

# Developing Intellectual Tools to Support C4ISR Analyses for Operations Other Than War

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## Abstract

On 28 - 30 January 1997, the Military Operations Research Society (MORS) conducted a workshop on Operations Other Than War (OOTW) Analysis and Techniques at MacDill AFB, Tampa, Florida. One of the panels at that workshop focused on the steps that should be taken to develop the intellectual tools needed to support command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) analyses for OOTW. This paper summarizes the major findings and recommendations that emerged from that panel's deliberations.

The paper begins with several frameworks for conceptualizing and scoping the problem. This is followed by a discussion of the nature of the problem. This subsumes a comparison of

conventional warfare and OOTW, an enumeration of key OOTW challenges, a summary of key characteristics of OOTW, and broad requirements for C4ISR intellectual tools. After a brief summary of major findings, the paper identifies and discusses several recommendations to ameliorate major issues. The major recommendations focus on the issues posed by the management of information.

## 1. Frameworks and Scope

### 1.1 Alternative Perspectives

The complexity of the C4ISR OOTW problem is such that it requires several complementary frameworks to help conceptualize the problem. The icon presented in Figure 1 depicts the component parts of the subject area and their relationships. The decomposition into the 12

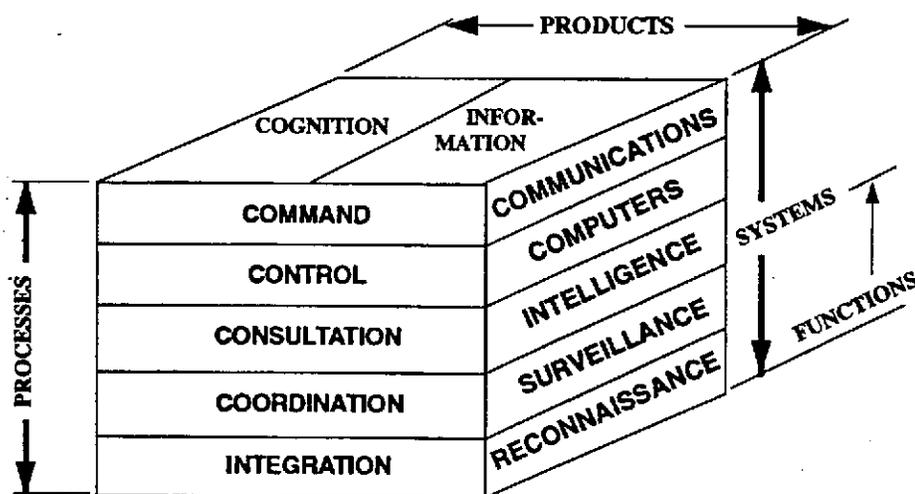


Figure 1. OOTW Decomposition: C4ISR

component areas suggests the inelegant acronym C<sup>7</sup>I<sup>3</sup>SR, vice the more traditional (and almost as inelegant) C4ISR that is used by traditional warfighters.

The acronym C<sup>7</sup>I<sup>3</sup>SR will be used throughout this paper for the following reasons. First, it highlights the fact that **consultation** and **coordination** are generally of greater significance in OOTW operations than they are in traditional warfare. Second, it focuses attention on the difficult task of **integrating** the diverse processes, functions, and systems into a coherent whole. Finally, it gives visibility to the fact that the key products that are generated by these interrelated processes, functions, and systems are **information** and the **cognition** that guides the operators' actions.

From a mission perspective, LtGen Anthony Zinni, USMC, Deputy Commander in Chief, Central Command, a plenary speaker at the workshop, proposed the following taxonomy. He decomposed OOTW operations into the categories of assisting failed or incapable states; dealing with transnational threats (e.g., crime, environmental threats); and domestic support to civilian authorities (e.g., aid in coping with civil disturbance, counternarcotics operations, natural disasters).

## 1.2 Scope

The panel employed the decomposition depicted in Figure 1. Ten areas were addressed in turn (i.e., cognition, command, control, consultation, coordination, integration, communications, computers, information, and ISR<sup>1</sup>). For each of the ten areas, the panel identified key issues about the relevant tools, formulated recommendations to ameliorate/resolve those issues, and identified key organizations that should take the lead in addressing those issues. Particular attention was paid to the issues of information management, non-traditional organization, and "scouting".

From a mission perspective, the panel focused on the tools needed in operations designed to assist failed or incapable states. Within that

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<sup>1</sup> Intelligence, Surveillance and Reconnaissance (ISR) was treated as a single entity.

context it emphasized tools to support operations and training.

