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Complex Decision Making Experimental Platform (CODEM): A Counter-Insurgency Scenario

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***Abstract*—The complex decision making experimental platform (CODEM) is intended as a shareable research tool to stimulate multidisciplinary research on complex dynamic situation management and as an environment for training and testing cognitive readiness. The experimenter can set general parameters, configure the interface, specify the model, insert events and define the resources and capabilities of each player using the scenario development tool. No programming skills are required. Task complexity can be varied by introducing feedback loops, delayed effects, time pressure, situational uncertainty, adjusting model transparency and changing the relationships between system elements. CODEM creates detailed logs of events and actions essential for cognitive process tracing and the evaluation of decision making effectiveness. The first task designed with CODEM is a counter-insurgency scenario in which a coalition force seeks to stabilize a failing state. A genetic algorithm is used to estimate the best strategy in that scenario for comparison with human results. An adversarial version also allows insurgents to be controlled by a human opponent (or a red team) rather than an artificial agent. CODEM can be used as a cognitive engineering testbed and as a training environment for improving decision making and adaptation skills in complex situations.**

***Index Terms*—Cognitive readiness, complex system, decision making, genetic algorithm, testbed.**

I. Introduction

Success in the conduct of irregular warfare and coalition operations largely depends on achieving a keen understanding of the interrelationships within a complex dynamic adaptive system of systems [1]-[2]. Besides understanding the problem space, commanders require strong dynamic decision making skills and adaptability in order to determine how to best influence the situation, anticipate outcomes, adapt to surprise, and achieve enduring effects [3]. In fact, most national security issues that challenge our leaders today require attempting to understand, predict, and influence the behavior of complex systems. This includes key challenges such as border and immigration security, financial markets, resilience of national infrastructures, cyber-security and terrorism [4]. Failing to understand how policies or interventions impact the system as a whole (and in the long term) can lead to disastrous unintended consequences [5]. It is therefore critical to ensure that decision makers be sufficiently prepared through training and education, and supported through technology and teamwork, to effectively deal with the daunting complexity of these situations.

Applied cognitive research on situation assessment and decision making in complex domains seeks to identify how to best support these processes through human-in-the-loop testing. In order to identify psychometric predictors of effectiveness and resilience, and determine requirements in terms of training, cognitive support and team design, it is necessary to perform controlled experiments using a testbed presenting a relevant cognitive task, measuring various processes related to task execution, and logging intermediary outcomes. Here we present the results of our efforts at developing a flexible and generic testbed with applications for research, training, and evaluation purposes in the domain of complex situation management. The first complex cognitive task that we developed using the testbed's scenario editor is a counter-insurgency campaign where the goal is to help stabilize a failing state while suppressing insurgent forces.

The paper is organized as follows. Following this introduction, Section II characterizes the complexity of the challenges that decision makers are facing in the domains of defense and security and the need for a more comprehensive and long term approach to national and international operations. Section III describes the complex decision making experimental platform (CODEM), the counter-insurgency scenario, and a genetic algorithm extension. Section IV discusses the scientific and military applications of CODEM.

II. Complexity in Defense and Security

"When you are confronted by any complex social system […] with things about it that you're dissatisfied with and anxious to fix, you cannot just step in and set about fixing with much hope of helping. This realization is one of the sore discouragements of our century… You cannot meddle with one part of a complex system from the outside without the almost certain risk of setting off disastrous events that you hadn't counted on in other, remote parts. If you want to fix something you are first obliged to understand… the whole system…" [6].

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A. Complexity and adaptiveness

Complex systems comprise multiple interrelated variables involving time-dependent and non-linear relationships such that the problem situation changes over time in ways that are difficult to predict or anticipate [7]. The number of variables and possible courses of actions refer to what is generally called "detail complexity" (i.e., complicatedness). Yet some systems pose a considerable challenge to decision makers even when just a few variables interact, because time-delays and reinforcing or balancing feedback processes lead to emergent dynamics which are very hard to foresee (i.e., dynamic complexity) [8]. Indeed, even the intuitive judgments of highly skilled individuals have proven quite unreliable at anticipating the dynamic behavior of systems of 5 or 6 variables. Such failure is true even under ideal conditions in which the complete causal structure and all parameters of a system are known [9]-[10].

