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**Human Interoperability: experimentation to
understand & improve the human component
of complex systems**

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**NAVAL
POSTGRADUATE
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Monterey, California

**Human Interoperability:
Experimentation to Understand & Improve
the Human Component of Complex Systems**

by

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30 September 2008

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Prepared for: OSD NII

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13. ABSTRACT (Maximum 200 words.) The Human Interoperability (HI) initiative is intended to improve the responsiveness, efficiency, and effectiveness of organizations when they partner externally or internally. This document reports findings from initial research, led by OSD NII, to explore the discipline and dimensions of HI. The goals of the research team were to develop theory concerning HI, capture and analyze initial evidence of barriers to organizational collaboration, and to outline objectives for future research.				
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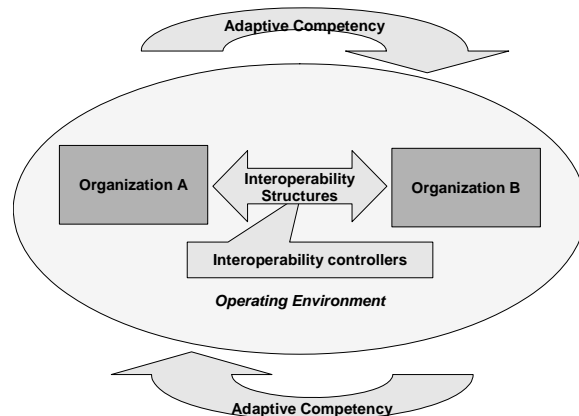
Executive Summary

The Human Interoperability (HI) initiative is intended to improve the responsiveness, efficiency, and effectiveness of organizations when they partner externally or internally. This capability should improve the ability of organizations to execute missions across the continuum from normal and routine (such as Maritime Domain Awareness and maintaining port security) to national crises (such as major terrorist attacks).

Human Interoperability research beginning in FY 08 and continuing in future years will produce three products: (1) a structured, multi-disciplinary method for studying inter- and intra-organization collaboration at the operational level, and a taxonomy of barriers and solution strategies; (2) a specification of barriers to Human Interoperability in DoD and its partners; and (3) tools for organization designers and leaders: case studies, guidelines, measures, and models that support partnership planning.

This document reports findings from initial research, led by OSD NII, to explore the discipline and dimensions of HI. The goals of the research team were to develop theory concerning HI, capture and analyze initial evidence of barriers to organizational collaboration, and to outline objectives for future research.

The team's initial approach to a theoretical framework of human interoperability between large organizations and organizational partnerships focused on organizations as complex systems. In this view, organizations shape, and are shaped bi-directionally, by their environments. Organizations employ a catalog of structures (personal relationships, liaisons, joint task forces, information sharing and systems, etc.) through which they coordinate and execute work, and trade valued products, such as information. Several mechanisms – policy, processes, cultural factors, information systems, and individual competency – modulate the type, method, speed, volume, and quality of activity over these structures. Astute organizations adapt structures and control mechanisms over time. They cannot reliably do this by choosing between structures and controls that are engineered into the organization a priori, because organizations typically are not designed for adaptation, nor would they be efficient or effective on any given mission if they were crafted to satisfy all possible future missions. Rather, the complex systems view leads us to postulate that organizations, like their individual members, develop an adaptive competence to form, use, and evolve structures and controls that improve inter- and intra-organizational performance. The nature of these competencies is a focus of proposed research, as is the catalog of structures and controls that organizations develop.



The first experimental HI event, HI 08, took place in June 2008. OSD NII assembled a research team to conduct this initial investigation of Human Interoperability issues. The team executed its

study during Trident Warrior 08 (TW 08, a NAVNETWARCOM sponsored field experiment) in June 2008. The data collected in interviews informed our understanding of many of the structures and controllers referenced above. We present a summary of these findings and of their implications for the design and conduct of organizational partnerships on page 18 in Table 1.

We recommend that a program of research be developed to significantly deepen and broaden our understanding of Human Interoperability barriers and solutions for DoD organizations. This work will produce refined methods for studying this and other complex fields of human interaction, and it will lay the foundation on which to develop products for training and aiding leaders as they develop partnerships that strengthen their organizations and accomplish missions. Critical to that research is the definition of objectives and questions it must address. We have drafted those products, and describe how they can be put to use on page 21.

The authors welcome comments and recommendations concerning this work. Please contact Dr. Shelley Gallup, Naval Postgraduate School, spgallup@nps.edu, or Dr. Jared Freeman, Aptima, freeman@aptima.com.

Introduction

Human Interoperability: Its Function, Form, and Future

The Human Interoperability (HI) research initiative is intended to improve performance within organizations and between them. More specifically, HI research is intended to improve the responsiveness, efficiency, and effectiveness of organizations that must partner or dynamically integrate elements of their organization (people, processes, resources, authorities, responsibilities) with those of others in periods of unique and possibly disorienting need. This improved adaptability of organizations is theorized to also increase their ability to execute missions across the continuum from normal and routine (such as Maritime Domain Awareness and maintaining port security) to national crises (such as major terrorist attacks).

Barriers to effective cross-organization collaboration are increasingly a subject of concern as DoD and its partners attempt to coordinate activity at multiple levels during unique operations that bring together new combinations of organizations to address a broad spectrum of needs. This is precisely the challenge facing the Department of Homeland Security; DHS has struggled and sometimes failed to integrate its seven operational units¹ (Hocevar, Thomas, and Jansen, 2006). The HI research initiative attempts to (1) to develop a structured, multi-disciplinary approach to analyzing collaboration, co-operation, and coordination success and failures at the operational level; (2) identify and categorize barriers to these activities; (3) and design, develop, and test solutions that overcome these barriers. To accomplish this, the HI initiative must develop theory, experimental methods, measures, and experiments that grow knowledge of human interoperability, as well as products of direct benefit to organizations: dynamic models to support HI diagnosis and design, guidance to leaders, exemplars that motivate improvement.

In somewhat greater detail, the HI research team aims to develop:

- Experimentation -- Conduct an initial study, piggybacking the resources of Trident Warrior '08, that surfaces barriers to HI. Conduct more structured and rigorous experiments beginning in FY09.
- Methodology -- Define an efficient and productive method for studying HI in experiments.
- Theory -- Define a theory that enumerates the types of human interfaces and protocols that enable effective collaboration between organizations. Test and refine this theory through experimentation.
- Measures -- Define measures of human interoperability between enterprises, and of the effectiveness of interfaces that support interoperability.
- Exemplars – Identify, foster, and publicize examples of HI, organizational interfaces that the community can inspect and replicate to improve the enterprise.

¹ The operational entities within DHS are Transportation Security Administration, U.S. Customs and Border Protection, U.S. Citizenship and Immigration Services, U.S. Immigrations Customs Enforcement, U.S. Secret Service, the Federal Emergency Management Agency, and the U.S. Coast Guard.

- Management resources – Develop guidance that helps leaders efficiently, reliably, and measurably improve HI. This guidance will be identified through sensitivity analyses conducted using the modeling technology, above.
- Organizational design resources – Apply systems engineering principles to define design elements – structures, processes, training, etc. – that increase the potential for human interoperability.
- Model – Define formal models of HI that support reliable diagnosis of causes of failures of HI and prediction of intended and unintended effects of actions to improve HI. Implement this model in a software tool that aids leaders of organizations, as well as researchers who must test new hypotheses about HI and methods of managing it.

The first HI experimentation, HI08, took place in June 2008. OSD NII assembled a research team to conduct this initial investigation, under the direction of Stefania Brown-VanHoozer, Ph.D. The team executed its study during Trident Warrior 08 (TW 08), a field experiment sponsored by NAVNETWARCOM. Data collection in HI08 focused on three dimensions of HI:

- (1) human infrastructures (personal relationships, liaisons, joint centers, etc.) that people establish to coordinate their work with other humans – person-to-person, person-to-organizations, person (s) to systems;
- (2) factors that control the volume and quality of work executed through this infrastructure, e.g., policy, processes, social-cultural nuances, cognitive issues, human interaction with information systems, authoritative lanes, and other factors of human interactions;
- (3) sharing of information

Findings from that effort are reported here, as are recommendations concerning future HI experimentation. We begin, however, by presenting a draft theory of HI to help the reader understand the orientation of this effort and the structure of the analyses reported below.

Toward a theory of Human Interoperability

This section of the report presents a draft theory of Human Interoperability. The theory serves several functions. First, it clarifies what we mean when we talk about Human Interoperability. Second, it familiarizes the reader with the structure used to categorize and analyze findings from HI08 (below). Third, the theory provides the research team with considerable leverage on the problem of defining research objectives for future Human Interoperability studies.

A variety of research disciplines address questions concerning how organizations function. Organizational psychology explores characteristics of team members and team interactions that predict effectiveness. Systems engineering methods such as the DoD Architectural Framework (Department of Defense, 2007) specify operational aspects of socio-technical systems (“OV” diagrams of organization function, connectivity, information dependencies, roles and relationships, activities, and states), technical aspects of these system (“SV” diagrams of entity interfaces, functions, activities, performance parameters, technologies, information formats, and others), and standards employed by the system (“TV” diagrams). Cultural research defines attributes of culture (e.g., power distance, individualism, etc.) that differ reliably between national or ethnic groups and that can help predict attitudes and behaviors (For a concise review of these literatures, see Appendix A: Literature Review).

None of these approaches provides the diagnostic or predictive power needed to understand and shape interactions within and between organizations at the operational level. It is at this level that organizations systematically create, use, and evolve internal and external partnerships. In particular, the system engineering methods on which DoD heavily relies (e.g., the DoD Architectural Framework, 2007) were not designed to define how humans within organizations interact; they were not designed to model highly adaptive organizational structures and processes; and they are typically applied to model the integration of entities within one organization, not the actual or potential interoperability between organizations. In short, existing engineering solutions represent single, static, organizations, and not human activity within organizations that collaborate dynamically and opportunistically.

Interactions at the human-human interface are, however, of increasing concern as the scope and complexity of missions grows – from warfighting to hybrid missions involving peacekeeping, political change, humanitarian assistance, nation building, infrastructure restitution, law enforcement, and other activities. In these cases, units within organizations and organizations themselves often must ally and collaborate in new ways to define and resolve problems. Further, these complex collaborations often must create or extend a capability for sharing information in order to achieve the close coupling and synchronization that missions demand.

However, it is often difficult for units and organizations to join forces, despite ubiquitous information sharing technologies (e.g., web browsers, common databases, teleconferencing, chat, email). Barriers of several types often afflict the effectiveness and efficiency with which organizational entities interact.

- **Policy barriers** may prevent institutions from collaborating effectively. For example, non-governmental organizations (NGOs) often have policies that prohibit interaction with DoD, even when DoD offers material aid of high value to NGO missions. Legal barriers (e.g., the Health Insurance Portability and Accountability Act of 1996) prohibit health care providers from sharing certain information about patients, and the Posse Comitatus Act (1878) prohibits DoD from participating in police actions on U.S. soil.
- **Structural barriers** may effectively disable the very interfaces through which interaction should occur. For example, an element of one organization may have no corresponding or effective element in another organization.
- **Process barriers** occur when there are no procedures for sharing information, decisions, and tasks across organizations, or when the procedures of one organization are obscure or even infeasible (e.g., with respect to security) for another.
- **Data interoperability barriers** exist when the information products of one institution have no relationship to the information input requirements of another, when systems with potential information value cannot be used by a given organization, or when the language used in one organization is ambiguous or conflicts with the language used at another.
- **Cultural barriers** exist when authority, reward structures, tolerance for uncertainty, time orientation, and other constructs (Hofstede, 1980, 1994) are in conflict. For example, the military command hierarchy often is seen as in conflict with the relatively flat and adaptive (or flexible) authority structures of law enforcement and civilian organizations.
- **Cognitive and affective barriers** exist when an individual cannot effectively support collaboration between organizations because they do not have the knowledge and skills to

do so, or when they fail to develop trust² and other requirements of relationships efficiently and effectively.

The length of this list may give the reader some sense of the complexity of HI. Existing approaches to the analysis and design of organizations (see Appendix A: Literature Review) do not address many of these aspects of complexity, nor do they confront this fact: organizations evolve with their missions, their interactions with other organizations, and the initiatives and ambitions of their members. Recent literature addresses these issues of evolution in part by viewing organizations as complex systems. Marion and Uhl-Bien (2002) approach organizations as networks of agents seeking to fulfill their individual and collective requirements. While this approach allows for the creation of intentionally designed organizations, it also accounts for spontaneous emergence of organizations and partnerships, and for behaviors in organizations that reflect local requirements (and even may conflict with global, organizational requirements). The theory accounts for the dynamic response of organizations in complex and uncertain environments given their state.

