

Complexity symposium

On 28 February, CNA hosted an all-day symposium titled *Complexity: An Important New Framework for Understanding Warfare?* The purpose of the symposium was to explore the science of complexity as a potentially powerful new tool for use in military operations research in general, and for understanding the fundamentals of warfare in particular.

The study of complex adaptive systems has grown rapidly in recent years. A complex adaptive system is a dynamic system comprising many, typically nonlinearly, interacting adaptive parts. Complexity theory is rooted in the belief that much of the overall behavior of ostensibly diverse complex systems (such as natural ecologies, economic webs, and immune systems) stems from the same set of underlying principles.

Military conflicts, particularly land combat, possess the characteristic features of complex adaptive systems:

- Combat forces are composed of a large number of nonlinearly interacting parts and are organized in a command-and-control hierarchy.
- Local action, which often appears disordered, induces long-range order (i.e., combat is self-organized).
- Military conflicts, by their nature, proceed far from equilibrium; in order to survive, military forces must continually adapt to a changing combat environment.
- No master voice dictates the actions of each and every combatant (i.e., decentralized control).

The symposium featured several well-known and respected researchers in the field of complexity and evolutionary programming techniques. LtGen Paul Van Riper, USMC (Ret.), who introduced many of the ideas and metaphors of complexity into the military lexicon while he was Commanding General, Marine Corps Combat and Development Command (1994–1997), set the stage for the day's proceedings by providing the keynote speech.

CNA speakers included Dr. Andy Ilachinski, who presented his ongoing work developing an agent-based model of land combat called EINSTEIN; and Dr. Dave Taylor, who discussed preliminary results from the USMC Ground Combat Study using EINSTEIN as a testbed to explore squad and fire team size and organization. EINSTEIN is notable for being one of the first models to come out of the military operations research community to focus on *individual behaviors* and *personalities* rather than hardware. Additional information regarding CNA's complexity-related work may be viewed at www.cna.org/isaac.

In all, nearly 100 attendees represented a diverse mix of military, academic, and commercial interests. Although many attendees were from the surrounding areas (and included representatives from JWAC, MCCDC, IDA, SAIC, and MITRE, to name a few), many others came from out of town: the Air Force Research Laboratory, the Royal Military College of Canada, West Point Military Academy, U.S. Naval Academy, U.S. Army War College, and the CNO Strategic Studies Group at the Naval War College. Look for the conference brochure at www.cna.org/isaac/complexity_conference_1.htm. (Dr. Andy Ilachinski, (703) 824-2045)

Information-intensive environment

The new information technology now available to ships at sea has altered the operating environment for embarked staffs. The challenge of managing and absorbing the enormous quantities of information sometimes outweighs the promise of increased capability that accompanies increased access to broad sources of information. This problem is particularly keen for forward numbered fleets, such as Seventh Fleet, which are assigned as component commanders for some contingencies and JTF commanders for others. The information requirements for these different roles and crises can vary dramatically. And, due to the perception of the power of today's access to information, the time given these staffs for planning is often decreased while the expectations for quality are increased.

In a study for Seventh Fleet, we offered two recommendations for managing the abundance of information. We recommended that the Navy develop software to automate routine functions for which the fleets are responsible. Without the help of automation, staffs will not have the time necessary to mine all the information available to them today. Although this idea sounds obvious, it will be difficult to accomplish. Routine functions will need to be identified Navy-wide, and the purpose of the function and the data necessary to perform it will have to be well understood for the automated products to actually fulfill the commanders' requirements.

Our study showed that in addition to time, expertise is required for effective data mining. Expertise is essential to understanding what information is necessary and to converting information into knowledge useful for decision-making. Current staff structures, when kept within their hierarchical bounds, do not permit direct links between commanders and their sources of expertise. Our study recommended considering the N-codes as clusters of expertise rather than

treating the current staff structure as a hierarchy. In this model, staff personnel with the requisite expertise can be task-organized in specially designed teams to support rapidly evolving situations. In this way, the staff becomes a matrix organization with the expertise resident in the N-codes and the processes necessary for each situation designed to meet the specific need. This model requires no change in the current staff organization but rather a change in the way the staffs are employed.

Seventh Fleet and other staffs are already building centers of expertise and operating their staffs in a flatter way. But, until routine tasks are automated to free up time, the full potential of today's information-intensive environment will be difficult to realize.

(Ms. Christine Fox, (703) 824-2445)

GPS support to the warfighter

Military use of Global Positioning System (GPS) signals has become commonplace in such functional areas as communications, datalink usage, targeting, and navigation. The U.S. military relies on GPS availability in these areas, in some cases without realistic backup systems. But the GPS signal itself is weak, making it a potential target for hostile jamming. Jamming can be effective at denying GPS to many military systems and platforms under varying sets of circumstances.

CNA examined U.S. reliance on GPS by exploring the pervasiveness of GPS applications in the U.S. military systems. Specifically, we determined the vulnerabilities of major warfare systems to GPS jamming, considered the likelihood of GPS denial, and investigated alternatives in the event of GPS denial. The most interesting warfare areas were those with systems vulnerable to GPS denial but with insufficient or no backup systems. These systems were the focus of our analysis.