Experiments have shown that although decision making performance in complex situations improves with practice, it typically reaches a plateau well below potential [11]-[12]. Moreover, in a number of studies, a naïve do-nothing rule was found to give better results than most participants [13]-[14]-[15]. Such systems are said to display *policy resistance*, i.e., a tendency for interventions to be defeated by the response of the system to the intervention itself. Sterman [16] provides several examples of policy resistance and discusses various barriers to learning such as misperceptions of feedback (i.e., failing to take into account delayed effects), judgmental biases and the inability to infer dynamics from static knowledge.

No practical quantitative measure of complexity has yet successfully accounted for the extent to which various complex situations are cognitively challenging for humans [17]. Yet complexity is not an all-or-none concept, there are clearly varying degrees of complexity as illustrated in Table 1.

Table 1. Types of problems and solution strategies (from [18])

	Well-Structured "Puzzle"	Medium-Structured "Structurally Complex Problem"	Ill-Structured "Wicked Problem"
Problem Structuring	The problem is self-evident. Structuring is trivial.	Professionals easily agree on its structure.	Professionals will have difficulty agreeing on problem structure and will have to agree on a shared starting hypothesis.
Solution Development	There is only one right solution. It may be difficult to find.	There may be more than one "right" answer. Professionals may disagree on the best solution. Desired end state can be agreed.	Professionals will disagree on: • How the problem can be solved. • The most desirable end state. • Whether it can be attained.
Execution of Solution	Success requires learning to perfect technique.	Success requires learning to perfect technique and adjust solution.	Success requires learning to perfect technique, adjust solution, and refine problem framing.
Adaptive Iteration	No adaptive iteration required.	Adaptive iteration is required to find the best solution.	Adaptive iteration is required both to refine problem structure and to find the best solution.

As seen in Table 1, complex situations require adaptability as operations unfold. The degree of understanding of the problem can significantly improve by interacting with the system and learning how various elements respond. Furthermore, the problem itself can also change over time, thus requiring keen observation, sensemaking and adaptation skills [19]-[20]. The Australian Army's Future Land Warfare Directorate published a key document relating adaptation to complexity, entitled "Adaptive Campaigning – the Land Force Response to Complex Warfighting" [21]. Operational adaptiveness is understood as involving four components [22]:

- *Operational Flexibility.* The ability to maintain effectiveness across a range of tasks and conditions;
- *Operational Agility*. The ability to dynamically reallocate effort across all lines of operation in space and time;
- *Operational Resilience.* The capacity to sustain loss, damage and setbacks and still maintain essential levels of capability across core functions;
- *Operational Responsiveness*. The ability to rapidly identify and respond to new threats and opportunities.

Grisogono and Ryan [22] proposed a cognitive method relying on the iterative development of shared causal and influence networks intended to support adaptive campaigning. Lizotte et al. [23] have been developing and testing advanced tools to support such a collaborative sensemaking process.

B. Comprehensive approach to operations

Contemporary military operations are unlikely to succeed through the use of military power alone. A comprehensive approach to operations means employing and aligning resources (diplomatic, defence, development, and commercial) from numerous agencies, and coordinating these operations through an integrated campaign plan [24]. Such an approach thus entails both traditional and non-traditional military activities. Fig. 1 illustrates the multiple interrelated factors in the operational space that require taking a comprehensive approach.

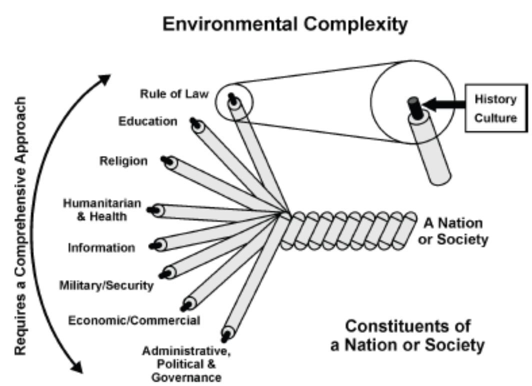

Fig. 1. The complexities of the environmental battlespace (from [25])