In practice, organizational adaptation is often slow, difficult, and somewhat unpredictable. Thus, adaptation often cannot be completed rapidly enough for time critical missions, nor can leaders have confidence that adaptation will improve execution. These problems have been found in laboratory experiments, as well as real world observational studies. Human-team-in-the-loop experiments showed that organizations can adapt their structure (Entin, Weil, Kleinman, Hutchins, Hocevar, Kemple, and Serfaty, 2004) to fit mission demands. However, the effort required to shift form is great, and thus the probability of successful adaptation is low. Further, the amount of effort required to change structure varies with the current, structural state of the organization. In experimental studies of military command and control (C2), organizations adapt more readily from divisional forms (in which members control assets in different regions) to functional forms (in which members control assets of different types), and they adapt less readily from functional to divisional structure (Moon, Hollenbeck, Ilgen, West, Ellis, Humphrey, Porter, 2000). This phenomenon is interpreted in system dynamics terms as hysteresis, a pattern in which change (or phase transition) is dependent on history. Relatively little is known about how to facilitate (or even measure) adaptation between organizational states. In short, it is difficult to change an organization's structure and process, often unpredictably so, and the source of difficulty is not well understood.

The perspective that organizations are complex or dynamical systems is not an argument that they are inherently suboptimal, unstable, or uncontrollable. There is ample evidence (Levchuk, Meirina, Pattipati, and Kleinman, 2004) that organizations can be designed to fit a mission or environment well. However, it tests credulity to propose that an organization could be designed, a priori, to be optimally effective and robust to all possible adaptations. Mission-specific effectiveness and general robustness typically must be traded off against one another. Nor is it feasible to design an organization with all of the interfaces it might ever need to interoperate with potential partners and to conform to new environments. No design or rules is likely to successfully address the infinite, or at least surprising, variety of future conditions.

² We define trust here as confidence in the intentions and capability of a partner to act in accordance with one's interests and plans.

By taking a complex systems perspective on this problem, we are able to propose instead that organizations acquire and exercise a competency to adapt³. This competency should enable organizations to invent or apply structures and processes that are well-suited to new missions, particularly when those missions take place in a highly unstable and environment (see Figure 1, from Daft, 2000).

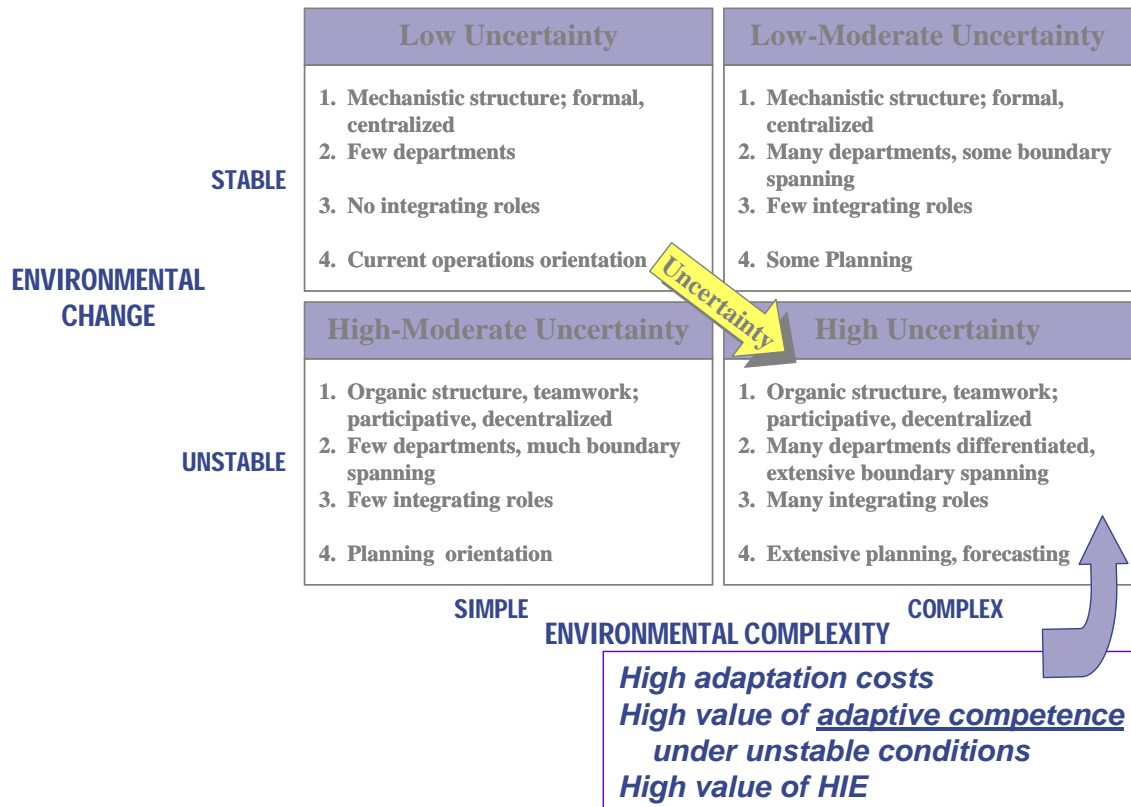


Figure 1: Organizations require an organic competency to adapt in unstable and complex environments.

We propose an initial theory of HI that specifies some of the competencies that may enable an organization to evolve its structure and control mechanisms to better fit environmental demands. Figure 2 illustrates this framework.

³ Adaptive competency is related to the notion of collaborative capacity proposed by Hocevar, Thomas and Jansen (2006).

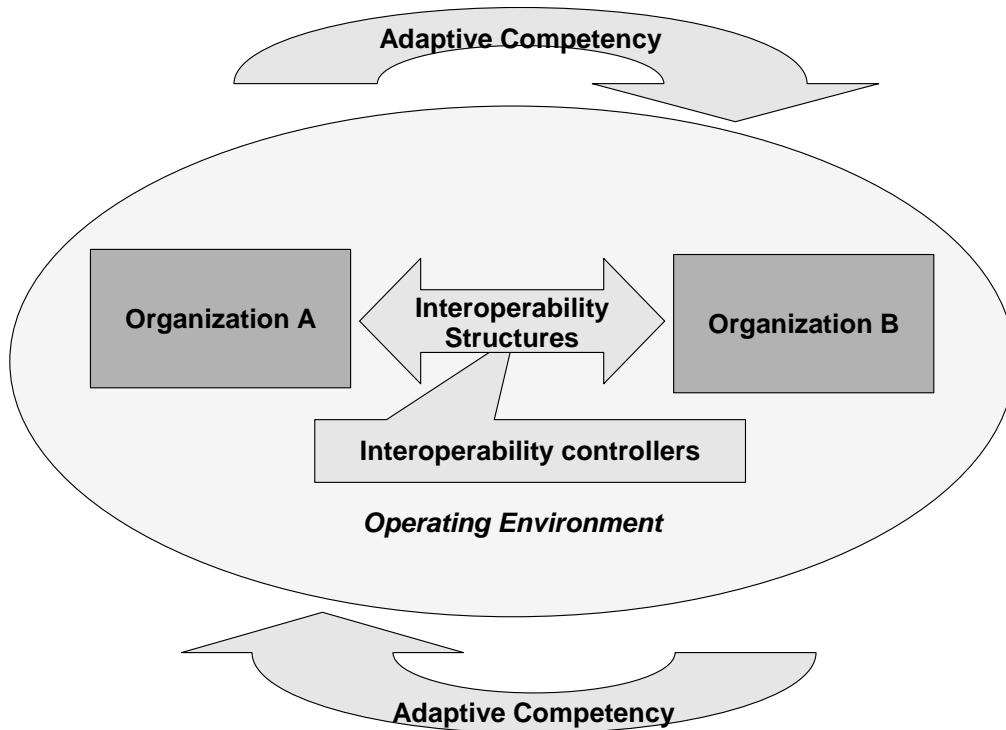


Figure 2: Adaptive competency enables an organization to adapt its structure and control mechanisms to the environment.

HI08 identified a number of structures through which organizational units and organizations interact (see Figure 3). These include personal relationships, formal liaisons, joint operation centers, trusted third party organizations that enable each organization to pass information securely, and information systems. The order of structures also reflects declining flexibility, from individual relationships that operate quite adaptively, to units whose policies and procedures may constrain interactions, to information systems that efficiently pass only the information they are designed to handle.

A variety of mechanisms, or controllers, modulate the volume, rate, and quality of activity that occurs through these structures. These include (see Figure 3):

- Organizational policy, such as objectives and rewards for achieving interoperability or goals that require it;
- Procedures that may support or restrict interoperability;
- Culture, which specifies customs, attitudes, and values that bear on collaboration;
- Cognitive competencies that enable individuals to execute taskwork and teamwork necessary for interoperability; and
- Data interoperability, which enables or hinders exchange of information.

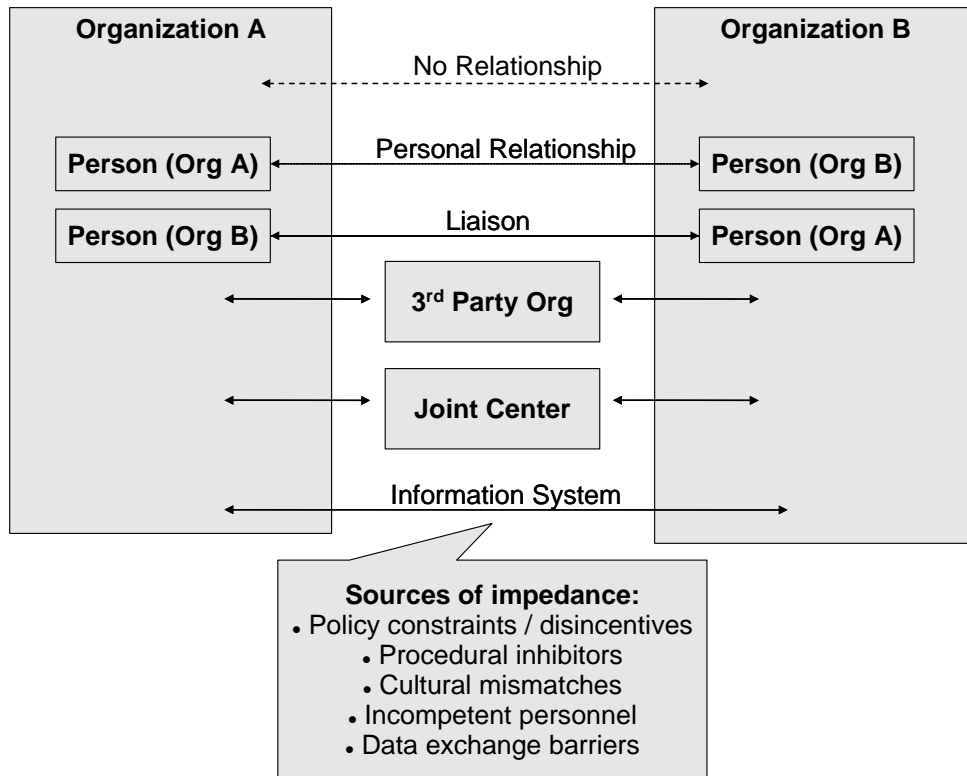


Figure 3: Structural forms and sources of impedance in organizational collaboration

As Figure 4 illustrates, organizational structure and controls are dynamic. Here time is laid on the vertical axis to illustrate an evolution of structures between organizations from personal relationships to a liaison, and then a joint center (such as the Joint Terrorism Task Force, which hosts FBI, NCIS, local law enforcement, and a variety of Federal agencies) and an information system that automates information transfer and governs it through business rules. We argue that organizations with high adaptive competence choose the best structure for the mission, and interviews in HI08 indicate that some organizations do systematically manage the evolution of structural forms, typically developing personal relationships into formal structures. The literature on how and when to evolve relationships is scant, however.

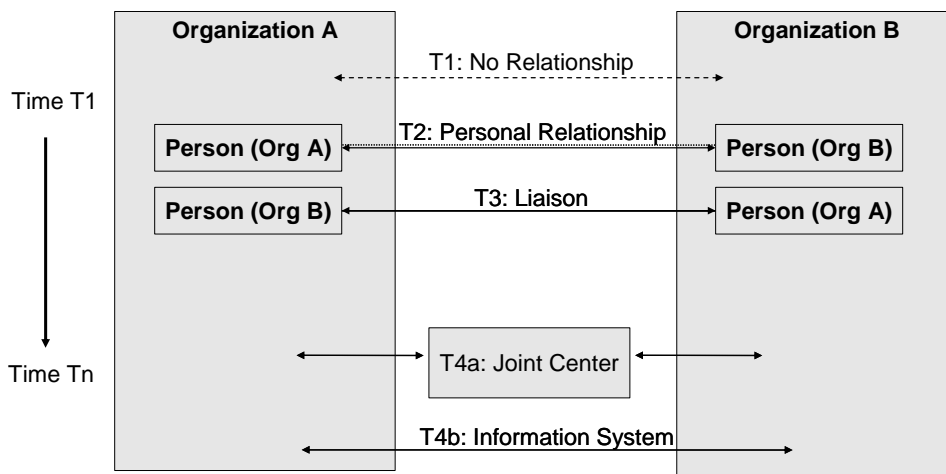


Figure 4: An example of structural evolution in response to operational need.

