SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED | 1b. RESTRICTIVE MARKINGS<br>N/A |
| 2a. SECURITY CLASSIFICATION AUTHORITY | 3. DISTRIBUTION/AVAILABILITY OF REPORT<br>UNLIMITED |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S) | 5. MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a. NAME OF PERFORMING ORGANIZATION / 6b. OFFICE SYMBOL (If applicable) | 7a. NAME OF MONITORING ORGANIZATION |
| 6c. ADDRESS (City, State, and ZIP Code) | 7b. ADDRESS (City, State, and ZIP Code) |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>Advanced Research Dept<br>8b. OFFICE SYMBOL (If applicable)<br>35 | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c. ADDRESS (City, State, and ZIP Code)<br>Naval War College<br>686 Cushing Rd<br>Newport, RI 02841-1207 | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO. |

11. TITLE (Include Security Classification)
Information Fusion and References to a Common Geospatial Framework Within the National Security Strategy

12. PERSONAL AUTHOR(S)
Mr. Alfred W. League

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Final | FROM Mar 97 TO Jun 97 | 13 June 97 | 65 |

16. SUPPLEMENTARY NOTATION

| 17. COSATI CODES | | | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | Imagery and geospatial information, National Security Strategy, and mission performance |


19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Warfighters, Foreign Service Officers and economic analysts demand more flexibility in the data they receive in order to tailor information displays locally. While increased flexibility enhances their options, it challenges interoperability without a common reference. That common reference constitutes a global geospatial framework supporting information fusion across the full spectrum of national security strategy. Ultimately, the application of a common geospatial infrastructure will substantially improve the effectiveness of our National Security Strategy, highlighting options available to decision makers in all branches of government through the application of geographic information and spatial analysis.


| | |
|---|---|
| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | 21. ABSTRACT SECURITY CLASSIFICATION<br>Unclassified |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>CDR Joe Vanderlip, Dep. Asst., ARP | 22b. TELEPHONE (Include Area Code) 401-841 6568 / 22c. OFFICE SYMBOL 35A |

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE


☆U.S. Government Printing Office: 1985—539-012

0102-LF-014-6602

# Information Fusion and References to a Common Geospatial Framework within the National Security Strategy



Al League

NAVAL WAR COLLEGE
Newport, R. I.

# INFORMATION FUSION AND REFERENCES TO A COMMON GEOSPATIAL FRAMEWORK WITHIN THE NATIONAL SECURITY STRATEGY

by

Alfred W. League

National Imagery and Mapping Agency

As an Advanced Research Project

A paper submitted to the Director of the Advanced Research Department in the Center for Naval War Studies in partial satisfaction of the requirements for the Master of Arts Degree in National Security and Strategic Studies.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Alfred W. League

13 June 1997

Faculty Advisor:

W. F. Sweitzer

W. F. Sweitzer, CDR, USN
$C^4$I Chair, Department of
Joint Military Operations

## Abstract of
## Information Fusion and References to a Common Geospatial Framework within the National Security Strategy

Although the current focus of information superiority is national defense, a broad range of civilian organizations require access to imagery and geospatial information to support a cohesive National Security Strategy. Detailed knowledge of the environment is fundamental to diplomatic, economic, and joint military operations. Expedient information fusion determines success in the marketplace, at the negotiating table and as a last resort, on the battlefield.

Today, multiple series of maps and charts, both paper and digital, provide a background for information analysis, challenging interoperability and unity of reference. The development of a common geospatial framework, enhancing understanding of information within an interoperable geographic context, provides the basis for true information superiority.

The National Security Strategy directs the diplomatic, economic and military organizations to increase mission performance with decreasing resources resulting in demands for increased system efficiencies. Increased computer and communication system capabilities enable decision makers and operators alike to visualize and create technological opportunities for the transfer of information in huge quantities and at speeds revolutionizing international relations. This flow of digital data opens a globalization of situational awareness, which in turn increases the demand for framework data.

Warfighters, Foreign Service Officers and economic analysts demand more flexibility in the data they receive in order to tailor information displays locally. While increased flexibility enhances their options, it challenges interoperability without a common reference. That common reference constitutes a global geospatial framework supporting information fusion across the full spectrum of national security strategy. Ultimately, the application of a common geospatial infrastructure will substantially improve the effectiveness of our National Security Strategy, highlighting options available to decision makers in all branches of government through the application of geographic information and spatial analysis.