The Canadian Land Forces have been developing the concept of Joint, Interagency, Multinational and Public (JIMP-enabled) capability as a way to operationalize a comprehensive approach. A JIMP-capable force means that it is prepared to actively engage other players in each of the above categories in a cooperative relationship in pursuit of the desired end-state. Furthermore, success will require an awareness of the potential impact that actions of one organization have upon other players and the overall strategic objectives [24]. Human capital is the key to developing a better JIMP capability, both in terms of training for adaptive dispersed operations [26], and better preparing soldiers and commanders for non-warfighting functions [27].

The strategic advisory team – Afghanistan (SAT-A) is another example of Canada's efforts at implementing a whole of government approach. This team was comprised of a small group of military members, a defence scientist, and a member of the Canadian international development agency working in consultation with the Canadian Embassy toward strengthening the national government of Afghanistan, and serving as a tool at the operational and strategic level. SAT-A was able to operationalize the strategic objectives of the Afghanistan National Development Strategy in order to facilitate the campaign design of each of the provincial reconstruction team commanders. As LCol St-Louis stated, "The complexity of the challenges facing Afghanistan called for an integrated, long-term approach to nation-building […] what the SAT brought was the ability to use critical thinking and to establish strategies, and, more importantly, to pass on that knowledge to the young public servants with whom they were working" [28].

To be successful, comprehensive operations will clearly require a systemic cognitive approach to formulate more integrative campaign designs and strategies. Two well-known approaches designed to help frame the problem space and solution space more effectively are the "effects based approach to operations" [29]-[30], and systemic operational design [31]-[32]. Yet ensuring that such approaches are implemented and used effectively will require further concept development [33], education [34], and experimentation [35]-[36]-[37]. A flexible experimental platform will help achieving those requirements.

III. Experimental Platform

A. *Generic Testbed for Cognitive Engineering and Training*

Cognitive engineering (also know as cognitive systems engineering) is the domain of human problem solving with tools: "It draws on the knowledge and techniques of cognitive psychology and related disciplines to provide the foundation for principle-driven design of person-machine systems" [38]. According to [39], the three main themes of CSE are:

- How humans cope with complexity;
- How work is accomplished by the use of artifacts;
- How human-machine systems and socio-technical systems function as joint cognitive systems.

Despite significant progress in technologies and methods that support decision making in complex domains, a better understanding of human cognitive requirements is needed to guide the development and evaluation of support technologies and training. For that purpose, experiments with a high degree of control over variables affecting success are critical. One-shot exercises in highly realistic settings can offer valuable insights but make it notoriously difficult to draw firm conclusions on the actual causes of success or failure–there are just too many uncontrolled factors and possible competing explanations for a given result. In order to reliably assess the effect of a specific intervention (training, methodology, tool), it is necessary to compare decision making effectiveness in conditions with and without such an intervention (i.e., test vs. control or baseline group). Setting up a testing environment and a relevant scenario, developing the actual metrics and a standardized testing procedure can be very time-consuming and costly.

The complex decision making experimental platform (CODEM) is designed as a reusable simulated testing environment by providing the necessary flexibility to create a very wide set of conditions and scenarios. Furthermore, CODEM is intended to be shareable, in order to stimulate the development of collaborative, coordinated, high leverage research programs for multidisciplinary research in cognitive systems engineering and complex decision making and adaptability training. One example of improved efficiency is the ability to test a newly developed intervention on a group of subjects and comparing results to data from a previous study's baseline condition. Furthermore, as the sample size in the baseline condition increases, the required sample size (for the purpose of having sufficient statistical power) for ulterior test conditions will tend to decrease. Finally, with the standardization of the testing procedure accompanying the reuse of the baseline data, it becomes possible to compare the effectiveness of various interventions across studies.

CODEM simulates a class of problems called dynamic decision making tasks (which can vary in complexity), characterized by three key features [40]:

- A series of interdependent decisions is required to reach the desired end-state;
- Each decision necessarily constrains future options;
- The situation changes both autonomously and as a consequence of the decision maker's actions.