## 2. Nature of the Problem

To clarify the nature of the problem, this section compares conventional warfare and OOTW, enumerates key OOTW challenges, summarizes key characteristics of OOTW, and cites broad requirements for C4ISR intellectual tools.

### 2.1 Comparison: Conventional Warfare and OOTW

The panel compared conventional warfare and OOTW with respect to four categories: mission, principles, information, and analysis (see Figure 2).

#### 2.1.1 Mission

In conventional warfare, the mission tends to be relatively stable, there is a clear focus on the enemy, and the military has a common understanding and commitment<sup>2</sup>. Conversely, in OOTW the mission is often more dynamic. This is captured by the (often pejorative) term "mission creep." In many of the operations in question, there is no "enemy." This is obviously true for operations such as humanitarian assistance and disaster relief. In addition, peacekeeping activities involve protagonists who must be treated even-handedly if the operation is to be successful. In the latter missions, political-military ambiguities frequently result in uncertain understanding of the goals and objectives of the mission and a limited commitment<sup>3</sup>.

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<sup>2</sup> As an illustration, General Colin Powell, then Chairman, Joint Chiefs of Staff, summarized the mission in Desert Storm by stating that "First, we will cut off the enemy and then we will kill it."

<sup>3</sup> As an example, the US Congress has continually sought to impose an arbitrary deadline for US forces to withdraw from Bosnia.

Category	Factor	Conventional Warfare	OOTW
Mission	Stability	Relatively stable	May be more dynamic
	Focus	Enemy	(May not be an "enemy")
	Understanding, Commitment	Common (mil)	Uncertain (pol-mil)
Principles	Unity	Of command	Of purpose
	Decisionmaking	Hierarchical	Consensus
	Operations	Surprise	Transparency
Information	Nature of the Problem	Known unknowns	Unknown unknowns
	Key Question	How to get info	What info to get
	Focus	Enemy military	Mil-pol-eco-social factors
	Situation Awareness	Common air-land-sea	Limited dissem, more complex
	Databases	Very large, well structured	Larger, less structured
Analysis	Unit	"Bn-level"	Individual behavior
	Ease in integration	Relatively easy	Very difficult
	Focus	Military (systems, org)	Pol-Mil and societal
	Approach	Traditional MOR	"Softer" analysis

Figure 2. Comparing Conventional Warfare and OOTW

### 2.1.2 Principles

Military theorists have frequently propounded basic principles of conventional warfare. Three often cited principles include the need for unity of command, the importance of hierarchical decisionmaking, and the criticality of achieving surprise in operations. A recent book has proposed alternative principles for OOTW [Alberts and Hayes, 1995]. It cites the need for unity of purpose, consensus decisionmaking, and transparency of operations.

### 2.1.3. Information

In conventional warfare, the issue of information gathering and management focuses on the issue of "known unknowns" (e.g., where are the enemy's battalions?). For that case, the key question is *how* to get the needed information (e.g., what are the key signatures for the targets in question? what sensors should we task to exploit those signatures?). Clearly, the focus is on the enemy military and one objective is to

assemble a complete, timely, and accurate common picture of the air-land-sea situation. The result is a very large, time sensitive database, but one that is relatively well structured (e.g., enemy order of battle). Conversely, in OOTW the problem of information gathering and management is dominated by "unknown unknowns." Thus, the primary question to address is *what* information to get. The information focus is much more diffused because of the myriad of military, political, economic, and social factors that must be considered. Consequently, situation awareness is much more complex and political considerations often make it prudent to limit the dissemination of information. In addition, the resulting databases are frequently larger and less structured.

### 2.1.4 Analysis

Over the years, the military operations research community has become relatively adept at analyzing key aspects of conventional warfare. As an illustration, analyses of ground warfare of-

ten focus on battalion level operations and techniques have emerged to integrate across those results to derive insights into campaign outcomes. The focus is on military systems and organizations and the techniques in question involve a broad set of methods (e.g., mathematical programming, decision theoretic approaches) and tools (e.g., models and simulations). Conversely, analyses of OOTW often require consideration of individual behavior and it has proven very difficult to integrate across these results to derive a comprehensive understanding of the problem. The problem is compounded by the many factors that have to be considered in the analysis process (e.g., military, political, economic, social). This has led to the application of “softer” analytic approaches (e.g., extensive reliance on expert elicitation).