(Mr. Bruce Borey, (703) 824-2374)

Amphibious lift requirements

In 1989 the Secretary of the Navy asked the Chief of Naval Operations and the Commandant of the Marine Corps to conduct a combined USN/USMC study to redefine amphibious lift and support requirements. Are those lift requirements still valid today? Many observers argue that an amphibious lift requirement based on an outdated operational concept and 12-year-old force structure data cannot be valid. Others believe that, although it is dated, the requirement remains a good basis for programming purposes.

CNA has undertaken a project to help the Marine Corps examine how new operational concepts and capabilities affect the lift requirement. We will develop a range of possible lift options based on various ideas for implementing the concepts; determine the physical parameters of each option; and compute their potential lift requirements. To do this, we are developing an analytical model that can be applied to a variety of scenarios. The model will allow planners to see and understand quickly the tradeoffs being made among the size of the assault force, the rate at which it comes ashore, the distance it travels from ship to shore, the kinds of maneuvers conducted ashore, the potential withdrawal and redeployment, and the amphibious force structure necessary to support the operation. The model will allow planners to explore a wide range of potential ways to implement the new concepts and determine their impact on the lift requirement—and ultimately on the amphibious fleet.

(Mr. Dwight Lyons, (703) 824-2595)

The P-3 replacement

After 40 years of service, the P-3s and EP-3s are finally reaching the end of their useful airframe lives. Fatigue and corrosion problems have reached the point where the lifespan of the airframes cannot be extended without large investments, and operating and support costs have

grown to inordinately high levels. The potential loss of the capabilities provided by these maritime patrol and reconnaissance aircraft creates significant warfighting deficiencies, especially for responsive wide-area tasking beyond the reach of battlegroup assets.

CNA is leading a team of analysts in an analysis of alternatives (AoA) to examine how the critical warfare capabilities currently provided by the P-3 and EP-3 can best be provided in the future. The team comprises operational analysts, conceptual design engineers, and cost analysts from NAVAIR and CNA. We began by examining a wide range of potential solutions for maintaining the required capabilities. We concluded that a manned platform, capable of carrying significant payloads and operating at extended ranges from land bases, is required to provide the capabilities. We identified four aircraft that satisfy the performance capabilities required. In addition, we recommended variants of the Global Hawk unmanned aerial vehicle (UAV) as potentially useful complements to a manned aircraft. UAVs could assist manned aircraft in performing their missions and conduct surveillance missions where manned aircraft capabilities are not required—potentially reducing required manned aircraft force levels. The UAVs extended time on station could also provide useful new capabilities.

Currently, we are examining the four aircraft types and Global Hawk alternatives to ascertain their cost and effectiveness and to identify unacceptable performance deficiencies.

(Mr. Joe Penny, (703) 824-2789)

Reducing heat effects on the flight deck

Aircraft carriers deploying to the Persian Gulf in the summer months can expect temperatures on the flight deck to soar to 140° F, placing carrier and airwing personnel in danger of heat stress or heat stroke. As part of a larger study, Com-

mander, Naval Air Force, U.S. Pacific Fleet asked CNA to investigate ways to reduce the detrimental effects of high heat and humidity on flight-deck personnel.

We enlisted the help of the U.S. Army Research Institute of Environmental Medicine, experts in the field of physiological effects of heat on humans. To determine the physical labor required of personnel working on the flight deck, CNA analysts observed flight-deck personnel during a recent underway period on USS *Constellation*. Coupling our understanding of the physical requirements with USARIEM's research and historical data on weather in the Persian Gulf, we are able now to assess the likelihood of flight-deck personnel suffering heat stress under a variety of operational conditions.

Our analysis also showed that, with access to cool spaces in which to take short breaks, flight-deck personnel are less likely to suffer heat stress or heat stroke. Although these spaces existed on USS *Constellation*—the carrier scheduled to operate in the Persian Gulf this summer—not all were sufficiently cooled to provide the potential benefit. After determining that modifying *Constella-*

tion's spaces before deployment was feasible and that funds were available for the modifications, we recommended to AIRPAC that those spaces be outfitted with additional air conditioners. CNAP endorsed CNA's recommendations, and auxiliary air conditioners have been installed in the flight-deck personnel's break spaces in time for *Constellation's* upcoming deployment.

(Dr. Angelyn Jewell, (703) 824-2373);
Dr. Timothy Roberts, (703) 824-2853)

Mr. Rick Kohout honored

In recognition of his outstanding performance as CNA's field representative to Marine Forces Pacific, Mr. Rick Kohout has been awarded the Department of the Navy's Meritorious Public Service Award. While assigned to MARFORPAC, Mr. Kohout contributed analytically to a variety of issues, including the deployable component headquarters, MARFORPAC's Strategic Vision Statement and Strategic Plan, and force readiness. The citation notes that Mr. Kohout's many contributions "have made a lasting difference in the staff's efficiency and the combat readiness of Marine Forces Pacific." Mr. Kohout is currently CNA's representative to I MEF.