Dynamic decision making is increasingly studied using "microworlds", i.e., simulated task environments focused on cognitive measurement and experimental control aiming to reproduce the fundamental cognitive challenges found in various real-world tasks [41]. CODEM falls within this category of virtual environments. The CODEM scenario editor allows developing complex decision making tasks by specifying an underlying situation model represented as an influence diagram and defining each causal relationship. It is generic: Scenarios can be configured to create various complex system models with different cover stories and objectives. The decision maker must influence a complex system (e.g., a counter-insurgency campaign) throughout the course of one or several turn-based strategy game-sessions. Multiple types of task conditions are possible. Time-pressure, information uncertainty, random noise, structural knowledge (information on cause-effect relationships) can be defined during scenario creation. No programming skills are required. Scenarios can be played individually or collaboratively, against one or multiple artificial or human agents (a red team for example). There is no limit to the number of actors in a scenario. Each actor requires an individual (networked) computer. Finally, CODEM creates logs of events and actions at the end of a session for detailed performance assessment.

B. Overview of the Counter-Insurgency Scenario

> "Ultimately, success for a counterinsurgency force rests largely on the elimination of the social, economic, and political factors that create public unrest and in the process fuel the insurgent cause, not on annihilating an insurgent's military capability." [42]

The first computerized scenario developed with CODEM is a counter-insurgency (COIN) scenario focusing on the need to understand the complex relationships between some of the key elements (political, military, economic, social, information, and infrastructure) generally considered the critical lines of operations in an unstable state in the midst of an insurgency. Consequently, the situation is represented at a high level of abstraction and does not require geo-spatial referencing nor specific tactical-level entities or events. The current effort seeks to capture some of the cognitive challenges that understanding such a situation presents and does not pretend to provide a complete or accurate model of insurgencies. In the single-player version, the participant receives the following instructions:

"You are coordinating a multinational effort to stabilize a failing state in the grips of a rising insurgency. Your mission is to return the host nation to a stable and self-sustaining condition. The operation will be considered a success if all situation indicators (except the mediating variable) are outside the RED zone. Your mission has failed if the allegiance of the local population falls to zero. Your tour of command will last up to ten turns - although the campaign will not necessarily be over. International support to the coalition forces (and to the insurgents) is represented by action points. At the start of each turn, you can allocate action points to influence the state of affairs. Half of unspent action points carry over to the next turn. This task is extremely challenging. It is highly advised to carefully consider the known cause-effect relations in the system and try to develop an effective long term strategy.

A word of caution: You should not rely on your knowledge or assumptions about how the real world operates. Instead, you should learn the relationships implemented here to help you understand this fictitious system. Note that relationships between variables can change as the situation evolves. Also, remember that for all variables, higher values mean "better" from the perspective of the Blue side. So, low values of variables such as crime or insurgent forces means that the situation is bad, not good. Finally, remember that you are facing an elusive and adaptive adversary who will adjust his behavior to detract you from reaching your goals."

The COIN scenario is currently calibrated to pose a considerable challenge on the first time the game is played, yet we avoided creating an excessively complex situation that would simply overwhelm all participants and create a "floor effect". This intermediate level of task difficulty makes the scenario a more sensitive measurement tool to help identify what individual behaviors or characteristics are predictive of a better decision making effectiveness.

C. Interface, Model, and Task Configuration

The CODEM interface is divided into tabs that serve different functions. We will describe each in turn. The *Situation tab* shown in Fig. 2 displays the current state of the key situation variables describing the state of the problem space. The scenario editor is used to specify variable names, minimum and maximum values and color coding. Variables can be categorized as either standard variables, agent variables or mediating variables (having no direct effect on other variables, but modulating their effects). Participants can also scroll the *Situation history* bar to view the state of past turns.