What are the competencies that enable organizations to adapt well to the environment? The competencies must include the following:

- **Detection:** A capability to detect and analyze the need for change, whether imposed top-down in the form of a new objective or mission, or arising from the bottom up in the form of unexpected opportunities to accomplish missions.
- **Selection:** A capability to select from experience or generate organizational structures and control mechanisms.
- **Evaluation:** A capability to think critically about the first- and higher-order effects of employing these structures and controls on the organization, its partner, other stakeholders, and the environment.

Recent research demonstrates that these characteristics enable organizations to adapt at least their procedures to successfully address novel or unexpected problems. Burke, et al. (1999) found that teams adapted more successfully when their leaders provided teams with situational awareness, made adaptation triggers explicit, and provided a rationale for adaptation. This is evidence of the need for a detection capability. Horn and Zaccaro (under review) provided evidence that team leaders (and presumably their teams) adapted more successfully if they had more varied experience on which to draw, evidence of a selection capability. Finally, Marks, Zaccaro, and Mathieu (2000) found that teams adapted better when they were trained to critique solutions from multiple viewpoints, evidence of the need for an evaluation capability.

We speculate that adaptive organizations will show greater evidence of these competencies than will non-adaptive organizations, and that selecting leaders or training members in these competencies may increase adaptivity. Such training and development might help organizations to ask and answer the questions as:

- **Detection:** Is there a collaboration or partnership that will dramatically increase our likelihood of success in this mission? What does the partner bring to this mission? What do I bring to this mission?
- **Selection:** How can we structure and manage collaboration so that we apply resources efficiently, synchronize action, maintain SA, and exploit opportunities to adapt further?
- **Evaluation:** How will the proposed structure and control system influence other aspects of this organization? How will other stakeholders respond to this partnership and its actions? Are collaborations and partnerships that are forged sustainable? Are they flexible should the environment change?

Adaptive competency may be applied in long term planning exercises, and this may help ensure smooth, relatively rapid, and successful development of partnerships. When it must be applied to emergent, high tempo missions, however, adaptive competency may be insufficient. Some organizational infrastructure and control mechanisms may also be necessary to adapt at speed. Assume that a new liaison relationship is required immediately for an emergent mission. The organization will implement this relationship better and faster if it has facilities, information system accounts, and training for incoming liaisons at the ready at all times.

In sum, this draft theory of HI focuses our attention and effort on three elements: organizational structure, control mechanisms, and adaptive competency. The challenge ahead of us is to define

experimental conditions that reveal and exercise these elements, to specify measures with which to compare the state of elements and their impact on mission outcomes, to design methods that enable organizations to acquire the competency to adapt, and to develop techniques that enable them assess tradeoffs and forecast effects of adaptation.

Research: HI08

HI08 studied the interactions between organizations conducting Maritime Domain Awareness Scenarios within TW08. Data were collected in interviews in the first week of HI08 (HI08.1), with law enforcement and military intelligence. Data were collected in interviews during the second week of HI08 (HI08.2) from DoD organizations tasked with defense responsibilities.

Below, we describe the objectives, participants, procedures, findings, and recommendations from this, initial experiment.

Objectives

The overarching objective of HI08 was to identify enablers of and constraints on Human Interoperability. This entailed identifying and examining interactions at several levels: human-human (communication and behavior), human-system, human-organization, and organization-organization. More specifically, data collection focused on several aspects of organizations that we hypothesized would enable or constrain human interoperability:

1. Intra- and inter-organizational structures that support collaboration, cooperation (sharing of behaviors) and coordination;
2. Processes that support collaboration, cooperation and coordination;
3. Social, cultural, and cognitive factors that influence inter-organizational collaboration, cooperation (especially) and coordination by the various organizations;
4. Policies/doctrine concerning information sharing & cooperation and coordination of activities; and
5. Attributes of information systems that enable or encumber collaboration, cooperation or coordination.

This research effort did not investigate the role of individual competency in organizational adaptation, nor did it examine environmental constraints on and affordances for adaptation. (Both are components of the framework defined above). Information systems themselves were not a focus of HI08, but we have captured, below, some general concerns about the usability, utility, socialization, and policies surrounding new technologies.

Participants

The interviewees for data collection in HI08.1 were drawn from the Naval Criminal Investigative Service (NCIS), the Joint Terrorism Task Force, the British Royal Navy, and the New Zealand Navy. In addition, data were collected in an observation of a video teleconference (VTC) between these organizations and the Multiple Threats Alert Center. These individuals were concurrently participating in the Trident Warrior exercise to test technologies for supporting collaboration (only) between Naval Criminal Investigative Service (NCIS) field offices, Joint Terrorism Task Force (JTTF), and Naval intelligence.

The interviewees in HI08.2 were from Third Fleet Joint Forces Maritime Component

Command (JFMCC), the Northern Command (NORTHCOM), the Pacific Fleet Maritime Operations Center (PACFLEET MOC), Naval Cooperation and Guidance for Shipping (NCAGS), and the Joint Interagency Task Force West (JIATF West). These individuals were concurrently participating in the Trident Warrior experiment to test a variety of technologies⁴ (see Appendix B: Trident Warrior Technologies in HI08.1).

Data collection was directed by Stefania Brown-VanHoozer, Ph.D. (OSD NII) and Shelley Gallup, Ph.D., NPS. Data collection was conducted by Jared Freeman, Ph.D., Aptima; Randall Murch, Ph.D., Virginia Tech; Tami Smith, from the office of the Deputy Undersecretary of the Navy; and Hal Moore, NORTHCOM. Art Glynn, NORTHCOM and Jeff Chilton, DHS, contributed to the data collection plans. Interviewees were obtained by the Trident Warrior lead for Maritime Domain Awareness (Dan Dunaway, Office of the Deputy Undersecretary of the Navy).

Procedure

Most interviews were conducted by two or more members of the HI research team with one interviewee. In some cases, small group interviews were conducted. The interviews were informal, but in most cases addressed all of the barrier issues identified above. Representative questions from these interviews were:

1. Tell us about a case in which your organization encountered challenges collaborating with another organization to accomplish your mission.
2. What structure – liaisons, working groups, or other entities – enabled your organization to collaborate with other organizations?
3. How (by what processes) did you execute your work?
4. What made this collaboration challenging?
5. Were there differences in the culture of these organizations that you had to address?
6. Were there policies that enabled or prevented you from collaborating?

Findings

Findings from HI08 interviews are organized, below, into observations concerning **organizational structure, process, culture, policy, and human-system/program interactions**. Recommendations related to these findings are presented in a subsequent chapter of this report.

Structures for collaboration between organizations

Interviews conducted in HI08 investigated the range of structures that organizations use to facilitate collaboration, coordination and cooperation; and the benefits of these structures. The informants represented NCIS, the British Royal Navy Fleet Intelligence, the New Zealand Navy liaison to the National Maritime Coordination Center, the Maritime Threat Analysis Center (MTAC), and non-governmental organizations.

⁴ These TW08 technologies spanned these domains: command and control, coalition, distance support, fires, human systems integration, information operations, ISR (intelligence, surveillance, and reconnaissance), knowledge management, networking, Sea Shield, wireless information transport, and cross domain solutions.

1) Organizational structures vary; their relationship to collaboration requirements needs to be determined

A variety of individual and organizational structures support collaboration and cooperation between organizations. Examples were found of personal trust relationships, liaisons, joint task forces, third party intermediaries, and information systems that pass data using mutually agreeable business rules. The structures have different strengths, according to the interviewees: an NCIS representative to the JTTF, the British Royal Navy Fleet Intelligence, a New Zealand Navy liaison to the National Maritime Coordination Center, members of the Maritime Threat Analysis Center (MTAC), and a specialist in non-governmental organizations. More research is required to fully map out the utility that organizations perceive and receive from different organizational forms in various mission contexts.

2) Collaboration and cooperation between law enforcement organizations depends heavily on personal relationships with trusted partners.

The centrality and sensitivity of personal trust relationships to law enforcement was emphasized in most interviews. These relationships are built informally through repeated exchanges of information that may deliberately hide or credit the source organization, as the case requires. Information exchange can be conducted without a strong foundation of trust; however distrust can rapidly build barriers that make exchange of information much more difficult. As noted below, security procedures substituted for personal trust between military organizations in exchange of information.

3) Co-location is a strong factor in effective collaboration and cooperation.

Though communication technologies make it relatively simple to create distributed teams that are physically located within their organizations, co-location is widely used. Several examples were found of creating liaisons within partner organizations, and of gathering representatives to create a new entity such as a joint task force or working group. These strategies may enable collaboration to occur more opportunistically, ensure coordination, and simplify access to the information and resources of the participating organizations. For example, in the JTTF, the local contacts of the police department complement the information resources and technical capabilities of Federal agencies. NCIS, the New Zealand Navy, and many other institutions use this strategy when they co-locate liaisons at the operation sites of key stakeholders and provide civilian entities with the opportunity to task military ISR assets. The JTTF in Hawaii uses this strategy by co-locating representatives of the FBI, NCIS, CIA, NSA, several Hawaii police departments, the FAA Air Marshals, Immigration and Customs Enforcement, Coast Guard, the U.S. Marshal's Service, Secret Service, and other entities. This "inner circle" of agencies expands to routinely include the U.S. Attorney, Army, National Guard, and others as needed. The number of participants provides backup should any one entity be unable to execute a mission, though presents a cost in administrative overhead. JIATF West, similarly co-locates U.S. representatives in operating centers of international partners to provide the training and guidance that may dramatically increase partner effectiveness, accomplish U.S. goals such as controlling drug traffic in the countries of origin (not just on American soil), and build strong relationships for future missions. JIATF-W is currently transitioning from tactical to operational missions that require deeper understanding of policies and doctrine for international interaction.

One of many possible concerns about creating liaisons is that these assignments can hamper career progression, a disincentive to those who fill these posts.

4) Collaborating through a third organization anonymizes exchanges of sensitive information.

Collaborating through a third party potentially enables agencies to share sensitive information while concealing sources or methods. The United Kingdom employs this strategy to pass information between military intelligence and the police by interposing the National Ports Analysis center between entities in the UK, the Mediterranean, Balkans and Horn of Africa. This entity currently relays information pertinent to criminal investigations between intelligence and law enforcement, and in the future may relay information pertinent to organized crime and terrorist activity. Intermediary organizations can be stood up temporarily, as is the case for the Crisis Action Center (CAC) of MTAC. The CAC stands up to manage information flow from NCIS, with the concurrence of the MTAC director in response to MOTR calls and in other cases of emergency. This type of collaboration provides a means to limit and/or deny cooperation.

5) Current information systems support efficient, though inflexible, distributed collaboration.

Information systems potentially enable participants in different locations, with limited personnel resources, to interoperate through embedded collaboration technologies. NGOs use this strategy in humanitarian crises. In response to the hurricane in Burma, NGOs organized into functional clusters⁵ and shared information in part through websites. However, information systems built to benefit the enterprise sometimes do not have value to local units, and so those technologies are neither welcomed nor used.

6) Structures that link partners consist of substructures that are sometimes antagonistic or incongruent.

A given organization may develop a complex network of organizational relationships, some multilateral (involving information flow among a set of partners), some bilateral (involving information flow that is exclusive to a pair of organizations). Two competing or conflicting organizations (e.g., two law enforcement agencies) may both fall within such a network, and in this case the constraints on sharing information must be defined explicitly so that the organizations are confident that their information and interests are secure.

These findings bear on the variety of HI structures to investigate in future experiments.

Processes for collaboration between organizations

Interviews conducted during HI08.1 elicited insights concerning the processes agencies use to facilitate inter-agency collaborations. The interviewees represented NCIS at JTTF, the New Zealand Navy position within that nation's National Maritime Coordination Center, British Royal Navy Fleet Intelligence, Naval Cooperation and Guidance for Shipping (a Navy organization that provides advice for safe passage of merchant ships worldwide), JIATF West,

⁵ NGOs typically avoid engaging with U.S. government or military in crises in countries opposed to the U.S. Such engagement would make NGO personnel targets of attack for their alliance with the U.S.

and Third Fleet JFMCC. Both informants have experience facilitating collaboration between military and law enforcement entities.

7) Effective inter-agency relations are built on exchanges of valued assets.