# Table of Contents


Abstract ii

List of Illustrations iv

1. Introduction 1

2. Geospatial Requirements: A National Perspective 6

3. Geospatial Information: Service Perspectives 17

4. Infrastructure Supporting A Common Geospatial Framework 22

5. U.S. Strategic Command: Integrating Multiple Current Geospatial References 26

6. The Future 28

7. Near Term Interfaces to a Common Geospatial Framework 33

8. Developing Technologies Enabling Realization of a Common Geospatial Framework 36

Collaborative Computing Tools 36

Tactical Sensors 37

Object Oriented Data Structures 38

9. Integration and Transition to a Common Geospatial Framework 41

10. Opportunities 46

11. Conclusion 51

Selected Bibliography 55

## List of Illustrations


1. Information Fusion Referenced to a Common Geospatial Framework 9

2. Geospatial Information Integration 13

3. Joint Vision 2010 Missions Requiring a Geospatial Framework 17

4. Integrated Split-Based Support Using Combined Communications Architectures in Support of the Bosnia Peacekeeping Operations 21

5. Networks Available for Transmission of Geospatial Framework 22

6. Geospatial Information on USSTRATCOM J2 Spatial Data Server 27

7. JWID-97 Demonstrations Interacting with Geospatial Information 30

# 1. Introduction

To operate successfully in current and projected environments, decision makers, diplomats and warfighters need an awareness of the mission space that allows them to make faster and more complete decisions than their adversary. Be it in the marketplace, at the negotiating table or, as a last resort, in the implementation of military power, expedient fusion of information facilitates improved decision making. This does not mean to suggest that military requirements are secondary to economic issues, but rather they are integral to a holistic approach to data supporting the National Security Strategy. We, of course, must never loose perspective that "in a purely commercial environment, maneuvering successfully on the electronic superhighway can mean the difference between enrichment and maintaining the status quo. On the electronic battlefield, reliability and security determine the difference between dominating and merely surviving."[1]

We cannot assume we have or will have an information monopoly. The "challenge for future operations is to get inside the time-cycle of potential adversaries"[2] who also have information, advises RADM Daniel March. Information fusion is key to

[1] Lt. Gen. Albert J. Edmonds, USAF, "Teamwork for the Warrior," Defense 97, Issue 2, American Forces Information Service, Washington, DC, 25.

[2] Interview with RADM Daniel March, USN Ret., National Correlation Working Group, Chantilly, VA, 3 April 1997.

implementation of our national policies. This is the core concept of a knowledge-based National Security Strategy.

The data contained in a knowledge base that supports information superiority[3] is however, of little use without a contextual reference. The display of information over geography provides this context. With the power of spatial analysis, information truly becomes a force multiplier.

Since man first time waged war, detailed knowledge of the combat environment, including the location of the enemy and navigation to and from the battle area, was fundamental to success on the battlefield. The keys to successful modern warfare have not changed. The ability to locate enemy targets and successfully put the bomb on target remains the essence of combat operations. Napoleon was, perhaps, the first military mind to realize the value of accurate maps in his implementation of the corps and division structure for offensive military operations. By possessing superior knowledge of the battlespace[4], even though it was two dimensional in his era, Napoleon had a geographically aware command and control that allowed him to more effectively coordinate offensive operations over large areas.

---

[3] Lt. Gen. Albert J. Edmunds defines information superiority as "the ability to collect, process and disseminate an uninterrupted flow of information while denying our enemy that ability" in "Teamwork for the Warrior," 25.

[4] For the purposes of this study, "battlespace" is intended to describe areas of interest (AOIs) that may or may not involve the employment of military power. For example, trade negotiations involve contested issues that exist within a geospatial context.

In the modern context, this means operational forces rapidly obtain highly precise target location coordinates, as well as those of surrounding defenses and have the requisite information to navigate successfully to target areas, delivering weapons. Although technology has made it easier to locate an adversary's position on the earth, improvements in weapon technologies and warfighting techniques significantly increases the precision and timeliness required for mission support data. What was previously needed in days is now often required in hours or minutes, and in the future, seconds.

Although many of the fundamentals of warfighting have not changed, the last decade has seen significant changes in military capabilities, planning, and operations that has been brought about by a series of concurrent revolutions. The first, a technological revolution in computing, communications, and weapons technologies, allows unprecedented improvements in warfighting capabilities. Many of these new weapons require precise navigation over long distances, and, as such, are increasingly dependent upon geospatial information.[5] The second revolution, geopolitical in nature, ended the Cold War. Multi-faceted regional threats replaced the monolithic Soviet threat. Finally, a revolution in military force structure is materializing, brought about by force down-sizing and major military realignments in roles, missions, and forces. These collective revolutions result in the requirement for today's strategic planners and forces to function

[5] Naval War College, Battlespace Information, Command and Control(C2), Operational Intelligence and Systems Integration, Joint Military Operations Department, November 1996, 20.

with rapidly changing technologies in unfamiliar command and operational environments. The dilemma of the modern warrior is to do more with less, to be more timely in a global environment, and to conserve precious combat resources, while responding to many non-traditional missions.

The effect of the above revolutions in the Geospatial Information community is dramatic. In many areas, the implications are not yet fully understood. The effect of moving from lithographic paper map products to digital displays of geospatial information is as profound a change for the modern producer and user as was the marriage of the printing press and the cartographer hundreds of years ago. The modern revolutions affect the geospatial information community by requiring different ways of doing business, new methods to represent information about the earth, new ways to collect, process, manage, and distribute information to the military user, all in a significantly compressed set of timelines.