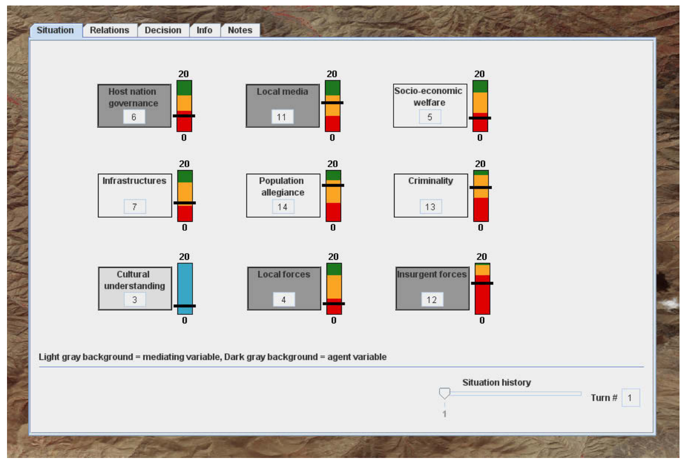

Fig. 2. The Situation tab, displaying the current and past states of the operational environment

In the present scenario, following a review of military doctrine [25]-[43]-[44]-[45] and recent models of COIN [46]-[47]-[48]-[49], nine situation variables were selected to describe the main problem space:

- Host Nation Governance: Capabilities and effectiveness of the government and public administration;
- Population Allegiance: Relative allegiance of the local population (on average) toward the host nation government as opposed to the insurgents;
- Insurgent Forces: Overall capabilities of insurgents in terms of number, skills, and resources;
- Local Forces: Overall capabilities of local military and police forces in terms of number, skills, and resources;
- Infrastructures: Adequacy and sufficiency of essential services, schools, roads and communications;
- Socio-Economic Welfare: Average well being (quality of life) of local population in terms of health, lodging, safety, education and wealth;
- Criminality: Extent of criminality and corruption (lower value = worse situation);
- Local Media: General attitude of the local media (high value means favorable to the host nation government and the COIN campaign);

- Cultural understanding: Global level of understanding of the local culture by the blue force. This is a mediating variable with no direct effect on the situation but which increases the effectiveness of various blue interventions.

The starting conditions, the criteria for mission success and failure, and the maximum number of turns are configured using the scenario editor. Other configurable parameters include the set of tabs available, the background image, the window size, the layout of variables, the sounds and end-state pictures. Optionally, uncertainty about the current state of specific variables can be introduced, either by hiding its value or displaying a range within which the current value lies.

The *Relations tab* can be used to display an influence diagram that represents domain knowledge about how variables interact with one another. As shown in Fig. 3, putting the mouse over a variable highlights all the incoming influences. Right-clicking highlights all the outgoing arrows. A double-bar on an arrow means that the effects are subject to a delay. Influences can also be hidden. It is thus possible to display different domain knowledge to different participants, and to display approximate or erroneous information.

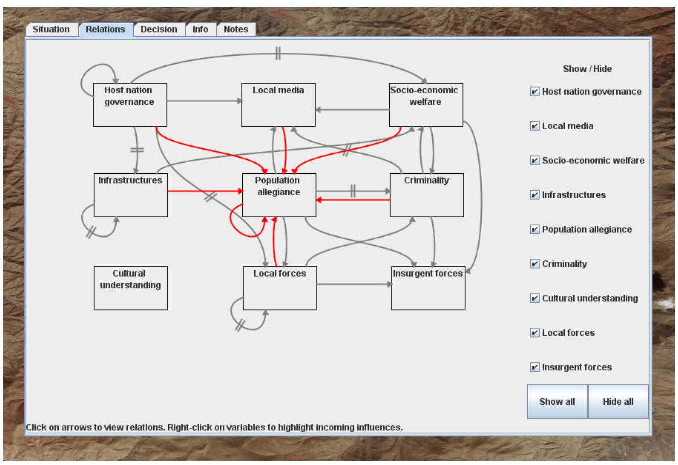

Fig. 3. The Relations tab, displaying the relationships amongst system variables

By clicking on a specific arrow, the participant can display the known effects of one variable on another (can be enabled/ disabled for each variable). A graph, like the one shown in Fig. 4, illustrates how one variable (on the x-axis) will influence the other variable (on the y-axis), as a function of the present state of the variable (identified by the dot). The influence takes effect either at the end of the present turn or after a specified delay (*x* turns). A text description of the effects of one variable on another can also be shown here. For added flexibility, the relationship between two variables can be set to change as a function of the situation. Logical propositions can be defined in the scenario editor that will change the effects of a variable under different conditions. For example the function shown in Fig. 4 applies in the context of an active insurgency and might change when the insurgency is over.