A key step in establishing new relationships is to identify assets that potential partners value and that they can (by policy or law) trade. For example:

- The first step that JIATF West takes in developing new partnerships with law enforcement entities in Southeast Asia is to contact the country team, especially representatives in country, to learn what US information or support has value to the prospective partner: training, transportation, information resources, etc. With that knowledge, JIATF can assess U.S. capability to provide that information or support, and assign a program manager to pool resources across U.S. organizations and kick off a relationship through exercises and provision of support services.
- Local entities – such as airport authorities and port authorities – provide valued information concerning their infrastructure, processes, activities, assets, and vulnerabilities to Federal law enforcement authorities in exchange for information, services (e.g., accelerating a procedure), or materiel (e.g., access to technology).
- In the international arena, the New Zealand Navy's military liaison to the New Zealand National Maritime Coordination Center provides the civilian members with training to improve human resources, and it provides up to 450 hours of military ISR support. The New Zealand Navy, in return, receives the support of specialized personnel for boardings, certain civilian training, and access to an open source COP that is in some ways superior to their classified COP. At a political level, the involvement of the New Zealand Navy in the growing civilian missions of the NMCC gives the Navy a rationale to request increases in its budget in support of commercial security.
- Third Fleet JFMCC has built working relations with a large number of organizations. At the heart of each relationship is an exchange of valued information. For example, JFMCC helps Pacific island nations maintain a shared watch list of vessels; JFMCC trades information about the presence of vessels from superpowers with TRANSCOM; Customs and Border Patrol provides cargo data to JFMCC, which in return recommends vessels for boarding.

8) Information exchange costs can encumber collaboration.

A variety of other factors can hinder information flow between groups, including cumbersome processes and physical barriers. Processes designed to protect information – information declassification and requirements to move information through trusted sources – increase the cost of doing business, lower the efficiency of collaboration, and can decrease trust between organizations. Some mechanisms do exist to address this problem, including the Intelligence Information Sharing Dispute Resolution (to be issued as Intelligence Community Policy Memorandum 501-3), and Executive Order 12333. Physical barriers can have similar effects, as we heard in complaints about the recent sealing of a door between PACFLEET MOC and the JIOCC. The value of such security measures should be carefully weighed against the costs.

9) Intra and/or Inter-organizational partnerships can grow from opportunity or mandate (bottom-up or top-down).

Organizations use a range of methods to discover or develop potential partnerships. Some approaches are driven from the bottom up, by opportunity. For example, Third Fleet JFMCC recruits partners in part through personal contacts made at exercises, at conferences, cross-briefings, in working groups and in other venues. These partnerships then develop as a function of mutual benefit or need. Organizations may partner by mandate, or top down. For example, JTTF was formed through a strategic national initiative to combat terrorism.

10) Organizations institutionalize personal trust relationships.

By transforming productive, personal relationships into institutional alliances, organizations ensure that intra and inter-organizational ties survive the inevitable transfers and retirement of individual relationship holders. For example:

- An FBI field office has sustained its relationship to municipal police by inviting them to quarterly firearms re-certifications (target practice), followed by a cookout. Police departments were invited to take the spare ammunition for their own training events. This recurring interaction between officers helps to build and sustain personal trust relationships that are important in solving criminal cases.
- A British intelligence officer codifies his personal relationships between civilian entities and his military organization by (1) identifying a trusted organization that can serve as an intermediary between information sources and information consumers, and (2) developing procedures that enable the intermediary to conceal the information source and the originator's methods, and transfer it in a reliable, timely, and secure manner to the consumer.

11) Organizations seek to learn the capabilities and constraints of others, and educate others about their own capabilities.

Organizations extend their knowledge of the capabilities of others, and may learn from them, by participating in exercises and by participating in the training at other organizations. NCAGS, for example, has learned some exemplary watch processes from Canadians in exercises, and participates in British training concerning managing and monitoring commercial shipping. The JTTF, seeks to convey its joint capabilities to new staff during increasingly structured and comprehensive in-briefs. JTTF also involves a variety of its members in operations specifically to expose them to each others capabilities.

12) Organizations require procedures for triggering and managing collaboration.

Procedures to facilitate collaboration are not always in place, or at least not in play. This was the case in parts of in HI08.1. For example, participants at NCIS had some difficulty determining when to reach out to (other) field offices. Participants had no apparent process for defining a lead entity, a "command and control" node for an investigation that crossed venues. Second, a video teleconference between MTAC (in DC) and representatives (in Hawaii) of NCIS, Third Fleet MOC, and the New Zealand Navy was complex or confused on the topics of how and with whom to collaborate and coordinate across organizations, and what assets were available to accomplish the mission. The VTC participants did not reference any procedures for making these decisions more crisply and systematically. Explicit procedures for planning and coordinating joint operations are often needed to accomplish missions.

13) Venues are needed for testing work flow processes between military and non-military entities.

The Maritime Domain Awareness mission requires interaction between military, law enforcement, and the vast international commercial shipping enterprise. However, current exercises focus largely on military collaborations within national military forces (e.g., Trident Warrior) or between national military forces (e.g., Rim of the Pacific Exercise, RIMPAC). These designs largely ignore or minimize the role of commercial shipping. In interviews, NCAGS leadership recommended exercises that engage commercial shipping at a realistic scale, and that address questions such as the following:

- How can we pick a specific Vessel of Interest from other commercial or private vessels almost identical to it?
- How do we communicate securely and confidentially with a single ship among tens or hundreds in an area?
- How can we coordinate actions with a crowded field of internationally flagged white vessels in order to execute mission tasks, given the complexity of communications and the cost (to commercial interests) of compliance⁶?
- How will the military address inevitable errors in its interactions with commercial carriers and white vessels, errors that may lead to lawsuits, future non-compliance, strained international relations, etc.?

These findings have implications (presented below) concerning how to investigate processes in HI09.

Culture in inter-organizational collaborations

Interviews conducted during HI08.1 elicited insights concerning the role of culture in inter-agency collaborations. The interviewees were an NCIS special agent at JTTF, a liaison from the New Zealand Navy to an information center concerned with commercial shipping, members of JIATFF West, and a member of the British Royal Navy Fleet Intelligence. Both informants have experience facilitating collaboration between military and law enforcement entities.

14) Historical enmity between groups can foul interoperability

Deeply ingrained prejudices between groups can complicate coordination, as one interviewee illustrated by describing conflicts between Greek and Turkish entities in the Sea Breeze 2007 exercise. Greece and Turkey have a history of conflict stretching back to the entry of Turkish nomads to Greece in the 11th century, the subsequent dominancy of Ottomans over Greek, and the current stalemate over control of Cyprus.

15) National cultures differ regarding the importance of rank.

Members of JIATF-West noted cultural nuances such as the importance of rank may be more significant in Asia than the U.S. In discussions with potential Asian collaborators, JIATF-W found it is often important to ensure that the participants are peers in rank. This is consistent with the findings of Hofstede (1980). In some cases, this is less important in interactions between U.S.

⁶ NORTHCOM estimates that the cost of delay to commercial vessels is \$10,000 per hour.

organizations, where depth of technical knowledge or decision authority may be the essential elements.

These findings have implications concerning the aspects of organizational culture to investigate in HI09.

Policy issues in inter-organizational collaboration

Interviews conducted with representatives of JIATF West, NCIS, and NORTHCOM produced useful insights concerning the role of policy in inter-organization collaborations.

16) Policies affecting information flows between organizations or across secure domains differ, and often conflict, between military and law enforcement entities.

- Military organizations have formal policies governing the distribution of sensitive information. This formal process obviates the need for personal trust relationships (1) to move information quickly between organizational elements that do not share personal relationships, (2) when the trustworthiness of members is established a priori through security clearances, and (3) when personnel rotate frequently. However, it encumbers collaboration, and thus, cooperation, with some partners, including foreign military and domestic law enforcement (below).
- Law enforcement entities often pass sensitive information primarily on the basis of *trust*, through interpersonal relationships with known individuals. The reliance on trust obviates the need for development of certain policies and procedures, works well when the organization must interact with other entities that lack such policies and procedures, and provides flexibility based on individual judgment about trustworthiness in context. We note, however, that information sharing in law enforcement will increasingly become subject to policy (business rules) as it is automated by information systems such as LInX (see Appendix B: Trident Warrior Technologies in HI08.1).

17) Organizations differ on how proactive they are about refining policies.

JIATF-West representatives take an assertive approach to resolving conflicts between mission requirements and policy. Specifically, JIATF West often pushes its recommendations for policy revisions up the chain of command. This strategy for controlling policies from the bottom up was not mentioned by other organizations.

Information systems for collaboration between organizations

Information systems designed to ensure and accelerate information flow sometimes present challenges to organizations and to inter-organizational collaboration, according to interviewees representing LInX, NCIS, the New Zealand and British Navies, JIATF West, NORTHCOM, JFMCC, and in related MDA research with NAVCENT.

18) Information can be classified unintentionally; the cost of declassification to support collaboration can be high.

Information is sometimes classified simply by its passage onto restricted military networks and systems, though it may not warrant classification⁷ (per the categories specified in Executive Order 12958). The process of declassifying those data is manual, slow, and thus, rarely used. This makes it difficult to transfer important information from the military to law enforcement organizations, to coalition partners, and to others.

19) Delivery of systems that local users cannot support (“drive by fielding”) diminishes return on technology investments.

As interviewees at JIATF-West indicated information systems designed to serve the enterprise may lack local utility, and systems are sometimes discarded for that reason. More specifically, interviewees reported that technologies are sometimes pushed on their organizations though they do not have sufficient staff to use them, lack training that clarifies how to apply the technology to their specific mission, and find the systems to be extraordinarily difficult to use.

20) Communities of interest can help unify users and standardize use.

In the case of LInX, disparate policies about information sharing have developed in the different LInX regions. However, the LInX program has addressed this by creating regional steering committees that set policy, and an executive steering committee that attempts to standardize policy across regions.

21) Information quality must be assured for user confidence.

Information quality can vary greatly within a system. Users of LInX, for example, must often call the originating law enforcement office to interpret records, must deconflict coincidental relationships between records (e.g., the same name may be used for different suspects), and must correlate records that appear to differ but in fact concern the same individual (e.g., different name spellings or aliases may be used for the same suspect). Cost-effective methods of assuring information quality are needed.

22) Information systems and systematic information handling create value and advertise expertise.

Third Fleet JFMCC has used a home-grown information system to establish itself as an efficient broker of critical information about white shipping to military intelligence and operational forces. Specifically, JFMCC has developed technology that prioritizes vessels for action by partners at DoD and in law enforcement. The technology also enables JFMCC to turn around requests for information in minutes, rather than a day. Like the best information systems, this one effectively exposes and advertises the expertise of JFMCC (its categorization scheme and business rules) so that clients can inspect and negotiate JFMCC’s prioritization judgments about vessels, calibrate their trust in JFMCC, and act on its judgments.

23) Information systems have hidden dependencies that can foil collaboration.

Participants in the law enforcement component of TW08 (HI08.1) had some unexpected technical problems with collaboration technologies. These included lack of familiarity with

⁷ A NORTHCOM representative reports that 70% of all work executed on SIPRNET is unclassified.

required file types (e.g., the .pdf format for documents) or software to open them, and lack of connectivity (e.g., lack of unclassified data ports). More generally, systems have dependencies on user knowledge or certifications, operating environment, and mission that often are not made explicit, and thus present unwelcome surprises to users.

These findings have implications concerning the interaction between information systems and the organizations they are designed to support.

Discussion and Recommendations

In this section, we draw implications from the findings above, and we leverage HI theory to specify objectives for future research. We refer to the next research events as HI09, in anticipation of the creation of an HI research program.

Implications of HI08 research findings

For each of the findings documented above, we have drawn one or more implications for leaders and managers of inter- and intra-organizational collaborations. These suggestions are preliminary. By that, we mean that they arise naturally from the interview findings of HI08, but they should be validated in a broader and deeper program of research concerning human interoperability.

Table 1: Implications of HI08 research findings

Factor	Finding	Implications
Structure	1) Organizational structures vary; their relationship to collaboration requirements needs to be determined	Support research into the form and function of structures for collaboration. Educate leaders concerning the effectiveness, costs, and benefits of these options.
	2) Collaboration and cooperation between law enforcement organizations depends heavily on personal relationships with trusted partners.	In partnering across professional domains (e.g., military to law enforcement), give preference to forms of partnership that are familiar to prospective collaborators (e.g., personal trust relationships for law enforcement). Develop and train reliable methods of building quick trust. Develop certifications of trustworthiness (e.g., demonstrable proof of competency) to accelerate development of trust between organizations that have the potential to collaborate. Some technology solutions may be required.