## **2.2 Key C<sup>7</sup>I<sup>3</sup>SR OOTW Challenges**

During the course of his plenary presentation LtGen Zinni identified a number of key OOTW challenges. Several of those challenges were relevant to the C<sup>7</sup>I<sup>3</sup>SR community. As a context for this paper, those C<sup>7</sup>I<sup>3</sup>SR-related challenges are summarized briefly below.

### **2.2.1 Command and Control Arrangements**

LtGen Zinni observed that traditional warfare command and control arrangements are inappropriate for many types of OOTW. As an illustration he cited his experience in assisting failed or incapable states (e.g., Somalia). He suggested that a non-traditional command and control arrangement be considered that featured a “committee” of affected participants at the top, a less-burdened Civil-Military Operations Center (CMOC), and subordinate CMOC Teams.

### **2.2.2 Rules of Engagement (RoEs)**

LtGen Zinni noted that formulating and implementing appropriate RoEs is an extremely challenging task for OOTW. As an illustration, he cited situations in Somalia where women hid weapons under their clothing which they delivered to men after passing through checkpoints. In a Muslim society, it would have been incon-

ceivable to subject the women to body searches. The RoE challenge is likely to grow with the development and potential application of non-lethal weapons in support of OOTW.

### **2.2.3 Participant Incompatibilities**

Many OOTW actions involve a heterogeneous coalition of national entities as well as a spectrum of Non-Governmental Organizations (NGOs). Recent experience has served to highlight the cultural differences among these participants that tend to hinder effective consultation and coordination (e.g., differences in agenda and sympathies). In addition, the problem is exacerbated by technical differences (e.g., many NGOs lack contemporary information systems or communications systems; the capabilities that they possess are rarely interoperable with military systems).

### **2.2.4 Measures of Merit**

One of the fundamental challenges is to formulate and monitor Measures of Merit (MoMs) that can be used to understand the situation, measure progress, and reconcile disparate assessments. As an illustration, LtGen Zinni recalled an incident in Operation Provide Comfort where the availability of meat in Kurdish butcher stores was employed as one MoM. It was originally reported that the operational situation was improving because there was a great deal of meat available for sale. It was subsequently concluded that the availability of meat was a negative measure because it revealed that the Kurds were forced to slaughter their herds since they could not sustain them and that the prices were so high that no one could afford to buy the meat. This argues for the generation and monitoring of a family of insightful, linked MoMs.

### **2.2.5 Cultural Intelligence**

One of the greatest challenges confronting the military is the acquisition of relevant cultural intelligence (e.g., who is the real leadership elite? what do they value?). LtGen Zinni observed that the problem is exacerbated by the asymmetry in the problem. Many of the indigenous leaders in a flashpoint operation have been educated in the West and understand

western culture extremely well (e.g., western values; opportunities to influence the media). As an example, General Aideed from Somalia was educated at Ft. Leavenworth and Harvard University. Thus, they are frequently adept at influencing western public opinion while we lack a comparable understanding of how to identify and manipulate local levers of power.

### 2.2.6 Consistent Postures

An effective OOTW often requires the generation and implementation of an internally consistent posture and story. This consistency is required to ensure that standard operations, psychological operations, and media relations are coherent and mutually reinforcing.

### 2.3 Key Characteristics of OOTW

During the deliberations of the panel, six key characteristics of OOTW were identified. These characteristics reflect many of the challenges cited by LtGen Zinni. First, many OOTW are characterized by a highly uncertain, time-varying environment. One manifestation of this characteristic is the phenomenon of "mission creep." Second, it was emphasized that for many OOTW, there is no "enemy." In the case of peacekeeping in a failed state, there may be antagonism on the part of the disputants, but even-handedness must be manifested on the part of the peacekeeping force. Third, these operations are generally heterogeneous in many dimensions. This includes the participants who often subsume supra-national organizations (e.g., United Nations personnel), many national entities (from the military-diplomatic-social sectors), and non-governmental entities, as well as the information systems that these participants employ. Fourth, the political-social-economic dimensions of the operation frequently imply the need for contextual and specialized knowledge that is not easily available to the military. Fifth, many recent OOTW are characterized by severe time pressures. This generally implies that there will be inadequate time to create needed tools after the need for the operation is apparent. Finally, it is difficult to select and evaluate meaningful, unambiguous MoMs to support decisionmakers at all levels. These observations helped the panel focus its further deliberations.