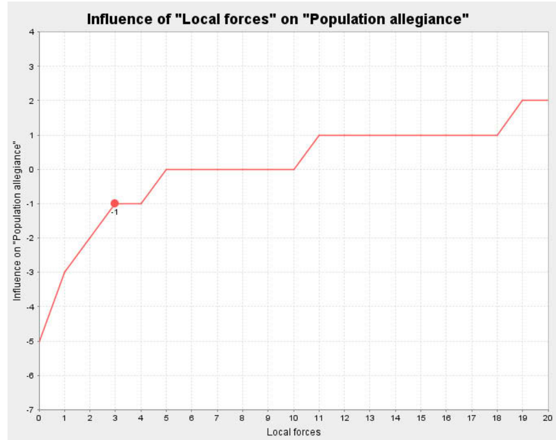

Fig. 4. Graphical view of specific interactions between two variables

The simulated environment can be modeled either as being deterministic or as including random variability, in which case effects occurring on each turn are randomly altered within a specified range.

The *Decisions tab* displays the possible interventions that the participant can undertake to influence the situation. Participants receive action points at the beginning of each turn which can be allocated amongst the possible interventions. Unused actions points can be fully or partially transferred to the next turn, as specified in the configuration file. The amount of action points received each turn can be fixed or depend on the state of the situation (i.e., different variables may contribute to the action points received). Interventions can have one or multiple concurrent effects (listed in a scrolling menu). The various effects of an intervention can be made visible or hidden. Clicking on the "show" button displays the graph showing the specific effects of *x* on *y* (plus descriptive text, delay information). This detailed information can be activated or disabled. Finally, participants can also scroll the *Decision history* bar to view past decisions.

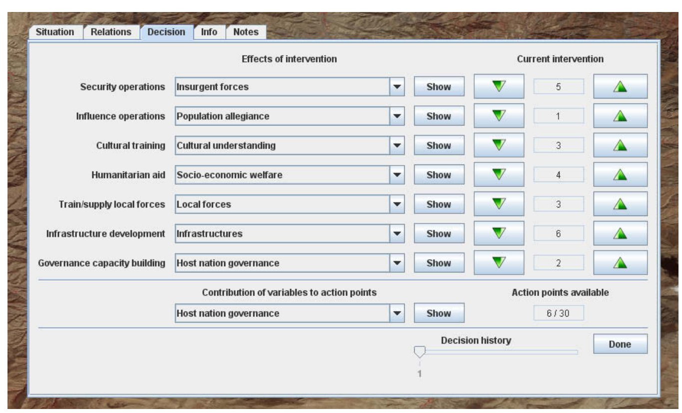

Fig. 5. The Decisions tab, displaying the possible types of interventions and the action points available

In the single-player version of the COIN scenario, seven possible interventions are available:

- Security Operations: Coalition efforts to locate and combat insurgent forces and reduce criminality;
- Influence Operations: The overall information and psychological operations directed toward the insurgents, the local population and the local media;
- Cultural Training: Measures taken to improve the coalition forces' awareness and understanding of the local culture;
- Humanitarian Aid: Coalition efforts to provide critical supplies and medical help to the local populace;
- Train/Supply Local Forces: The coalition effort and providing training, equipment and supplies to the host nation military and police forces;
- Infrastructure Development: Building shelters, wells, roads, bridges, schools, communications, etc.;
- Governance Capacity Building: Coalition support to governance institutions (advisory support, knowledge transfer, development and reconstruction).

CODEM allows the experimenter to set a time-limit for each turn, with a counter indicating to the participant the time remaining. After entering a decision and changing turn, a feedback panel displays the changes in the value of each variable. The feedback panel is also interactive and placing the mouse over a specific variable will show the various factors that lead to this change. This feedback, shown in Fig. 6, then remains permanently available in the *Info tab*. The *Info tab* also allows browsing text messages previously received, shows a diagram of how each situation variable evolved over the course of the past turns, and provides a history of past decisions and states. Each sub-tab can be activated/deactivated in the scenario editor.