	3) Co-location is a strong factor in effective collaboration and cooperation.	Carefully weigh the economy of distributed or virtual teams against the value of personal trust relationships and insights gained through co-location of personnel. Where liaison requirements can be anticipated, arrangements should begin early enough to find the fit between the position, the organization, and the environment or problem being worked. Where they can't be anticipated, ensure that processes (e.g., training) and infrastructure (e.g., facilities) are in place to create them rapidly.
	4) Collaborating through a third organization anonymizes exchanges of sensitive information.	Consider establishing third party intermediaries or information infrastructure to move information when (1) sources and methods must be concealed (2) and findings must be rapidly communicated between organizations that do not have interoperable information systems (e.g., common access to SIPRNet or IntelLink).
	5) Current information systems support efficient, though inflexible, distributed collaboration.	In assessing value of proposed information systems, evaluate the utility to the enterprise and to each of its members. Ensure that relatively inflexible systems (e.g., highly structured databases) return sufficient value to users given the cost of using them. Make flexibility a design criterion for information systems; discourage "stovepipe" systems.
	6) Structures that link partners consist of substructures that are sometimes antagonistic or incongruent.	Assess the compatibility of partners – their history, goals, processes, and culture – before investing heavily in developing partnerships. Invest in monitoring and managing potential incompatibilities.
	7) Effective inter-agency relations are built on exchanges of valued assets.	Develop and exercise capability to assess the value of assets each party brings to a relationship. Make trade of these assets an explicit goal of partnership agreements.
Processes	8) Information exchange costs can encumber collaboration.	Assess the costs of exchanging information (e.g., delay or information loss due to declassification) and other assets. Manage these costs and partner perceptions of them.
	9) Intra and/or Inter-organizational partnerships can grow from opportunity or mandate (bottom-up or top-down).	Formalize methods of identifying and growing partnerships from the bottom up, and the top down. Ensure that these methods are in place and function for time critical and unanticipated configurations.

	10) Organizations institutionalize personal trust relationships.	Manage personal trust relationships as an enterprise asset by identifying them and developing them selectively into enduring structural entities. Define working styles and processes that enable lower the amount of interpersonal interaction required to build or verify trust in emergent organization relationships.
	11) Organizations seek to learn the capabilities and constraints of others, and educate others about their own capabilities.	Develop systematic methods of evaluating potential partners, and of representing your own organization's capabilities to support others in unique or time critical situations.
	12) Organizations require procedures for triggering and managing collaboration.	When planning missions of significant complexity and missions in new domains, systematically assess the utility and manageability of collaboration. In preparation for emergent, unforeseen missions, develop mechanisms that accelerate this assessment or obviate the need for it.
Culture	14) Historical enmity between groups can foul interoperability	Identify areas of historic conflict between potential partners. Monitor and manage problems that arise from these seemingly irrelevant sources.
	15) National cultures differ regarding the importance of rank.	When staffing meetings that cross cultures, attend to partners' requirements for showing/seeing authority and technical expertise.
Policy	16) Policies affecting information flows between organizations or across secure domains differ, and often conflict, between military and law enforcement entities.	Ensure that partners make information sharing constraints and mechanisms explicit.
	17) Organizations differ on how proactive they are about refining policies.	Define channels and methods for pushing critical policy revisions upward.
Information systems	18) Information can be classified unintentionally; the cost of declassification to support collaboration can be high.	Identify information critical to collaboration that may be unintentionally compartmentalized. Ensure alternative access routes to this information.

	19) Delivery of systems that local users cannot support (“drive by fielding”) diminishes return on technology investments.	Provide transitional support and utility assessment with the delivery of new technologies.
	20) Communities of interest can help unify users and standardize use.	Establish communities of interest around technologies and practices that deliver high value information.
	21) Information quality must be assured for user confidence.	Ensure that partnering organizations understand which information elements are least reliable. Develop procedures for testing and verifying this information.
	22) Information systems and systematic information handling create value and advertise expertise.	Proceduralize information handling and structure information products where it is feasible, productive, and affordable to do so. Advertise and share those products, invite critiques to increase product value.
	23) Information systems have hidden dependencies that can foil collaboration.	Ensure that users and their systems satisfy the requirements for using new systems on critical tasks.

Objectives for HI09 research

The goal of the Human Interoperability initiative is to develop knowledge and methods that improve the responsiveness, efficiency, and effectiveness of organizations that partner or dynamically integrate their own units. The implications of HI08, reported above, provide some insight into the guidance that HI research can offer. They must, however, be extended, deepened, and developed into a body of knowledge that can be taught, executed by organizational leaders and membership, implemented in organizational process architectures, incorporated into decision aids, and converted into measures that support monitoring of organizational state and effects.

Much of what we have learned in HI 08 has resolved into several themes:

- Organizations must build on historical experiences to improve human interoperability in collaborations they can foresee;
- Organizations must develop mechanisms that allow them to partner rapidly and effectively under conditions that cannot be foreseen, because these are inevitable;
- Organizations must develop the self-awareness to assess their capability and performance in both of these possible states.

To address these themes requires research that defines (1) useful organizational structures and controls used in the past, (2) human dimensions that enable organizations to adapt creatively to unforeseen future states, and (3) technical means that may serve as proxies for the time-tested but time-consuming human interactions on which successful interactions are historically based.

We recommend a program of research concerning Human Interoperability, one that explores the challenges and solutions to Human Interoperability. It is fundamental to such research that we specify its objectives in detail. We do so, below, by presenting objectives and research questions related to each of the dimensions of the draft theory (see page 2, “Toward a theory of Human I”): organizational structures, adaptive competency, structure, policy, procedures, culture, cognitive competency, and data interoperability.

- Adaptive competencies
 - Objective: Identify the adaptive competencies of organizations
 - Research questions:
 - How do organizations perceive triggers or cues to change structure, processes and control mechanisms?
 - How do organizations select partners?
 - How do organizations capture and test knowledge about the capabilities of partner organizations? How and when do they communicate their own capabilities?
 - What is the variety of experiences that enable adaptation?
 - How do organizations select or generate feasible structures and controls and under what conditions?
 - How do organizations anticipate or react to direct and indirect effects of adaptation?
- Structure
 - Objectives: Assess structural barriers to inter-organization collaboration and mechanisms for overcoming them
 - Research questions:
 - What structures do organizations have in place that support collaboration with other organizations?
 - What structures do organizations create for collaboration? How elastic are organizations to new structural forms? What influences this flexibility?
 - What are the evolutionary patterns of structural change (e.g., from personal relationships to working groups)?
 - What is the effect on intra- and inter-organization collaboration when antagonists enter the membership network?
- Policy
 - Objective: Identify policy barriers to inter-organization collaboration and mechanisms for overcoming them
 - Research questions:
 - Are members of organizations able to identify policy barriers, violations of policy, and new policy requirements?
 - Is the organization able to modify or work around policy barriers when needed?
- Process
 - Objectives: Assess procedural barriers to inter-organization collaboration and mechanisms for overcoming them
 - Research questions:

- How do organizations specify who coordinates with whom, when, how, and based on what information or circumstances? Are those procedures known in the organization?
 - What is the valued information or capability that is exchanged between organizations? What are the benefits and costs of exchanging information?
 - Do organizations have mechanisms to identify and institutionalize personal relationships?
- Culture
 - Objectives: Identify barriers at the cultural interface between organizations
 - Research questions
 - Does the effectiveness of partnerships vary with differences in power distance, individualism, uncertainty handling, short- vs. long-term perspective and other factors?
 - How do organizations resolve or manage cultural conflicts?
- Cognition
 - Objective: Identify the barriers to individual ability to identify, form, and implement collaborations and specify the knowledge, skills, and attitudes required to overcome these barriers.
 - Research questions:
 - What competencies enable individuals to lead inter- and intra-organizational partnerships?
 - What competencies enable individuals to participate fully in partnerships?
- Data interoperability
 - Objectives: Assess barriers to collaboration at the information interface and mechanisms for overcoming them
 - Research questions
 - How do organizations balance and rebalance the requirements to protect and to disseminate sensitive but valued information?
 - Do technology users have staff, mission-relevant training, resources and a community of interest to support use and maintenance of new technology?
 - What methods of information quality assurance are used to test and communicate the validity of data?

Methods of HI09 research

Research planning specifies measures, materials, venues, and procedures. NPS has refined techniques for this through its leadership of analysis activities in all Trident Warrior experiments. In brief, this technique involves the following steps:

- Measures are defined that explore and test the potential answers to each research question. Measurement instruments are developed for use in research studies.
- Venues are identified in which research can be conducted. These include field sites at which observation and interviews can be conducted, tabletop exercises in which organizational leaders demonstrate the process and outcomes of decision making, laboratory experiments in which alternative tools and treatments are contrasted, and

military experiments⁸ that exercise operational personnel and technology on representative missions.

- Scenarios and scenario threads are defined for selected venues. These scenarios specify opportunities to apply measures.
- Procedures are defined to train research teams (e.g., concerning when and where to use measurement instruments); train research participants in technologies, procedures, structures, and missions they will use; install technologies required for the study; schedule and synchronize events; analyze data; and generate reports.

These activities are executed synchronously in meetings, and asynchronously using collaboration technology, such as the NPS website called FIRE: FORCEnet Innovation & Research Enterprise. That site provides collaboration functions: email, voicemail, calendar, task lists, discussion forums, web conferencing, fileshare, and administrative controls. Critically, many of the products of activities executed live and through the workspace are stored in a database – accessible to the entire team of researchers and stakeholders – that relates objectives, measures, scenarios, venues, and procedures. This highly structured method of developing and disseminating product significantly improves management of experiments, and accelerates analysis and reporting.

A number of more detailed ideas concerning future experiments are presented in Appendix E: Notes Towards Experimentation.

Conclusion

This document reports a framework for understanding the Human Interoperability, data concerning Human Interoperability at Trident Warrior 2008, implications of those findings, and objectives for future research. That research must refine HI theory, report findings from systematically designed studies using quantitative measures, and develop products – case studies, guidelines, and diagnostic and predictive models – that help organizations grow their capabilities to interface at the human level with their current and future partners.

⁸ We remind the reader that experiments conducted by DoD differ from the controlled, laboratory events conducted in science and engineering communities. DoD experiments often inject a new technology or process into an existing organization or operational system. No control conditions are established. The effects of the manipulation are generally assessed by subject matter experts and by participants who have substantial personal experience with standard technologies or processes. Further, DoD experiments serve several functions above and beyond the discovery of effects. These events:

- Advertise new technologies and procedures to participants
- Test the interoperability of technologies
- Test training for these technologies and procedures
- Produce nominal plans for executing the tested mission, as well as new tactics, techniques, and procedures
- Produce knowledge of how enemy forces may respond to changes in U.S. technologies or processes

References

- Barnes, C.D., and Laughery, K.R., Jr. (1997). In S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson (eds.), *Proceedings of the 1997 Winter Simulation Conference of INFORMS*.
- Beaubien, J., Knott, C., Orvis, K., and Freeman, J. (2008). *Collection of Psychological Operation (PSYOP)-relevant Cultural, Attitudinal, Motivation, and Perception Data for the Joint Psychological Support Element*. Report to the Air Force Research Laboratory, Contract FA8650-05-C-6656.
- Burke, C. S. (1999). Examination of the cognitive mechanisms through which team leader promote effective team process and adaptive team performance. Unpublished dissertation. Fairfax, VA: George Mason University.
- Cannon-Bowers, J.A., Tannenbaum, S.I., Salas, E., and Volpe, C.E. (1994). Defining competencies and establishing team training requirements. In Richard A. Guzzo and Eduardo Salas (eds.), *Team effectiveness and decision making in organizations*. San Francisco: Jossey-Bass Publishers, pp. 333-380.
- Carley, K.M., and Svoboda, D.M. (1996). Modeling Organizational Adaptation as a Simulated Annealing Process. *Sociological Methods & Research*, 25(1), pgs 138-168.
- Daft, Richard. (2000). *Organization Theory and Design*. West Publishing Company.
- Day, D. V., & Silverman, S. B. (1989). Personality and job performance: Evidence of incremental validity. *Personnel Psychology*, 42, 25-36.
- Department of Defense. (23 April 2007). DoD architecture framework, version 1.5. Volume II: Product descriptions. Retrieved from the internet 12 September 2008. Available at www.defenselink.mil/cio-nii/docs/DoDAF_Volume_I.pdf.
- Entin, E. E., Weil, S. A., Kleinman, D. L., Hutchins, S. G., Hocevar, S. P., Kemple, W. G., & Serfaty, D. (2004). Inducing adaptation in organizations: Concept and experiment design. *Proceedings of the 2004 Command and Control Research and Technology Symposium*, San Diego, CA.
- Hocevar, S.P., Thomas, G.F., and Jansen, E. (2006). Building collaborative capacity: An innovative strategy for homeland security preparedness. *Innovation Through Collaboration: Advances in Interdisciplinary Studies of Work Teams*, 12, p255-274.
- Hofstede, G. (1980). *Culture's consequences: International differences in work-related values*. Beverly Hills, CA: Sage.
- Hofstede, G. (1994). Hofstede values survey. Available at: <http://feweb.uvt.nl/center/hofstede/manual.html>.
- Hofstede, Geert. (1991). *Cultures & organizations: Software of the mind: Intercultural cooperation and its importance for survival*. New York: McGraw-Hill.
- Hogan, J., Rybicki, S. L., Motowidlo, S. J., & Borman, W. C. (1998). Relations between contextual performance, personality, and occupational advancement. *Human Performance*, 11(2/3), 189-207.
- Horn, Z. N. J. (2008) Explaining the Influence of Stretch Assignments on Adaptive Outcomes: The Importance of Developing Complex Frames of Reference. Dissertation Abstracts International.
- Levchuk, G. M., & Chopra, K. (2005). NetSTAR: Identification of network structure, tasks, activities, and roles from communications. *Proceedings of the 10th International Command and Control Research and Technology Symposium*, McLean, VA.