Decision-makers will continue use of paper products for some time, not much different from Napoleon's,[6] as aids in mission planning or mission execution. However,

---

[6] Currently, topographic map sheet size standards are about 24" by 28" which has been a major obstacle in the effort to develop "tailored print on demand" maps in forward deployed locations. Interestingly, this standard seems to have evolved from history as opposed to developing for required military function. The current standard derives from a contemporary friend of Gerardus Mercatur, a Flemish map maker, who published a set of maps in 1569 using a mathematical formula that became known as the Mercatur projection. Abraham Ortelius published the first modern atlas in 1570 and buying Mercatur's maps, redrew, colored and reprinted them in a standard size of roughly 24" by 28," according to Dan Morrison in "Ancient Worlds," SPIRIT, May 1997, 70-71.

over the past twenty years the accelerating demand for digital products[7] reflects the improved speed of data processing, the increased complexity of software applications, and the decreasing cost of high-powered hardware. In the recent past, digital products adequately satisfied the data needs of only one customer, or one system, or a limited suite of applications. In the future, the geospatial data community must revise traditional digital data for a variety of information needs.

This said, "Information Fusion and References to a Common Geospatial Framework within the National Security Strategy" addresses this topic by investigating the requirement for a common framework from both national and service perspectives. A current USSTRATCOM initiative highlights examples of several redundant data formats and the challenge they present. Integration, transition and current opportunities follow a discussion of some current and future technologies that enable the development and application of a common framework for information superiority.

---

[7] National Imagery and Mapping Agency produces many digital products used by the commands, services and National agencies. Compressed Arc Digitized Raster Graphics (CADRG) is a digital reproduction of paper map products such as Joint Operations Graphics (JOGs), Operational Navigation Charts (ONCs), and Topographic Line Maps (TLMs). The Digital Point Positioning Data Base (DPPDB) is a stereo imagery-based product that supports targeting, intelligence analysis, Command and Control, and mission planning. Within DOD's targeting community, the DPPDB is the only authorized source of field-mensurated target coordinates. Digital Terrain Elevation Data (DTED) is a uniform grid of elevation data at approximately 100 meter spacing. Vector Smart Map (VMap) is a collection of databases that provide vector-based geospatial data at low, medium and high resolution. Digital Chart of the World (DCW) serves as a general purpose, 1:1,000,000-scale, vector database in support of Geographic Information Systems applications. The feature content originates from the 1:1,000,000 scale ONC. Vector data consists of points, lines and arcs representing and attributed to describe features normally found on standard topographic maps and hydrographic charts.

## 2. Geospatial Requirements: A National Perspective

Although the current focus of resources is on the national defense uses of imagery, imagery intelligence and geospatial information, a broad range of civilian organizations also requires similar information. As Secretary of Defense Cohen notes, "Our national security is not only a matter of defense, but also of diplomacy. Indeed, the two are closely linked. Our foreign affairs programs can strengthen America's security in close synergy with our military strength."[8] This is a synergy enhanced by a common understanding of the strategy laid upon a common geospatial framework. As a result, efforts must be made to ensure that policies and procedures being developed as parts of a geospatial framework supporting information fusion incorporate and exploit potential synergy with civil organizations' requirements.

The CINCs', Services' and Agencies' operational missions continue to drive National and DoD imagery and geospatial requirements causing the demand for information superiority, and subsequently overwhelming the resources available to meet them. While Operations Plans (OPLANs) and Contingency Plans (CONPLANs) drive collection and production of data over geographic areas, the content of the information

[8] William S. Cohen, Defense Policies & Budget Priorities, Defense 97, Issue 2, American Forces Information Service, Washington, DC, 4.

collected and produced is driven by intelligence needs, organizational task lists and functional performance requirements of Command, Control, Communications, Computers and Intelligence ($C^4I$) and weapons systems fielded by the Services.

The most stringent requirements for geospatial information come from commands extensively involved in operations other than war (OOTW) and Special Operations Forces (SOF) operations. Feature requirements in these disciplines are highly mission dependent, yet planning windows are often compressed. For operations in Haiti, compliance with rules of engagement required locations of single power transformers. In permissive operations, such as Bosnia Peacekeeping Operations, commanders task personnel to observe needed features because forces have reasonable access and control of target areas. Needed features include lines of communication, rivers, observation posts, villages and towns, and way points for navigation (cultural and hydrographic features). Non Combatant Evacuation Operations (NEO) and counter drug planning, may not allow sufficient access previous to mission execution, but still require data on rooftops, exact airport and alternative airfield location, flight obstructions and gridded imagery. Rivers and other drainage features must include seasonal variations. Power line and detailed airfield and vertical obstruction data are also recurring (because of the dynamic nature of these features) needs.

Today multiple series or versions of maps and charts and other well-defined digital or hardcopy products used by the National Command Authority, military, diplomatic corps and commerce form coherent information structures to support measurement, mapping, visualization, monitoring, modeling, terrain evaluation, and spatial reasoning applications. In recognition of the importance of geospatial information[9] to the military, the Joint Chiefs require commanders in chief (CINCs) of the unified commands to report their geospatial readiness levels as a regular part of the Joint Staff Joint Monthly Readiness Review (JMRR) process.[10]

In order to be responsive to mapping needs of the warfighter, the Defense Science Board Task Force recognized the need to change from paper maps to digital information to provide the warfighter with a common, interoperable view of the battlespace[11]. As illustrated in Figure 1, this common operational view would be built upon a foundation of geospatial information -- that is, precise data defining the physical and cultural phenomena of the earth's natural and man-made environment. Initial population of the foundation is at a medium level of detail. More detailed data can then be rapidly produced in response to specific mission requirements or as value added by deployed forces and capabilities.