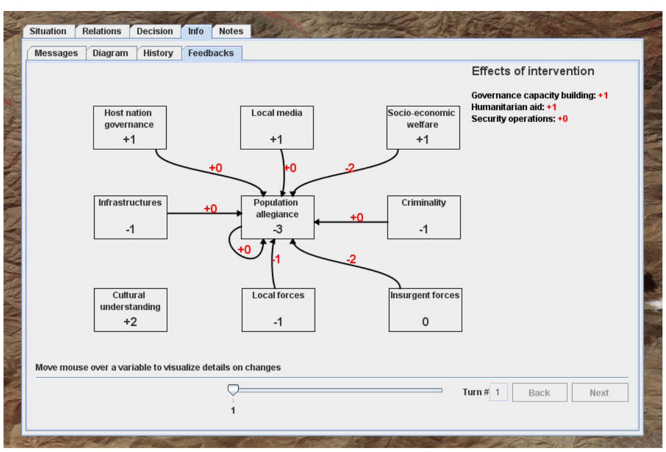

Fig. 6. The Info tab, displaying outcome feedback from past turns, previously received messages, a diagram of how the situation evolves, and a history of past states and decisions

An optional *Predictions tab* enables the measurement of the participant's ability to anticipate proximal outcomes (i.e., to predict the state of the system variables for the next turn). This measure specifically relates to one aspect of the concept of situation awareness, namely the projection of the current situation's implications in the near future [50]. Finally, the *Notes tab* allows the participant to inscribe text at his leisure. This can be valuable for both the participant (as a mnemonic tool) and for the experimenter (as qualitative input).

A two-player collaborative version of the COIN scenario action points has also been designed. Action points can be transferred from one player to another. Each player can only allocate action points to a subset of interventions, requiring participants to coordinate their strategy. A two-player adversarial version has also been designed to allow insurgents to be controlled by a human opponent rather than an artificial agent. In principle, an unlimited number of players and sides can be setup using CODEM.

D. Logging and Process Tracing

CODEM creates two main logs (Excel documents) at the end of an experimental session: The Human log and the Game log. The human log contains the detailed traces of the actions the user performed during a turn (functions consulted, for how much time, time in a given tab, time to enter a decision, etc.). The game log contains traces of the state of the situation on each turn and the final predictions and decisions for each turn (i.e., if the user changes his predictions or decisions multiple times during a turn, only the final prediction/decision is logged).

A "score" variable can be arbitrarily defined to summarize performance/goal attainment. In the COIN scenario, performance is based on the relative distance from the eight sub-goals, and on the proportion of the ten-year mandate completed, resulting in a scale ranging from 0 to 100. Reaching the goal at the end of the tenth turn (the last turn in that scenario) does not yield a score of 100. In this particular scenario, a score of 100 is attributed to reaching the goal in as few turns as possible (i.e., on Turn 5).

The logs thus create the possibility to analyze not only outcomes but also overt cognitive processing behaviors (i.e., process tracing). These behaviors include *situation assessment* (time in the situation tab), *information acquisition* (proportion of functions consulted, frequency, and duration), *course of action development* (time spent in the decisions tab), and *outcome assessment* (time spent studying feedback). The total time taken to complete a turn is called the *decision cycle* (encompassing all of the above).

E. Genetic Algorithm Extension

A major challenge when evaluating decision making effectiveness in complex situations is that of determining what a good or poor decision making performance is in that context. Indeed, deriving an optimal (target) performance level may be excessively difficult and solutions must be approximated using computational intelligence techniques.

