Operational*

Operational challenges in using scientific and computational approaches to aid real-world decision making involve the need to maintain accuracy and high fidelity when representing real-world phenomena using abstractions.

This challenge can be addressed by developing and consistently applying pertinent operational metrics – i.e., structured representations of actors' organizational and operational characteristics. In order to ultimately produce actionable intelligence, any data inputs into C4I systems will need to be specifically structured, and any recommendation outputs will need to match the given missions and operational constraints. (Figure 4 provides an example approach using multiple models and metrics to estimate potentially threatening activity and produce indicators of likely intent and situation status).

To achieve this, the disparate information sources and data types will need to be structured and classified based on a set of uniform metrics and indicators developed with operational inputs from the warfighters and support personnel involved. The generated abstractions will need to insure the faithful and consistent representation of the "real-world" characteristics (including "blue" friendly, "red" enemy, and "green" human terrain layer entities, organizational structures, actor properties, activity patterns, etc.) and their accurate translation into relevant modeling categories.

Such metrics would facilitate uniformity of data structuring conventions allowing the subsequent computational modeling and simulations to retain the necessary material properties of the "real-world" thereby enabling C4I systems to generate meaningful, assessable, relevant and actionable outputs.

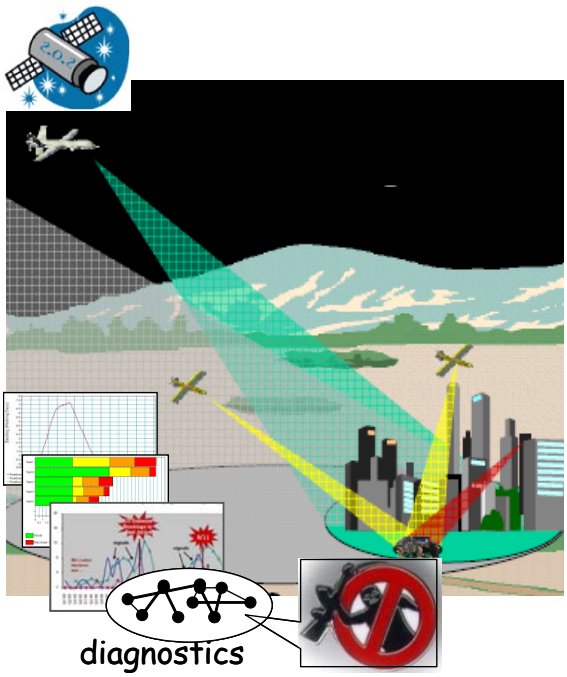

Figure 4: Integrating geo-special and geo-political aspects of human terrain into C4I systems. Using models, metrics and indicators of actor behavior and organization structure, as well as background environment characteristics – informed by the relevant concepts, models, theories, and data – to aid commander's ability to detect and disrupt terrorist or insurgent plots. (Figure background was adapted from the publicly-available [9] as well as analysis outputs generated using SimVision organization modeling and simulation software, among others.)

IV. C4I R&D Directions

The capabilities envisioned here suggest the need for advanced research and development activities to include:

A. Applying and developing advanced social-scientific methods to better understand the underlying social phenomena and generate actionable human terrain knowledge for C4I use.

B. Developing operational metrics and indicators, with corresponding computational representations and analyses, for integrating actionable human terrain knowledge into C4I systems.

C. Developing flexible, modular, interoperable C4I technology capabilities to meet dynamic battlefield demands in unfamiliar and hostile human terrains.

V. Conclusion

Modern and likely future national-security operations require improved knowledge of the populations and socio-cultural aspects of the operating environment. Integrating such knowledge with C4I systems offers opportunities to provide the needed information to commanders in a timely and

actionable fashion. Achieving such capabilities, however, will require overcoming a number of scientific, technological and operational challenges—including key ones discussed here with potential solutions.

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