---

[9] Geospatial information is any information that has associated with it some geographical and temporal reference including mapping, charting, geodesy, imagery and intelligence.

[10] U.S. Dept. of Defense, Requirements for Global Geospatial Information and Services (GGI&S), CJCSI 3901.1 (Washington: 1996), 4 and 9-10 define GGI&S as "worldwide, accurate, current, spatially co-referenced, attributed feature information about the earth arranged in a coherent structure to support measurement, mapping, monitoring, modeling, terrain evaluation, and spatial reasoning applications."

[11] U.S. Dept. of Defense, Report of the Defense Science Board Task Force on Defense Mapping for Future Operations (Washington: 1995), ii.

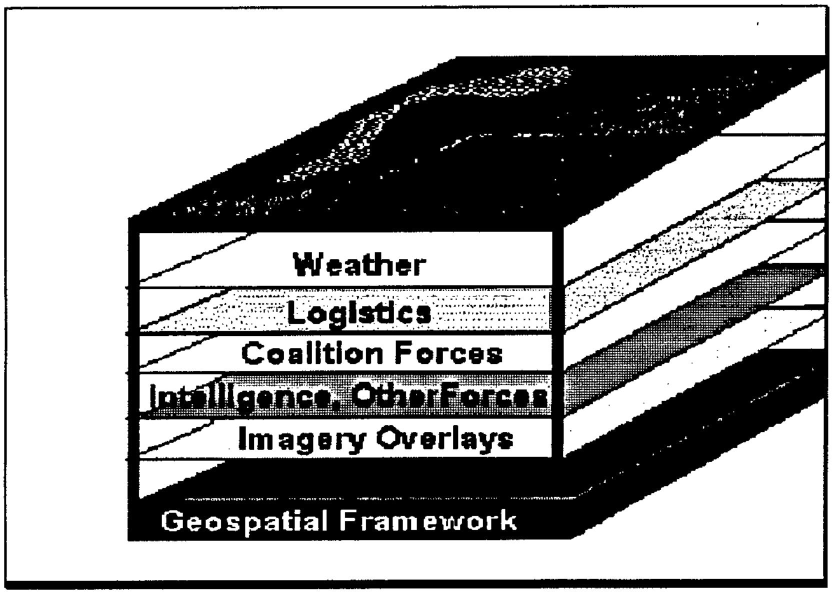


**Figure 1. Information Fusion Referenced to a Common Geospatial Framework.**

The Defense Science Board concluded that the CINCs, joint task force (JTF) commanders, and component commanders need distributed geospatial information to operate in projected DoD environments.[12] Justified by the drive for information superiority, commands require the capability to query, display, search, integrate, import, retrieve and exploit online geospatial data.

National Security Strategy drives these requirements as selective engagement requires the ability to project power with timeliness and efficiency. Often, power projection operations call for low risk, precise attack options with minimal collateral damage that meets both military and political objectives. In an era of increasingly constrained resources, new generations of commercial technology ranging from remote sensing satellites to software application programs make these capabilities even more deployable. These systems, however, require large amounts of geospatial data to provide information with spatial reference in a battlespace. The multitude of commercial technology available at increasingly affordable costs also jeopardizes interoperability within ever more prevalent ad hoc joint task forces and coalition efforts because of the proprietary nature of software algorithms and data formats used by differing vendors.

Manifesting these challenges are the higher operating tempos required to meet the demands of the National Security Strategy's expanding roles and missions. Additionally, these taskings regularly occur in areas of non-traditional national interest. Bosnia, Somalia, Rwanda and Peru-Ecuador are recent examples of United States interests that held little priority in the previous political-military world order. In these types of areas, there tends to be little if any Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance ($C^4ISR$) infrastructure, and often even less current and accurate geospatial information in formats exploitable by modern systems. In some cases, even standard paper products at tactical scales are unavailable.

An objective architecture for geospatial information, in broad terms, provides for these situations via rapid dissemination of accurate, current and spatially referenced information about the **entire earth**. With the defense community's drive toward

[12] Ibid., iv.

multifunctional, multi-media terminals in a battlespace providing fused information for the integrated tactical picture, this data must be consistent enough to support an integrated global infosphere. "The emerging world order, with its frequent regional unrest, grapples with networked operations that range from humanitarian to counter-proliferation."[13] The requirement for design, population, and management of a user accessible database of global geospatial infrastucture is a critical need to support the current and future national security strategies.

The challenge for geospatial information suppliers like the National Imagery and Mapping Agency (NIMA)[14] is to provide user accessibility to accurate data, which they can leverage into trusted information for various needs. DoD policy, accepting technical challenge across the spectrum of research and development, directs a joint doctrine to enforce common views of the battlefield and extension to coalition partners. Secretary of Defense Cohen stated, "We already do a good job of international cooperation at the technology end of the spectrum; we need to extend this track record of success across the

---

[13] Roberta A. Lenczowski, "Global Geospatial Information and Services," 05 September 1994, <http://164.214.2.57/> (14 September 1996).