- Levchuk, G. M., Chopra, K., Levchuk, Y., & Paley, M. (2005). Model-based organization manning, strategy, and structure design via Team Optimal Design (TOD) methodology. *Proceedings of the 10th International Command and Control Research and Technology Symposium*, McLean, VA.
- Levchuk, G. M., Meirina, C., Pattipati, K.R., & Kleinman, D.L. (2004). Normative design of project-based organizations: Part III - Modeling congruent, robust and adaptive organizations. *IEEE Trans. on SMC: Part A: Systems and Humans*, 34(3), 337-350.
- Levitt, R.E. (2004). Computational Modeling of Organizations Comes of Age. *Computational & Mathematical Organization Theory*, 10(2), pgs. 127-145.
- MacMillan, J., Diedrich, F. J., Entin, E. E., & Serfaty, D. (2005). How well did it work? Measuring organizational performance in simulation environments. In W. B. Rouse & K. R. Boff (Eds.), *Organizational simulation* (pp. 253-272). New Jersey: John Wiley.
- Marion, M. and Uhl-Bien, M. (2002). Complexity Theory and Al-Qaeda: Examining Complex Leadership. Presented at Managing the Complex IV: A Conference on Complex Systems and the Management of Organizations, Fort Meyers, FL Dec. 2002; available from http://www.isce.edu/site/Marion_Uhl-Bien.pdf; Internet; accessed 12 October 2003.
- Marks, M., Zaccaro, S., and Mathieu, J.E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology*, 85(6), pgs. 971-986.
- McIntyre, R.M. & Salas, E. (1995). Measuring and managing for team performance: emerging principles form complex environments. In Richard A. Guzzo and Eduardo Salas (eds.), *Team effectiveness and decision making in organizations*. San Francisco: Jossey-Bass Publishers, pp. 9-45.
- Moon, H., Hollenbeck, J., Ilgen, D., West, B., Ellis, A., Humphrey, S., Porter, A. (2000). Asymmetry in structure movement: Challenges on the road to adaptive organization structures. *Proceedings of the Command and Control Research and Technology Symposium*, Monterey, CA.
- Nisbett, R.E. (2003). *The geography of thought: How Asians and Westerners think differently...and why*. New York, NY: The Free Press.
- Organ, D. W., & Ryan, K. (1995). A meta-analytic review of attitudinal and dispositional predictors of organizational citizenship behavior. *Personnel Psychology*, 48, 775-802.
- Orvis, K. L. & Zaccaro, S. J. (2007). Team composition and member selection: optimizing teams for virtual collaboration. In J. Nemerino, M. M. Beyerline, L. Bradley, and S. Beyerlein (Eds.), *The handbook of high performance virtual teams: a toolkit for collaborating across boundaries*. San Francisco: Jossey-Bass.
- McCormack, R. K., Duchon, A., Geyer, A., Orvis, K. L. (in press). A case study in data mining for automated building of teams. In E. Eyob (Eds.) *Handbook of Research on Social Implication of Data Mining and Information Privacy: Interdisciplinary Frameworks and Solution*. Hershey, PA: IGI Global.
- Salas, E., Sims, D.E., & Burke, C.S. (2005). Is there a big five in teamwork? *Small Group Research*, 36(5), 555-599.
- Salas, E., Stagl, K.C., & Burke, C.S. (2004). 25 Years of Team Effectiveness in Organizations: Research Themes and Emerging Needs. *International Review of Industrial and Organizational Psychology*, 19, 47-91.
- Stewart, Greg. (2006). Relationship between team design features and team performance. *Journal of Management*, Vol. 32 No. 1, February 2006 29-54.

- Thurstone, L. L. (1934). The vectors of the mind. *Psychological Review*, 41, 1-32.
- U.S. Joint Forces Command. (2003). *Doctrine for Joint Psychological Operations*. (Joint Publication 3-53). Suffolk, VA: Author.
- Van Scotter, J., & Motowidlo, S. J. (1996). Interpersonal facilitation and job dedication as separate facets of contextual performance. *Journal of Applied Psychology*, 81(5), 525-531.

Appendix A: Literature Review

Several bodies of literature bear on the phenomena we call the Human Interoperability: (1) theoretical and empirical research by industrial / organizational psychologists concerning team effectiveness, (2) design and testing techniques of systems engineers (3) and cross-cultural studies. None of these literatures satisfactorily inform the analysis, design, development, and testing of the human interface between organizations. So that the reader can draw their own conclusions regarding this claim, we provide an overview of this literature, below.

Psychology of Team Effectiveness

Industrial / organizational psychologists have developed a diverse body of theory to explain how the competencies and behaviors of team members influence the effectiveness of teams. This work is characterized by:

- A focus on team members, rather than the environment in which they work
- A focus on interactions within teams, rather than between
- No assumptions that the activities of teams are well-defined or ill-defined
- A large number of abstract constructs (e.g., leadership) that are experimentally operationalized in a variety of ways, rather than a limited number of relatively concrete factors
- Research methods that apply surveys of team members or observers in operational or training settings, rather than laboratory methods

The flavor of this literature is evident in a few, representative theories selected a brief survey of this literature. (For a more extensive review, see Salas, Stagl, and Burke, 2004.)

Salas, Sims, and Burke (2005) drew on a broad body of theory and research (Salas, Stagl, and Burke, 2004) to define a “Big Five” factors in teamwork⁹:

- Team leadership
- Mutual performance monitoring
- Backup behavior
- Adaptability
- Team orientation, an attitude favoring interdependence and interaction

They identified several mechanisms by which teams coordinate to apply these five capabilities well:

- Shared mental models
- Mutual trust
- Closed-loop communication

Prior work by McIntyre and Salas (1995) touched on these factors and others in a review of survey research conducted on military teams that execute naval gunfire support, antisubmarine

⁹ The phrasing is a play by Salas, Sims, and Burke (2005) on the Big Five personality factors: neuroticism, extraversion, openness (or intellect), agreeableness, and conscientiousness (Thurstone, 1934).

warfare, and guided missile operations. The authors specified 20 principles that touched on four of the “Big Five” factors (excluding adaptability), as well as:

- Feedback between team members
- Taskwork skills of individual team members
- Context-driven selection of skills and styles (e.g., authoritarian vs. interactive style) from a large repertoire
- Evolution of skills over time

In a broader review, Cannon-Bowers, Tannenbaum, Salas, and Volpe (1994) organized what they termed the “confused and contradictory” literature on team skills into eight factors, several of them familiar from the lists, above:

- Adaptability of teamwork strategies to the environment
- Shared situational awareness
- Performance monitoring and feedback
- Leadership and team management
- Interpersonal relations to optimize cooperation
- Coordination of team activities
- Communication
- Decision making

There is, then, some consensus concerning factors and behaviors between individuals that enable teams to be effective. It is not clear, however, what role these factors play as teams and organizations build alliances with others.

In related work, personality researchers have developed a small but growing body of evidence that individual personality characteristics – not just individual taskwork proficiency (Stewart, 2006) – influence team performance (Van Scotter and Motowidlo, 1996; Day and Silverman, 1989; Organ and Ryan, 1995; Hogan, Rybicki, Motowidlo, S., and Borman, 1998). Because personality characteristics are not highly malleable, this literature has more utility with respect to the selection of team members than their training or management. However, it is not entirely clear how much variance personality characteristics account for given other team-level variables (above).

Systems Engineering Approaches to Team Design

The systems engineering community has developed methods of representing teams, in efforts to design organizations or the systems they command and operate. This work implicitly defines a theory of human interoperability, because it specifies the environment in which people operate. The characteristics of this work in large part contrast with those of team effectiveness research. In the design literature, one finds:

- A focus on the environment in which teams function, rather than on the team members
- A focus on phenomena between organizational entities (typically teams), rather than on activity with those entities
- An assumption that the activities of teams are well-defined, and thus, that they can be formally represented and modeled

- A small number of relatively concrete constructs (entities, resources, tasks) , rather than a large number of abstract factors
- Research that, though scant, employs mainly laboratory methods, rather than survey techniques in operational settings

A few examples represent this field well.

The DoD Architecture Framework (Department of Defense, 2007) specifies methods of representing the operational aspects of a system (“OV” diagrams of its function, connectivity, information dependencies, roles and relationships, activities, and states), technical aspects of system entities (“SV” diagrams of entity interfaces, functions, activities, performance parameters, technologies, information formats, and others), and standards employed by the system (“TV” diagrams).

A small, more diverse, and largely academic community of engineers has defined other methods of representing and computationally modeling the activity of organizations. This work applies multi-objective optimization techniques (Levchuk, Chopra, Levchuk, and Paley, 2005)), simulated annealing (Carley and Svoboda, 1996), discrete event simulation (Barnes and Laughery, 1997), network analytic methods (Levchuk and Chopra, 2005) and other techniques (Levitt, 2004) to design, test, or infer the command and control relationships among organizational entities (their structure) and the precedence of tasks (their process). These models represent a variety of factors, typically some subset of:

- Mission / Process – defined as a task precedence graph
- Events – defined as cues to task
- Tasks – characterized by the resources required to execute them
- Assets / Resource – the capabilities of materiel entities to perform tasks
- Role / Decision maker – the capabilities of human entities to perform tasks
- Organization – the command, control, and communication structures that constrain authority over people, asset allocation, and information exchange

Integration of Psychological and Engineering Approaches

A recent body of work combines the I/O and systems engineering approaches to understanding and designing effective human organizations.

Research by Ilgen and Holloway (Moon, Hollenbeck, Ilgen, West, Ellis, Humphrey, Porter, 2000) uses experimental methods and statistical modeling techniques characteristic of the social sciences to explore the behavior of organizations that are structured in ways that systems engineers would readily recognize. Their work has discovered surprising effects, such as an asymmetry in structural adaptation by which teams more readily shift their structure from functional (in which each member controls a unique type of assets, e.g., aircraft) to divisional (in which each member controls all types of assets in a given geographical region) than from divisional to functional, which the mission conditions demand structural adaptation.

Orvis and colleagues (Orvis and Zaccaro, 2007; McCormack, Ducchon, Geyer, and Orvis, in press) have addressed to problem of composing effective teams by representing factors from the

I/O tradition and the systems engineering paradigm in a single model. This approach is intended to specify teams whose members possess the competencies to perform well-specified tasks, are available to perform those tasks, and have the leadership and followership (team skills) competencies to collaborate well with teammates.

Skarin (personal communication, 25 September 2008) is approaching the problem of team composition by modeling the knowledge and knowledge requirements of team members. Statistical language processing techniques are used to infer the knowledge of members of an organization from the content of documents they read and write. The relationships among those individuals are mapped as social networks from data concerning email correspondence, phone calls, and physical proximity (using RFID badges). These data are sufficient to make inferences concerning which individuals currently outside a team might bring needed knowledge into that team.

Cross-Cultural Studies

Researchers of culture vary in their methods from the largely exploratory methods of anthropology, which are designed to enable relevant social constructs to emerge through observation and participation, to more formal schools that employ survey methods identify constructs or dimensions that reliably distinguish one culture from another. We focus here on the more formal school, whose work is characterized by:

- A focus on the society or culture, rather than on individuals, teams, or their environment
- A focus on reliable differences in the character of each culture, rather than on interactions between organizations or individuals
- No representation of tasks, and thus no assumptions that they are well-defined or ill-defined
- A modest number of relatively abstract constructs (e.g., authority relationships) , rather than a large number of abstract factors
- Research using surveys whose items often are not grounded (or constrained by) specific context or missions, and thus may lack validity.

The current touchstone in this field is Hofstede's (2004) five dimensional cultural model, in which cultures are characterized in terms of *power distance*, which reflects the degree of equality or inequality among the population; *individualism vs. collectivism*, the degree to which individual or collective achievements are rewarded; *masculinity vs. femininity*, the degree to which men and women within a culture differ in their respective roles; *uncertainty avoidance*, which reflects how well individuals handle unexpected and ambiguous situations; and *time orientation*, the degree that a culture does or does not embrace a long-term perspective and a respect for traditions. The scores of each nation on the Hofstede dimensions are represented in **Figure 5**.