## 2.4 Broad Requirements

Two broad classes of requirements emerged during the course of the workshop. These requirements can be aggregated into the categories of "operational tools" and "analyst<sup>4</sup>."

### 2.4.1 Operational Tools

One of the plenary speakers, BG Brown, USAF, J5, Special Operations Command (SOCOM), identified the broad requirements that intellectual tools must satisfy if they are to support OOTW effectively. He observed that these tools must be easy to use and train on. From a SOCOM perspective, it is important that they be small, portable, and relatively compact. In addition, constraints on personnel and available organic skills suggests that these tools be supported by others (e.g., for maintenance, help desks). Since each OOTW tends to be distinctive, these tools must be easily adapted/tailored. To meet the needs of users, these tools should be capable of supporting both information push (i.e., selectively sending key information to the user) and information pull (i.e., enabling the user to identify, locate, and extract needed information). In view of the heterogeneity of the environment, the tools should be designed to be interoperable with other cultures and systems/data. Finally, if the tool is to be useful, its products must be understandable and explainable.

### 2.4.2 Analyst

The panel felt strongly that the analyst is an inseparable component of the OOTW intellectual tool-analyst team. To discharge that responsibility effectively, the analyst must be educated and trained in doing OOTW analysis. This implies that the analyst must be conversant with the multiple dimensions of an OOTW (i.e., military, political, social, economic). If the tools are to be useful, the analyst must be involved in specifying them and providing feedback as they evolve. In addition, the analyst must understand the tools sufficiently that he can explain the meaning of their outputs.

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<sup>4</sup> Additional requirements for OOTW Support Tools are cited in [Hartley, 1995].

### 3. Findings

The panel developed five major, inter-linked findings. First, it concluded that C4ISR for war and C7I3SR for OOTW differ considerably with respect to mission, principles, information, and analysis. For example, the broader scope of OOTW operations (e.g., subsuming humanitarian, social, political, and economic factors, among others) generally makes a fundamental difference in the nature of relevant information. In war, the focus is on "known unknowns" and the basic issue is *how* to get the information. Conversely in OOTW, the focus is often on "unknown unknowns" and the basic issue is *what* information to get.

After analyzing these differences, the panel concluded that they mandated substantial differences in the kinds of tools that were needed to support C7I3SR for OOTW (vice C4ISR operations in support of conventional warfare). This was particularly apparent in the areas of cognition, command arrangements, selected staff control functions, consultation, coordination, integration across functions, and information management. The panel concluded that, currently, there is a dearth of tools to support operations in those areas. This problem is exacerbated by our lack of understanding of OOTW C7I3SR.

However, in the near term, the panel was able to identify several opportunities to ameliorate deficiencies in the tools needed to address selected C7I3SR issues. For example, it was felt that efforts to enhance education and training of the analyst-operator team, in the area of OOTW and C7I3SR, could significantly improve operational effectiveness. In addition, several information system products (e.g., commercial data mining tools, auto summarizer software) have the potential to ameliorate selected, specific deficiencies.

The panel felt, however, that it would take concerted, long term action to ameliorate the most critical deficiencies in tools across the full range of C7I3SR issues. The thrust of this effort should be to develop an integrated family of diverse tools, taking advantage of information technology and the broader reservoir of knowledge and skills that lie outside the traditional

military OR boundaries. The following section identifies and discusses recommendations to respond to this finding.

### 4. Recommendations

#### 4.1. Information Management

The primary issue identified by the panel revolves around the need to manage information strategically to provide a meaningful context for the product/process "Cs" (i.e., cognition, command, control, consultation, coordination). To respond to this challenge, the panel recommends that an orchestrated, tiered set of tools be developed to address the issue. As a foundation for these tools, a strategic conceptual framework is needed. This would include a taxonomy that identifies key knowledge domains of interest, associated key variables and their relationships, and a hierarchy of measures of merit (e.g., ranging from measures of system performance through measures of policy effectiveness).

Second, a database must be assembled that instantiates the conceptual frameworks cited above. In view of the potential size of the database it is important to take a strategic perspective in conceiving and implementing it. It is envisioned that the database will begin with a core capability and evolve in time, reflecting the knowledge derived from OOTW experiences. The database would subsume encyclopedic information, a world almanac, demographic information, media databases, maps, information derived from political and diplomatic sources, and lessons learned from prior OOTW experiences. It is anticipated that the database will be highly distributed and that appropriate steps will be taken to assure access to authorized users.