[14] The National Imagery and Mapping Agency (NIMA) stood up on 1 October 1996, as directed by the Defense Authorization Bill for FY97 to form a single combat support agency dedicated to imagery, imagery intelligence, and geospatial information, acting as a focal point for support of all imagery intelligence and geospatial information customers, including customers in the Department of Defense, the Intelligence Community, and related agencies outside the Department of Defense. This consolidation of the Central Imagery Office (CIO), Defense Mapping Agency (DMA), Central Intelligence Agency's National Photographic Interpretation Center (NPIC) with all imagery support resources of the Defense Intelligence Agency (DIA), and resources of the Defense Airborne Reconnaissance Program Office and the National Reconnaissance Office (NRO) associated with imagery exploitation and dissemination fundamentally changes the means by which the National Command Authority (NCA) and Commander-in-Chiefs (CINCs) exploit national information resources including imagery and geospatial information.

remainder of the spectrum; to include major defense systems." He went on to say "the US military must:

- deploy and support standardization/interoperable equipment with potential coalition partners,
- engage allies as early as possible to identify common missions and find acceptable mission performance requirements to ensure affordability, interoperability, and satisfaction of coalition needs,
- designate appropriate defense acquisition programs as international cooperative programs,
- give favorable consideration to transfers of defense articles, services and technology consistent with national security interests,
- ensure international cooperative research and development use to enable international armaments cooperation programs to begin at an earlier time."[15]

Admiral William A. Owens adds, "If we can combine the new military capabilities the transition [to a system of systems] will give us with foreign and security policies that are consistent with those capabilities, we will be able to influence the character of the international system."[16]

---

[15] William S. Cohen, Secretary of Defense, Department of Defense Press Conference, Washington: 28 March 1997.

[16] Admiral William A. Owens, U. S. Navy, "The Emerging System of Systems," U.S. Naval Institute Proceedings, Vol. 106, May 1995, 39.

Although a common view of the battlespace across the Joint Planning and Execution Community,[17] Joint Task Forces, allied and ad hoc coalitions is facilitated by common tools or applications, it is attainable only with consistent input. Common geospatial reference enables sharing of the information contained in the geospatial reference database and access by a wide range of users to support various user activities as depicted in Figure 2.

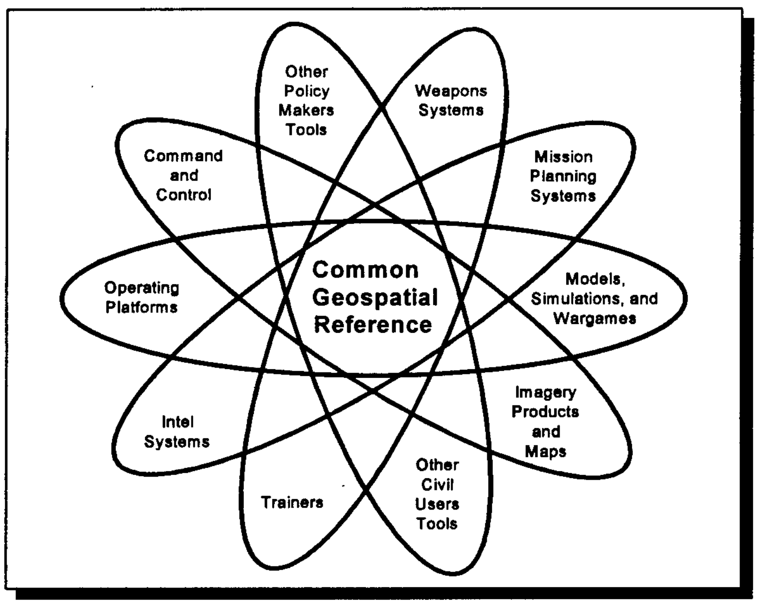


**Figure 2. Geospatial Information Integration**

As participants in the information infrastructure proliferate with newer analytical tools, their concern about available data and its associated quality broadens. Most data

[17] Joint Planning Execution Community (JPEC) includes the National Command Authority with representatives from the Department of State, Department of Defense, National Security Council and the Director of Central Intelligence.

sets currently carry auxiliary information regarding absolute and relative accuracies. Because so many data sets, however, were intended for specific systems and are now being extended to new uses, requirements specific to an application must be generalized, reducing the effectiveness of the individual system.