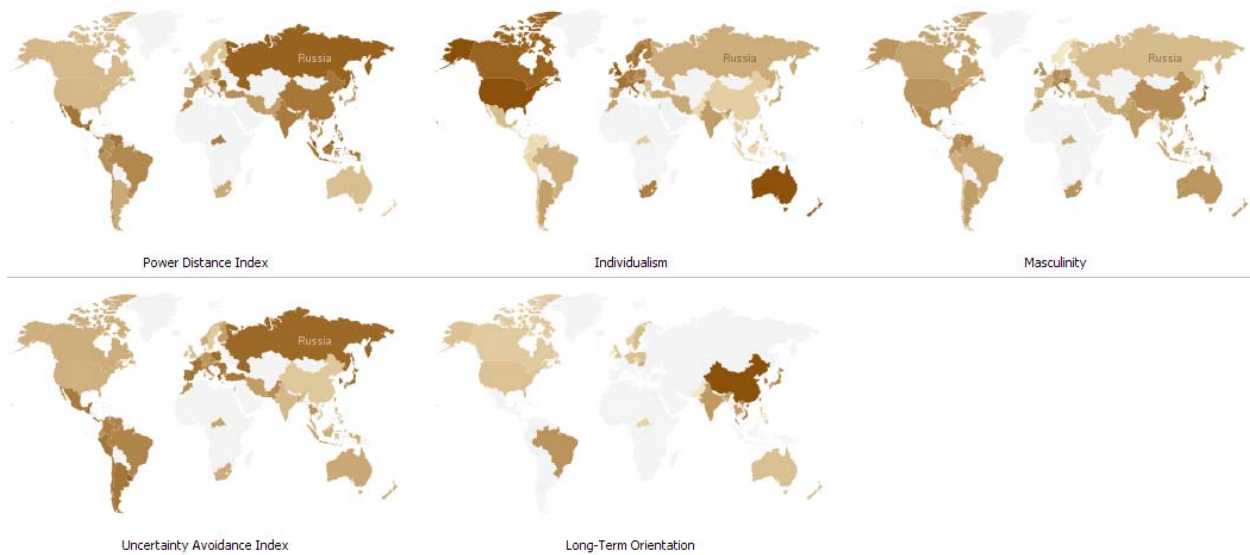


Figure 5: Map of national scores on Hofstede’s five cultural dimensions

Note: Darker shading indicates higher scores. Blank areas indicate missing data. This map was generated using the ManyEyes web service¹⁰ using a data set published by Hofstede¹¹.

Related work by Nisbett, 2003) and others has introduced *the importance of honor*, or the degree to which society sanctions the use of violence as a justifiable tactic for resolving affronts to one’s character. Under Hofstede’s, Arab culture is characterized by high power distance (meaning wide disparities of equality among social classes and great deference to status individuals), and high uncertainty avoidance (in which daily interactions are governed by societal rules that lower uncertainty). Beaubien, Knott, Orvis, and Freeman (2008) developed descriptions of situations that tested the standing of respondents on most of the dimensions, above, and found that unique linear combinations of these dimensions reliably predicted the responsiveness of members of one Asian culture to strategies typically used in advertising and psychological operations¹².

Traditional demographics analyses are often used to profile cultures for purposes as diverse as market analysis, political forecasting, and psychological operations, in which decisions concern what style of communications – rational explanations, visionary statements, testimonials, etc. – will most effectively convey a message. Demographic analysis typically considers data concerning income, age, sex, working status, language, position in the household (father, daughter, etc.), marital status, and religion. These variables more or less reliably predict purchasing behaviors, voting, and other behaviors. Note, however, that demographic methods are typically within a culture, rather than between cultures. It is not entirely clear whether traditional demographics reliably predict institutional behaviors or define its culture.

¹⁰ ManyEyes is available at: <http://services.alphaworks.ibm.com/manyeyes/view/SLinXQsOtha6b6FrBV6bQ2~>

¹¹ The Hofstede data set is published by the author at: http://www.geert-hofstede.com/hofstede_dimensions.php

¹² The goal of PSYOP is to always tell the truth, as evidenced by the motto of COL James Treadwell, Commander of the 4th Psychological Operations Group: “The truth is the best propaganda.” This strategy helps ensure the credibility of influence campaigns (U.S. Joint Forces Command, 2003).

Appendix B: Trident Warrior Technologies in HI08.1

Two collaboration technologies were explored in the part of TW08 focused on law enforcement (HI08.1). These technologies were the Law Enforcement Information Exchange (LInX) and the Force Protection Portal (FPP).

- LInX is a database of law enforcement records from several participating regions of the United States. LInX presents the user with access to pawn shop data; a rapid, tactical search capability typically used by police during arrests; an analytic search capability that provides Boolean search, search of free text (narrative) fields, and link analysis; a personalized home page; and system administration functions. A search on LInX can return a suspect's name, date of birth, aliases, criminal incidents, role in those incidents (witness, cited), vehicles involved, weapons involved, incident type, a narrative (e.g., pocket litter), photo, warrant information, contact information for the suspect, and contact information for the issuing law enforcement agency. Link analysis reports graphically represent the relationships between many of these entities (e.g., suspects to addresses to vehicles). The quality of these reports varies somewhat due to uncorrelated data (e.g., separate records for John Hartwick, John J. Hartwick, and Johnny Hartwik may concern the same person), spurious correlations (by which innocent individuals are coincidentally associated with suspects). The utility of the reports is in part a function of their volume; a search against the current one million records can return a very large number of hits. Users generally may not use LInX records as the basis for warrants or arrests, but must contact the issuing agency for the source data. LInX legal records may not be transferred to the military. These and other policies are currently being standardized across the LInX user community. In this exercise, LInX was populated with actual, but anonymized criminal records.
- FPP is an unclassified, password protected internet portal that provides file sharing, chat, email. FPP presents users with access to news, upcoming events, a document repository, sites of interest (DHS, Department of State, CNN, etc.), and the NCIS portal. The latter provides email, a document repository, chat, a calendar, and current briefings. NCIS participants and observers in TW08 exercised the FPP portal to access documents concerning scenario events, and to communicate with each other and the controller. All users had access to all documents on the portal. (In actual use, there may be legal or regional policy constraints on information access and dissemination). FPP is designed for operational use, and not for experimentation. Thus, it does not support observers with features such as email logging.

The scenarios that exercised LInX and FPP in this part of Trident Warrior consisted of base materials and a four-day stream of injects that required participants to detect several threats:

Scenario 1a: A planned anthrax attack against Oahu

Scenario 1b: A planned anthrax attack against Seattle

Scenario 2: A planned radiological attack against a Hawaiian sonar range

Participants in this element of Trident Warrior field offices of the Naval Criminal Investigative Service (NCIS) in Bahrain, Dubai, Hawaii, Japan, Seattle and Singapore; the Joint Terrorism Task Force, Third Fleet MOC, the British Royal Navy, and the New Zealand Navy. In addition, data were collected in an observation of a VTC between several of these organizations and the Multiple Threats Alert Center.

Appendix C: HI08 Data

Data collected at HI08 are available in sanitized form (i.e., without personally identifying information) with the permission of OSD NII. For further information, please contact Jared Freeman, freeman@aptima.com, 202-842-1548 x316.

Appendix D: Controller communications in HI08.1

In addition to the interviews reported in the body of this report, we examined a sample of email between participants and the controller¹³ in HI08.1 in order to understand the level of participation and the types of interaction between participants and experiment organizers. We found several classes of communication:

- Technical support communications provided users with instructions about where to put files, how to use the systems, how to handle different file formats, and so forth.
- Logistical communications concerned coordination between controllers, how to reach controllers, etc.
- Scenario event communications provided new injects, copies of injects, background information, responses to requests for information (e.g., summaries of requested (but unavailable) reports), responses to participants' planned actions (e.g., "When you call the Bahraini Minister of the Interior, you will learn that..."), and corrections of participant misunderstandings.
- Participant activity reports documented what participants had done and what they planned to do within or outside the artificial confines of the scenario. Only one participant in the sample of ~30 emails provided detailed accounts of these activities.

¹³ No email between participants was available for analysis.

Appendix E: Notes Towards Experimentation

Experiment Themes

Several specific themes for HI09 experimentation arose in discussions among members of the research team:

- Optimizing Human Interoperability Performance in Law Enforcement Enterprises which Leverage Investigative Data Sharing Systems (e.g., LInX)
- The Role and Contribution of HI in the Developing, Establishing and Advancing Common Operating Pictures
- Aligning Distinct Different Organization Cultures through HI Principles, Standards and Practices for Improved Enterprise Performance, Study One: The Military and Embedded and External Law Enforcement (this could be the first in a series, which could go on and on)
- The Contribution of HI to Senior Policy Formulation and Decision Making (contact Neil Palmer, UK MOD)
- Agency Ideology and Culture and Its Influences on Establishing and Maintaining Peer External Organizational and Individual Relationships (JTTF as one experimental environment)
- Trust, Relationships and Enterprise Effectiveness in Multiagency Constructs (established as in JTTFs for law enforcement, or task forces—various military- non-military constructs; hastily formed and established or mandated and forming)
- Influence of Personnel and Career Practices on Enterprise Performance in Agencies Dependent on Specialized Relationships, Experience and Expertise
- Role of Relationships in DOD-Non-DOD Engagements: The NCAG Model (can identify others for study too to broaden the effort)
- Comparison of International and USN NCAG Operations: The HI Component
- HI in Crisis and Non-Crisis Environments, Strategic, Operational and Tactical Considerations In Established and Hastily Formed Multiagency Constructs

Experimental Participants

HI08.1 successfully engaged military law enforcement. HI09 should engage civilian entities, as well.

Recommendation: *An NCIS analyst s recommended that future experiments engage a major police department with command-and-control capabilities such as the NYPD, DHS entities such as the FBI, and European law enforcement entities such as EUROPOL.*

Experimental Materials & Process

A data collection instrument was defined to elicit, in interviews and observations, data concerning policy barriers, inter- and intra-organizational processes and structure, and other matters. The draft instrument is in Appendix F: Data Collection Instruments

Recommendation: Review, revise, and use the draft data collection instrument in HI09.

The analysis of controller-participant communications identified several classes of communications for which controllers might prepare in advance of the experiment.

Recommendation: To prepare for their technical support role, controllers should conduct at least one pilot study to identify the types of technical support questions that may arise and the types of workarounds that may be needed.

Recommendation: To prepare for their technical support role, controllers should conduct one tabletop exercise using the experimental materials to determine what information or documents participants may request from whom, how to structure fileshares, how to conduct chats (e.g., how to schedule them across time zones), and so forth.

Recommendation: White cell and controllers should map out the potential network of contacts with whom participants might try to communicate during the scenario, specify the questions that might be asked, and sketch out provisional answers to deliver in response.

Recommendation: If it is not possible to monitor participant activity, controllers should encourage participants to document the activities they did execute (e.g., “Issued RFI concerning...”) and those they plan to execute (e.g., “Will call the Bahrain Ministry of the Interior to ask...”).

Experimental Venue

A fundamental concern in inter-agency experiments is where participants should be as they execute the experiment.

Participants who convene at a central site lose access to some of the human and material resources on which they depend, but they are at less risk of distraction, they have the technical support they may need to use experimental technologies effectively, and they are readily accessible to observers.

Participants working from their own workplaces have access to the human, technical, and document resources that enable them to respond to scenario events in a natural way. However, they are inevitably distracted by real-world tasking, they may have difficulty using new technologies or procedures being studied in the experiment, and it can be more difficult to observe their behaviors or elicit their opinions.

Distributed participants are inevitable in any richly defined inter-agency experiment. Methods are needed to engage distributed participants more fully in the experiment.

Recommendation: Place a trusted agent working at each, distributed site to win fuller engagement from participants there.

Recommendation: Engage distributed participants in pre-experiment planning, in-experiment hot washes, and post-experiment lessons learned events to develop a community of interest and raise their level of involvement in the experiment. In these sessions, emphasize the institutional value of the experiment (e.g., fulfilling an official requirement), and the professional benefits to participants: learning new technologies, building relationships with others in the field, fulfilling goals for performance review, or intellectual challenge.

Organizational Structures

A variety of organizational structures for HI were identified in HI08.1.

Recommendation: HI09 should sample the variety of structures used to build HI: co-location of agency representatives, collaboration through trusted parties, and distributed collaboration through technology.

Organizational Culture

Law enforcement and military organizations exhibited important cultural differences in HI2008.1. The next HI should exploit such differences.

Recommendation: HI09 should assess the cultural attributes of participating organizations (e.g., using Hofstede's (1980) framework) and should design scenarios that exploit natural interactions between entities with conflicting cultures.

Organizational Process

Law enforcement and the military differ in the processes they employ for developing relationships between entities.

Recommendation: HI09 should assess the formality and effectiveness of procedures for institutionalizing productive relationships between entities.