Third, the analyst will need a set of tools to take advantage of the information contained within the database. These tools will include data mining tools (both to identify datasets that should be tapped to augment the strategic database and to extract meaningful data and relationships from the strategic database), information compression tools (to be discussed below), and visualization tools.

Fourth, it is recognized that any strategic database will be incomplete in terms of any new, unanticipated OOTW. To deal with this eventuality, the analyst will need an "electronic rolodex" to identify key subject matter experts and to facilitate access to them (e.g., at a minimum, phone numbers, e-mail addresses). If this source is to satisfy the analyst's needs, it is important to develop and nurture close relationships with key centers of excellence. As a model, the DoD has developed a strategic relationship with MEDEA, a set of environmental experts. A dialogue has been established to educate the environmental experts about the issues of interest to the DoD and to educate the DoD about how to work with them.

Fifth, it is often difficult to extract information from experts, particularly when there is no existing strategic relationship.<sup>5</sup> To facilitate that dialogue, systematic expert elicitation techniques should be developed and implemented. As an example, it may prove useful to build upon and extend RAND's Subjective Transfer Function technique [Veit and Callero, 1993].

Sixth, the analyst will need a set of predictive models to help evolve the strategic database and to support the generation of key information needs. In the first instance, it would be useful to have a tool to assist the analyst predict where and when OOTW operations are likely to be conducted. Such a tool will provide the analyst with lead-time in identifying and accessing key data and in identifying and locating key experts. An example of such a tool is the instability predictor developed by EBR [Scarborough, 1997]. In the second instance, decision aids are needed to help the analyst anticipate the implications of candidate actions (e.g., a transportation model to estimate the level of traffic congestion that would ensue if workers were sent home early in anticipation of an imminent natural disaster).

Finally, it would be valuable to provide an analyst with a handbook of key indicators to help him monitor and characterize an OOTW. LtGen Zinni noted that TRADOC had generated an early version of such a product. Overall, it must be stressed that the analyst will need a

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<sup>5</sup> E.g., "ask an expert what the time is and he will tell you how to make a watch".

family of orchestrated tools to support the broad information needs of the participants in an OOTW operation.

If an analyst is to be able to cope with the avalanche of data that can emerge from searching a strategic database, he will require several ancillary tools. One potentially interesting tool is auto summarizer software. To suggest the potential utility of such a tool, consider Microsoft's Auto Summarizer Software which is an element of Office 97. To suggest its capabilities, The New York Times employed the tool using President Clinton's 2,010 word Second Inaugural Address [Caruso, 1997]. The Auto Summarizer formulated a compressed 93 word version which effectively captures the main thrust of the Address<sup>6</sup>.

There are several points to draw from this example. First, it is obvious that the products of the media should be an intrinsic element of the strategic database. Second, even though this tool is just an initial version, it shows promise. Although some workshop participants argued that a political speech is too easy a test case, analysts supporting an OOTW will have to mine political utterances for their information value. Third, it is likely that an analyst would have to work carefully with any output to ensure that it is meaningful and effectively compressed.

Such a tool might have another value in support of operations. Where Napoleon would employ a corporal to ensure that his orders were clear and unambiguous, such a tool might one day play an analogous role.

The panel put forth two near-term recommendations on information management to establish a foundation for the longer-term recommendation. First, in recognition of the complexity and size of the objective capability, it is recommended that a plan of action be developed to guide and focus community action. It would be appropriate for all the directorates of the Joint Staff to participate in the drafting of such a plan, with appropriate assistance from the

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<sup>6</sup> As a tongue-in-cheek aside, one member of the panel further compressed the text to 24 words, only 9 of which were different (i.e., the word "blah" appeared 16 times).

CINCs. It is anticipated that such a team would gain access to appropriate technology expertise so that they are able to reflect those developments in their deliberations.

Second, it is recommended that a preliminary prototype set of tools be assembled and evaluated. As suggested above, there are several commercial off-the-shelf products available (e.g., SGI's data mining and visualization tools; Microsoft's and Apple's auto summarizers). These constitute "low hanging fruit" that could provide near-term support to the analyst. To establish proof of principle, it is recommended that such tools be assimilated and evaluated in on-going testbed programs (e.g., NRaD's Command Center of the Future).

## 4.2 Additional Recommendations

The panel developed several additional recommendations to respond to the needs of the other dimensions of the C<sup>7</sup>I<sup>3</sup>SR problem. A subset of these recommendations is identified and discussed briefly below.