Not only must a geospatial infrastructure tell where, but also about the quality of the location reference data. Because the earliest production of vector formatted products that are in use today like Digital Nautical Chart and Vector maps originated from existing cartographic sources, coordinates derived from automated systems using these geographic references provide no better accuracy. The geospatial infrastucture needs rebuilding from photogrammetric and radiometric sources with accuracies better than expected Global Positioning System capabilities. Such implicit data accuracy provides the precision required for the geospatially fused battleview. Air to air, air to ground, ground to sea, strategic and tactical operations then presented a consistent perspective even at the varying resolutions of data in use.[18]

The National Security Strategy calls for a variety of uses of military force across the full spectrum of conflict. Key topics with implications for forces include deterring and defeating aggression in two nearly simultaneous major theaters of war, providing a credible overseas presence, contributing to multilateral peace operations, and supporting

[18] Lenczowski, "Global Geospatial Information and Services," 05 September 1994. <http://164.214.2.57/> (14 September 1996).

counter terrorism efforts[19]. Other missions that may or may not require military force, but are equally important to the viability of United States policy include the protection of Americans from civil or international conflict and natural or man-made disasters.[20]

Regardless of philosophy, however, the United States remains the lone world superpower and, as such, remains engaged in those areas in which it has interests. The case for the need for a common geospatial framework to support information fusion is evidenced by a Presidential Decision Directive on intelligence priorities which states, "United States intelligence must not only monitor traditional threats but also assist the policy community to forestall new and emerging threats, especially those of a transnational nature. In carrying out these responsibilities, the intelligence community must:

- support diplomatic efforts in pursuit of United States foreign policy objectives,
- provide the timely information necessary to monitor treaties, promote democracy and free markets, forge alliances and track emerging threats."[21]

As Sun Tzu stated fully 2 millennia before this information revolution,

"When employing troops it is essential to know beforehand the conditions of the terrain. Knowing the distances, one can make use of an indirect or direct plan. If

[19] The White House, A National Security Strategy of Engagement and Enlargement. February 1996, 11-17.

[20] Ibid., 17.

[21] The White House, 24.

he knows the degree of ease or difficulty of traversing the ground he can estimate the advantages of using infantry or cavalry. If he knows where ground is constricted and where open, he can calculate the size of force appropriate. If he knows when he will give battle he knows when to concentrate or divide his forces."[22]

[22] Sun Tzu, *The Art of War*, trans. Samuel B. Griffith, (London: Oxford University Press, 1971), 65-66.

## 3. Geospatial Information: Service Perspectives

"Information superiority is the foundation of Joint Vision 2010 Battlefield Dominance, as well as the warfighting vision for each service. Network warfare, robust infrastructure and information dissemination to dispersed forces are key elements in achieving information superiority."[23] Joint Vision 2010 provides the defense guidance needed to begin the process of translating mission responsibilities, as indicated in figure 3, into requirements and capabilities needed to manipulate and exploit this information.

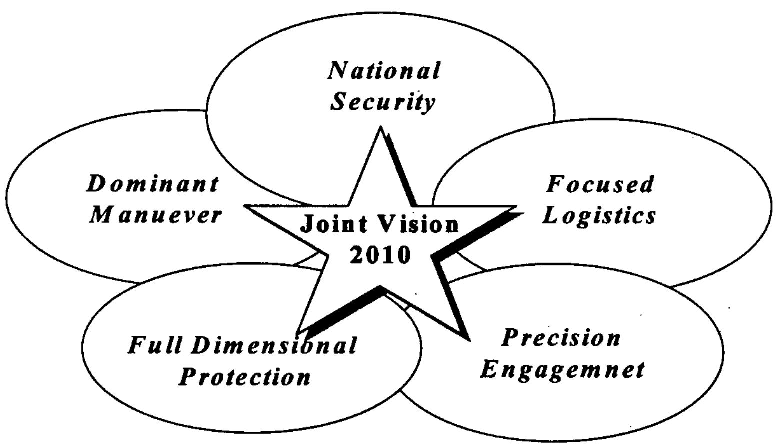


**Figure 3. Joint Vision 2010 Missions Requiring a Geospatial Framework.**

[23] U.S. Navy Dept., "Information Technology for the 21[ST] Century," (Pearl Harbor, HI: 1997)

The Army, as a major consumer of geospatial information, evidences the requirements for this information in its modernization efforts supporting the National Security Strategy. The Army has developed a vision, purpose, and modernization objectives for Force XXI that are versatile and flexible enough to support a wide range of changes to national policies and strategies. From the service perspective, the Army, exemplifying all of the services, must dominate maneuver throughout the depth of the battlefield.[24] All army missions require accurate, high resolution terrain data for success. In the past, this requirement has been primarily met with paper 1:50,000 Terrain Line Maps, Interim Terrain Data (ITD), Digital Terrain Elevation Data[25] (DTED) level 1 and 2, City Graphics, and Joint Operation Graphics (JOGs). The Army's Force XXI vision implies a need for greater resolution and accuracy. The current product suites such as TLMs, ITD, and 5 meter Controlled Image Base (CIB) can fully satisfy only some mission requirements.

Force XXI and Army Vision 2010 rely on the tenets of dominant maneuver, precision engagement, and information superiority. These concepts require more accurate

---

[24] U.S. Dept. of the Army, Field Manual (FM) 100-5, Operations (June 1993), defines the modern battlefield, or battlespace as it is called, as follows "Battle space is a physical volume that expands or contracts in relation to the ability to acquire and engage the enemy."

[25] Both accuracy and resolution of existing elevation data types meet most current command requirements, but newer systems in the development pipeline demand data densities with elevations spaced every 11 to 30 meters on the earth's surface. Elevation data provides underlying information for area delimitation analysis, cross-country movement, flight operations and calculating terrain radar masking.

and more feature rich terrain information than is currently available.[26] The value of geospatial information increases for this reason. Furthermore, there is likely to be long lead times to build or refine this needed information.