Information systems

Observers of HI08.1 saw successful use of LInX for searches of law enforcement data, and FPP for relaying scenario injects and communication with the experiment controller. Lessons learned concerning the FPP are particularly relevant to future experiments, which will use collaboration technologies. In general, these technologies or technologies ("wrappers") that incorporate them should provide services for experiment observers, not just participants.

Recommendation: Ensure that portal-based email systems copy every email between participants so that these messages are also delivered to controllers and observers. Ideally, participant email addresses will include their locations and/or roles.

Recommendation: Ensure that chat systems log all communications for inspection by observers.

Recommendation: *Ensure that file sharing system log file activity for analysis (e.g., to determine who did and did not read or write key files). It may be useful to push these logs like RSS feeds to observers and controllers.*

Recommendation: *Ensure that phone systems records voice communications and metadata, minimally participant identities, date, time, and call duration for each participant for each call (point-to-point or teleconference). Providing VOIP telephone capability through portals may facilitate this.*


Several minor technical glitches conveyed useful lessons.

Recommendation: *Ensure that participants have access to the infrastructure required to use new technology: unclassified network ports, utilities for opening required files (e.g., .pdf's), etc.*

Providing the human infrastructure for new technologies is an important aspect of technology insertion.

Recommendation: *Technology evaluations should assess the staffing requirements of new tools, the utility of training for performing locally critical tasks, and the plans for communities of interest to govern the use of new technology.*

Appendix F: Data Collection Instruments


	Human Interoperability 2008	
	Data collector:	Date/Time:
	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	

Instructions to HI08 Data Collectors

Please read the instructions for researchers to familiarize yourself with the objectives of the HI experiment objectives.

Please use the Briefing to Participants if you must provide a brief.

Collect data at major scenario events using the questionnaire, log, and other forms.

	Human Interoperability 2008	
	Data collector:	Date/Time:
	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	

Overview for HI08 Data Collectors

HI08 is an experiment designed to evaluate human interoperability in a complex environment – an inter-agency maritime security experiment by assessing

- Policies concerning information sharing
- Processes & structures within agencies that support collaboration
- Processes & structures between agencies that implement collaboration (e.g., cross-briefings, working groups)
- Response speed within and between agencies

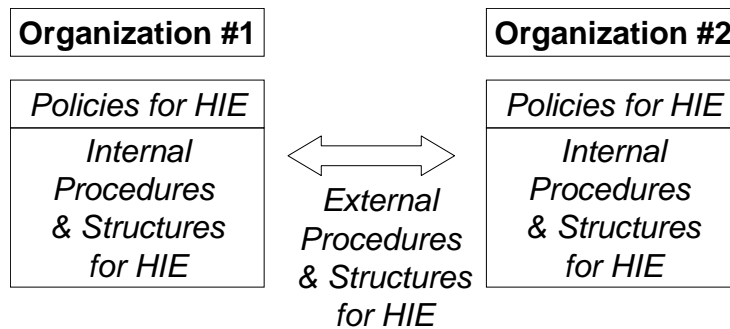



Figure 6: HI08 explores the policies, procedures, and structures (in italics) that enable HI.

The products of this experiment and future work will be:

- A process for planning and conducting HI09
- Gaps and opportunities for enhancing collaboration and coordination.
- New organizational structures and processes that enable disparate organizations to collaborate across legacy shared or ad-hoc boundaries
- Reliable methods for measuring and managing human interoperability in organizations

HI08 takes place 16-27 June 2008 at various locations as part of Trident Warrior 2008.


	Human Interoperability 2008	
	Data collector:	Date/Time:
	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	

Participating data collectors in this experiment are:

Person	Date	Task	Email	Cell
Tami Smith	23-27	HI data collection	tami.smith@navy.mil	703-362-5940
Randy Murch	16-20, 23-27	HI data collection	rmurch@vt.edu	703-731-2712
Jared Freeman	16-27	HI data collection	freeman@aptima.com	202-262-3030
Alenka Brown	22-27	HI data collection	stefania.brown-vanhoozer@osd.mil	571-309-4951 / 703-607-0740
Hal Moore	23-27	HI white cell	hal.moore@northcom.mil	(719) 554-8045
Bob Miley		TW08 lead for NCIS	Tbd	202-433-9103
Shelley Gallup	16-27	TW08 management	spgallup@nps.edu	831-594-0609
Dan Dunaway	16-27	TW08 management	ddunaway@systechnologies.com	tbd
Kevin Kurtz		TW08 manager	kkurtz@systechnologies.com	757-651-4800

The instruments below are designed for use by the data collectors. Please print several copies and take notes on these forms, or take notes as you wish while keying the answers to the question numbers listed below. Please administer these forms at every significant experimental event or scenario as defined in the TW08 schedule. Amend the forms with new items as you see fit. Please write neatly or transcribe your notes to electronic form. Keep all notes unclassified.

Return all materials to Jared by 1 July 2008. He will send Fed Ex to you upon request. Contact Jared at: freeman@aptima.com; office: 202-842-1548, x316; cell: 202-262-3030; fax: 202-842-2630; Aptima, 1726 M Street, NW, #900, Washington, DC 20036.

	Human Interoperability 2008	
	Data collector:	Date/Time:
	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	

Form #1: Briefing to Participants

The Office of Secretary of Defense is sponsoring an experiment to examine how organizations interact over Maritime Domain Awareness events. We call this experiment Human Interoperability 2008. This experiment “piggybacks” on Trident Warrior 2008, which you are participating now.


We are not assessing your performance in HI08. We are not assessing the performance of your organization. We are studying the interface between organizations, specifically within DoD and between DoD and DoJ, DHS and the Intel Community.

OSD will issue a report from this experiment that draws some initial lessons and specifies the design of a larger HI experiment in 2009. Future products of HI will help organizations to design their policies, processes, protocols, organizational structures, standards and technologies in ways that make MDA and other complex organizational enterprise responses more effective, efficient, timely and responsive.

This is the support we need from you:

- During parts of TW08:
 - A data collector will sit with you to observe and ask you questions.
 - We’ll request your job title and organization. (We don’t need your name).
 - We’ll observe your response to events in TW08, and we will interview you concerning these events.
- Please be prepared to introduce the data collector to other knowledgeable, appropriately placed experts in your organization. We’d like to gather their thoughts about the type of events, processes and opportunities for improvements to human systems performance that will be encountered in this exercise.
- Please play by the rules of TW08. Our presence is not meant to change your mission or actions in TW08.

Do you have any questions?

	Human Interoperability 2008	
	Data collector:	Date/Time:
	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	


Form #2: Participant Demographics

Instructions

For each participant observed or interviewed, gather the information below. Develop and document new questions as you see fit.

Demographics

2.1 Operator TW08 PIN # (4 digits chosen by operator)
2.2 First letter of Operator's last name:
2.3 Rank / Rate
2.4 Organization / Command:
2.5 Position/Role Title:
2.6 Length of Time in Position/Role:
2.7 Description of responsibilities:
2.8 Length of Time in MDA Missions:
2.9 List or network of superiors, peers, subordinates by role and function.

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Form #3: Interview Questionnaire

Instructions

For each major event or scenario, ask the participant(s) the Questions (below). Record the question numbers and answers in Observer Notes table. Develop and document new questions as you see fit.

Questions

Q#	Item	Objective
3.1	How does your organization decide to accept this task or respond to an event or message like this?	Objective v2: Process between agencies (Item: 14.01 Interface: process)
3.2	What is an acceptable range of time (minimum, average, and maximum) to respond to an event such as this?	Objective v2: Process between agencies (Item: 5.01 Interface: n.a.)
3.3	How do you process this task internally? Who does what?	Objective v2: Process between agencies (Item: 14.02 Interface: process)
3.4	Is there a format or protocol for sharing information about this event between agencies? If yes, name it.	Objective v2: Process between agencies (Item: 1.01 Interface: data)
3.5	Does the format convey the information that is necessary and sufficient for analysis or decision making in your (receiving) organization? If no, please comment.	Objective v2: Process between agencies (Item: 1.02 Interface: data)
3.6	What interactions with other agencies will you engage in to respond to this event? How long can you afford to wait (i.e., the maximum) for data or decisions from the other agencies?	Objective v2: Process between agencies (Item: 6.02 Interface: process)
3.7	Are interagency teams/collaborations defined before the event? If yes, name them.	Objective v2: Process between agencies (Item: 1.04 Interface: structure)
3.8	How do you ensure that responses or tasks are ready to hand off to other agencies?	Objective v2: Process between agencies (Item: 14.03 Interface: process)



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Data collector:

Date/Time:

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Participant Role(s) / Location

Vignette / Event:

Q#	Item	Objective
3.9	Is there a named process for sharing information about this event between agencies (e.g., a protocol, meeting, COP)? If yes, name it.	Objective v2: Process between agencies (Item: 1.03 Interface: process)
3.11	Are there policies that enable interaction between agencies in this event? What are they?	Objective v2: Process between agencies (Item: 9.01 Interface: policy)
3.12	What interactions in this event are not governed by policy?	Objective v2: Process between agencies (Item: 10.01 Interface: policy)
3.13	Are these policies ever suspended to facilitate interagency interaction? Under what conditions?	Objective v2: Process between agencies (Item: 11.01 Interface: policy)
3.14	Do the policies of other agencies conflict with these policies?	Objective v2: Process between agencies (Item: 13.01 Interface: policy)
3.15	What inhibits effective performance on this event?	Objective v2: Process between agencies (Item: 3.01 Interface: policy, structure, process, data, culture)
3.16	Is performance on this event handicapped by the structure of your organization: insufficient number of staff, missing roles, redundant roles, unnecessary roles?	Objective v2: Process between agencies (Item: 3.02 Interface: structure)
3.17	Is performance on this event handicapped by missing or awkward processes?	Objective v2: Process between agencies (Item: 3.03 Interface: process)
3.18	Is performance on this task handicapped by difficulty getting specific data or information?	Objective v2: Process between agencies (Item: 3.04 Interface: data)
3.19	Is performance on this task handicapped by cultural or personality conflicts within or between organizations?	Objective v2: Process between agencies (Item: 3.05 Interface: culture)
3.20	Are there policies that inhibit interaction between agencies in this event? What are they? How?	Objective v2: Process between agencies (Item: 9.02 Interface: policy)



Human Interoperability 2008

Data collector:


Date/Time:

Observed Organization /
Participant Role(s) / Location

Vignette / Event:

Observer Notes

Q#	Notes

	Human Interoperability 2008	
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	Observed Organization / Participant Role(s) / Location	
	Vignette / Event:	

Form #4: Observation Log

Instructions

For each major event or scenario, record significant events pertaining to each of the items using the Log and Log Addendum. Develop and document new items as you see fit.

Log

#	Item	Objective
4.1	What data or decisions are received at the beginning of this event? What is the format or protocol? In what medium? From what entity?	Objective: Process between agencies
4.2	When did the event arrive at the agency?	Objective: Responsiveness
4.3	When did this entity or agency accept responsibility for or first make a significant response to this event? Describe the response.	Objective: Responsiveness
4.4	What is the name (if any) of the organizational process that is invoked in response to this event? (“Sharing processes”)	Objective: Process between agencies



Human Interoperability 2008

Data collector:

Date/Time:

Observed Organization /
Participant Role(s) / Location

Vignette / Event:

#	Item	Objective
4.5	What teams/collaborations participate in the event? ("Sharing participants/venues")	Objective: Process between agencies
4.6	What data or decisions are requested while processing this event? By whom and of whom? What is the format or protocol? In what medium? ("Sharing behaviors")	Objective: Process between agencies
4.7	What policies (if any) are cited during task execution?	Objective: Policies
4.8	What tasks are performed in response to this event? ("Sharing behaviors")	Objective: Process within agencies
4.9	When did the agency issue a response or decision concerning the event?	Objective: Responsiveness



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Vignette / Event:

Log Addendum


#	Notes

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	Vignette / Event:	

Form #5: Workplace Layout

Instructions

For each physical space in which you observe operations, sketch the configuration and indicate the roles and organizations of each operator / decision maker.

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	Vignette / Event:	

Form #6: Social Network

Instructions

For each organization you observe, sketch the social network within and between organizations in which *organizations and roles are nodes*, and *directed arcs (arrows) are relationships*. Please label the arcs with terms that characterize the function the relationship serves (e.g., “Role #1 → is liaison to → Organization #2”).



Human Interoperability 2008

Data collector:

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Observed Organization /
Participant Role(s) / Location

Vignette / Event:

Form #7: HI09 Recommendations

Instructions

Record below the table your ideas for an efficient, effective HI09 experiment.

Q#	Item
7.1	Your ideas for HI09 research objectives
7.2	Your ideas for HI09 research measures
7.3	Your ideas for HI09 research participants (organizations)
7.4	Your ideas for HI09 scenario events & materials
7.5	Your ideas for HI09 research methods
7.6	Your ideas for HI09 analyses & reporting

#	Notes

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