### 4.2.1 Command

As noted by LtGen Zinni, there is a need for tools to support the generation of non-traditional, flexible C<sup>2</sup> organizations that can adapt to changing conditions (e.g., changes in missions). It is recommended that the community take advantage of the tools techniques and insights emerging from the Office of Naval Research's (ONR's) Adaptive Architecture for Command and Control (A2C2) program (e.g., employ graph decomposition techniques) [Serfaty, 1996]. ONR should take the lead in this activity.

### 4.2.1 Cognition

Due to the complexity and ambiguity of the situation in an OOTW, it is frequently difficult for the commander and the staff to develop a shared, coherent understanding of the situation. It is recommended that activities be undertaken to develop a conceptual framework and associated tools for characterizing the common operational picture, subsuming the military-political-social-economic aspects. A multi-

disciplinary team is required, to include NDU (ACTIS) and the Service Laboratories.

### 4.2.3 Coordination/Consultation

There is a need for tools to support coordination/consultation among heterogeneous participants (e.g., political, diplomatic, coalition, military, NGO). In the interim, a near-term capability should be developed, with DISA in the lead, taking advantage of existing Internet technology. In the longer-term, DARPA (ISO), should adapt advanced Internet and collaborative technology to the problem area.

### 4.2.4 Control

There is a need to make staff support tools more user friendly and less demanding on training. It is recommended that a testbed be established to enable users to experiment with innovative information technology products that promise to facilitate operator-system interfaces. Leading software innovators (e.g., MIT's Media Lab, Xerox PARC) should be tapped as a key source of technology. A facility like NRaD's Command Center of the Future should be considered as a potential testbed environment.

### 4.2.5 Communications

The staff needs tools to facilitate the creation and management of communications networks that reflect the mix of systems in the inventories of potential multinational participants in OOTW. It is recommended that DISA take the lead in assembling a database of feasible communications combinations (e.g., expanded, updated versions of JINTACCS products).

### 4.2.6 Computers

The networked computer systems of forces involved in OOTW operations must support required performance levels with a limited forward footprint. It is recommended that the DARPA/DISA JPO take the lead in achieving requisite performance levels through an application of the Global Command and Control System (GCCS) Anchor Desk concept.

#### 4.2.7 Integration

There is a need for tools to support the conceptual synthesis of all of the above. It is recommended that a testbed be developed to investigate integration issues. One possibility is for the J8, Joint Staff, to take the lead and expand the Joint Battle Center to include coalition, diplomatic, and NGO participation.

#### 4.2.8 ISR

In the area of ISR, the most critical element of the toolset is a properly educated and trained analyst. For the "scouting" problem, it is recommended that traditional methods of search and screening be adapted to the OOTW domain. Within this context human factors dominate and HUMINT is a vital ingredient. It is recommended that it is inappropriate to have tools that seek to provide "optimum" solutions. Rather, it is more appropriate to have timely, satisficing tools. In the near term, it is hoped that by following this approach, it will provide results to the operator that are sufficiently useful to win his trust and confidence.

#### 5. Conclusions

Based on its deliberations, the panel came to three broad conclusions. First, there is a need for an orchestrated spectrum of tools to support the mix of tasks associated with C<sup>7</sup>I<sup>3</sup>SR. It is clear that failure to orchestrate these efforts would result in an inadequate capability.

Second, a two-pronged effort should be pursued, in the near term. One prong should focus on developing a strategic action plan to ensure that the tool set is truly orchestrated. The other prong should seek to ameliorate pressing near term needs. This includes efforts to forge, educate, and train analyst-operator teams, and to begin to establish relationships with them and key subject matter experts (e.g., linguists, anthropologists, political scientists). It also involves the creative application of existing information technologies (e.g., data mining tools, auto summarizers, visualization tools).

In the longer term, a broader set of tools should be developed and orchestrated. These tools should include evaluation techniques (e.g.,

gaming activities, M&S, testbeds (such as the Joint Battle Center), exercises, and expanded lessons learned activities); data management techniques (going well beyond current capabilities in creating, sustaining, and exploiting extremely large databases), the adaptation of advanced information technologies (e.g., an advanced Internet, riding on NSF's Very-High Performance Backbone Network Service), and the establishment of partnerships with selected centers of excellence (e.g., MEDEA, Center of Excellence in Disaster Management and Humanitarian Assistance). This capability should be developed employing an evolutionary acquisition paradigm.

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