To support this objective, "Force XXI needs capabilities dominance through an ability to see the battlefield, move at great speed through its depth, and direct weapons of superior range and lethality. The ground commander must have the ability to rapidly detect, select, and destroy targets...throughout the depth of the battlefield." [27] A common geospatial framework focuses this vision. Ultimately, digital object oriented data files that display as maps, capable of three dimensional and sub-surface terrain analysis, will be down linked to maneuver data bases as changes are known. They will be locally updated to plot obstacle and enemy force locations. Global Positioning System receivers mounted on current and future maneuver platforms will continually update these displays to provide real time status and transmit value-adding updates back to the framework.

Our ability to defeat an enemy, as well as our ability to deter potential conflict directly relates to our ability to protect a joint force from threats by understanding the geospatial relationship of threats to our interests within the environment that is being contested. Once a military option is selected, a Joint Task Force is designated and begins

---

[26] Department of Defense, "Army Response to NIMA Reductions Proposed by the Quadrennial Review," (Washington: 1997).

[27] LTC Eric T. Mogren, "Engineer Force XXI," Unpublished Research Paper, U.S. Army War College, Carlisle, PA: 1995, 7.

receiving direct service support, which often includes geospatial information or references complicating a common view of the battlespace. Army ("split base"), Air Force ("reach back"), and Navy/Marine Corps ("shore support") provide information for warfighters from distant sanctuaries. With geospatial information integrated with and organic to each of these component strategies, the potential exists for discontinuities in battlespace awareness, and redundant and inefficient use of communications and computing assets. In Army split based operations, the commander deploys small, flexible, tailored military intelligence (MI) units with access to service supported intelligence bases and systems outside of the Area of Responsibility (AOR).[28] Split-basing design takes advantage of direct broadcast technology from collection platforms such as Unmanned Aerial Vehicles (UAVs) and national assets, like the Joint Broadcast System (JBS) employed in support of the Bosnia Command and Control Augmentation (B2CA) (figure 4) Advanced Concept Technical Demonstration (ACTD) to provide commanders with continuous, relevant, and timely military intelligence support during all stages of force projections.

[28] U.S. Dept. of the Army, Intelligence and Electronic Operations, Army Field Manual 34-1 (Washington: 1994), 1-7.

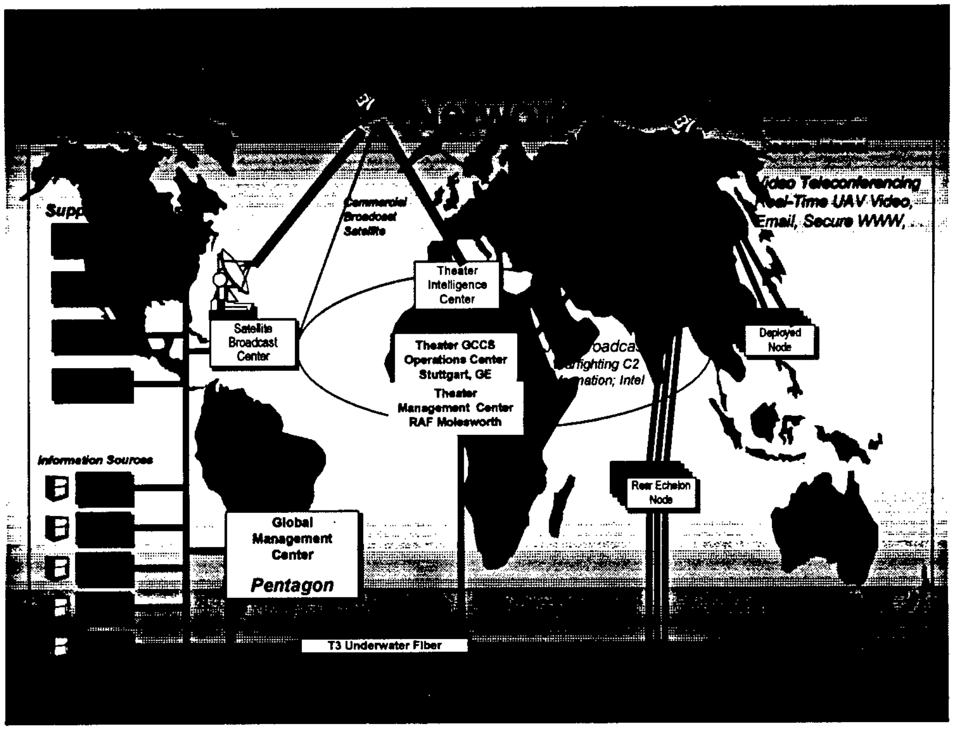


**Figure 4. Integrated Split-Based Support Using Combined Communications Architectures in Support of the Bosnia Peacekeeping Operations.**

Similarly, Air Force reachback doctrine includes provision of intelligence, surveillance, communications, navigation and geospatial information to sustain forward deployed forces.[29] The underlying geospatial data may be the same, effectively reducing available communications bandwidth for higher resolution data or other information warfare and battlespace knowledge requirements. A more challenging situation emerges, when the supporting elements use differing contextual information, perhaps different versions or accuracies of data.