We used the Evolver genetic algorithm (Palisade, Inc.) to search for the best possible solution to the COIN scenario. The goal of the algorithm was to search for a series of resource allocations (7 interventions X 10 turns) that would yield the highest possible score (reach the scenario objective in as few turns as possible). A specific CODEM mode was developed to enable communication between CODEM and an

Excel file. The parameters of the decision sequence were specified in the Excel file and optimized by Evolver (an Excel add-on). CODEM thus received input from the Excel file and performed a simulation for each set of parameters considered by Evolver. CODEM returned feedback in specific cells (score, and final turn number) of the Excel spreadsheet allowing Evolver to determine the fitness of candidate solutions. The fitness of solutions was defined using a multicriteria optimization approach (degree of satisfaction of the eight subgoals in the minimum number of turns).

The parameter values defined in Excel for each intervention in a given turn defined the relative distribution of the action points available for that turn amongst them. Initial trials searching the parameter space for up to 12 hours failed to converge on a satisfactory solution. Evolver never found a solution that satisfied all 8 criteria by the end of the 10^{th} turn. Clearly, considering each of the 70 decision elements as distinct parameters did not allow the Evolver algorithm to improve on past solutions. So, rather than requiring Evolver to search the 70-parameter decision space for greater amounts of time and thus solve the problem essentially through brute force, we reframed the problem into a linear (14-parameter) and non-linear (21-parameter) decision space. In the linear method, each of the seven possible interventions was represented using a distinct slope-intercept linear equation: $y = mx + b$. The intercept (b) corresponds to the initial priority of that variable on Turn 1. The slope (m) estimates how the priority of that variable increases or decreases as a function of x (i.e., as turns advance). The non-linear method used quadratic functions. The best fitness score obtained by Evolver (mutation rate = 0.25, cross-over rate = 0.5, population size = 50) with the linear method was 88%, compared to the non-linear method which found the best known solution (100%) to the COIN scenario, i.e., to reach all 8 sub-goals by Turn 5.

IV. CONCLUSION

CODEM was developed to provide an experimental platform for studying factors of effectiveness in complex decision making situations and as a testbed for the assessment of support technologies and methods. CODEM is a flexible simulation environment capable of generating turn-based decision making scenarios in any complex decision making domain. As an experimentation platform for cognitive experiments, CODEM is intended to help identify *requirements* for the design of training and technological support for decision making and adaptation in complex environments. As a cognitive engineering testbed, CODEM will be used to collect benchmark data and then provide an objective assessment capability for various support methodologies.

While the COIN scenario described herein focused on strategic level decision making, the ability to understand and adapt to complex situations is clearly important at all levels of command (strategic, operational and tactical). Indeed, many tactical decisions increasingly turn out to have major strategic impacts [51]. It would therefore be equally relevant to view the present COIN scenario from a more local/regional perspective. For instance, the UrbanSim simulated training environment (developed by the Institute for Creative Technologies for the U.S. Army Research, Development, and Engineering Command's Simulation and Training Technology Center) takes such a perspective, placing the trainee in the role of an Army battalion commander in charge of maintaining stability, fighting insurgents, and reconstructing the civil infrastructures in an urban setting [52]-[53]. Another potential application of CODEM is thus the development of cognitive training scenarios for individuals and teams [54]. The integrative concept of *cognitive readiness* refers to "possessing the psychological (mental) and sociological (social) knowledge, skills, and attitudes needed to establish and maintain effective performance and mental wellbeing in the dynamic, complex, and unpredictable environments of military operations" [55]. A series of experiments currently planned for CODEM aims to gather sufficient data to develop and validate a predictive model of cognitive readiness. The model, both guided by theory and specified using machine learning techniques, will combine individual characteristics (e.g., decision style, fluid intelligence, etc.), behavioral patterns (identified through process tracing), and the observed outcomes on a generic test in order to predict complex decision making ability and also to identify individual training needs.

The desired outcome of this applied research program is to augment the CF's ability for operational design and agility in complex operational environments. As aptly stated by LCol Cummings [56]:

> "A systemic understanding of all aspects of the battle space and linkages arising out of that battle space is required to allow for the intellectual flexibility to adapt to a highly agile adversary […] Operational Design is the foundation of Operational Art. Its pursuit informs the commander of the Operational problem and sets the theoretical underpinning and framework from which a Campaign Plan is created and conducted. The process of Operational Design has at its core, the aim of understanding the nature and form of an Operational problem such that a commander may best determine the critical path or way to achieving end state."

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