[29] Air Combat Command, Air Combat Command Intelligence Support to the JFACC Concept (3rd Edition) (Langley Air Force Base, VA: 1996), 4-23.

## 4. Infrastructure Supporting a Common Geospatial Framework

Today the vast majority of geospatial information used by the commands transmits via paper copy, magnetic tape and compact disks. Some softcopy geospatial information transmits by DoD networks as depicted in figure 5, and the demand for more current and enhanced digital geospatial information increases bandwidth requirements constantly.

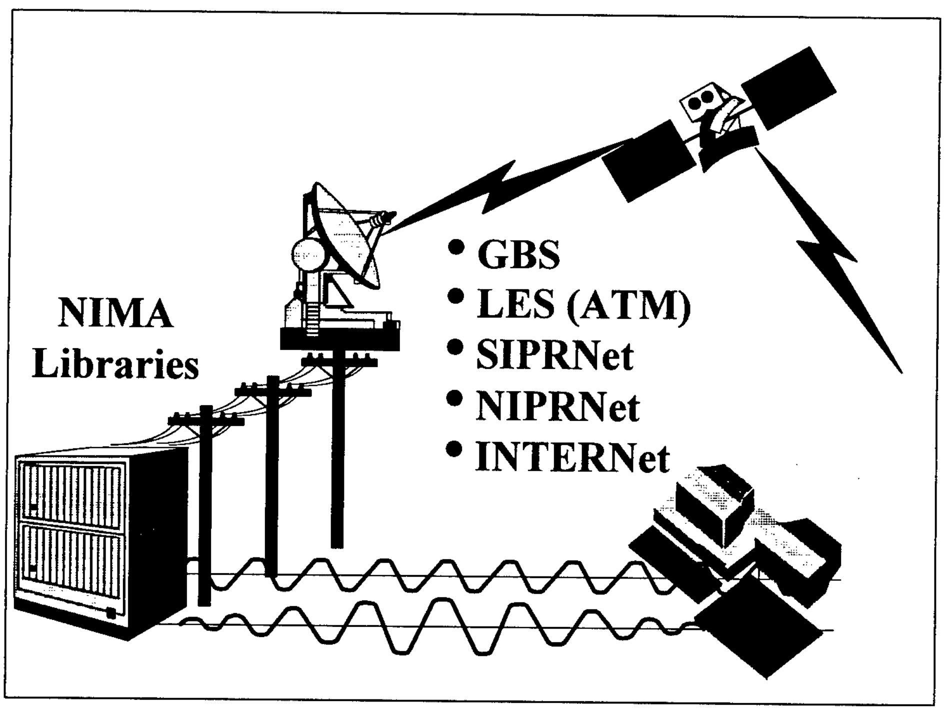


**Figure 5. Networks Available for Transmission of Geospatial Framework**

The Defense Information System Network (DISN) is the current underlying consolidated worldwide infrastructure that serves the delivery of this data from the strategic to the tactical level. The tactical connectivity occurs when movable and deployable assets link to the Defense Information Services Agency's (DISA) long haul communications infrastructure. While some intelligence and geospatial data move across router networks such as NIPRNET (unclassified but sensitive Internet Protocol Network) and SIPRNET (SECRET Internet Protocol Network), most distribution takes places through the Joint Worldwide Intelligence Communications System (JWICS).[30]

By shifting more information to the SIPRNET (much of which is unclassified anyway), future concerns about the availability of communications resources for the distribution of geospatial information from a common framework appear unwarranted for two reasons. Basic framework information needs broadcasting or distribution only upon initial tasking, leaving just updates to transmit. Second, "to assure satellite capacity is available in key scenarios, the Defense Information Systems Agency awarded the Commercial Satellite Communications Initiative in July 1995. This contract provides bulk satellite capacity at attractive rates and includes bandwidth management facility services to manage the space segment effectively and efficiently. DoD enjoys the first

[30] U.S. Dept. of Defense, C4ISR Handbook for Integrated Planning (Washington: 1996), 2-51.

right of refusal in specific areas where capacity is in short supply, thus ensuring service during a crisis."[31]

Geographic Information Systems (GISs) and Battlespace Visualization Systems, the display mechanisms for information fusion continue to develop at a rapid pace. These systems require a common underlying geospatial framework to effectively serve as force multipliers and analysis tools. Already, commercial GISs are featuring low-cost viewing applications that provide the average user manipulation and analysis capabilities, available in powerful scientific workstations only a few years ago. These desktop applications are transportable and feature interfaces to Global Positioning System (GPS) receivers, laser range finders and digital cameras, supporting multi-sensor input in field environments. The relevance of this aspect of technology infusion can not be discounted. An increasing amount of data collected in the field is more accurate and current than cartographic derived data, and through these new technologies the quality and detail of information virtually eliminate ambiguities in the data.[32]

As the Global Positioning System becomes a much more vital part of targeting, safety of navigation, reducing fratricide, deconflicting multiple fire missions, and providing a clearer picture to battle managers with the infusion of new system, caution

---

[31] Edmonds, "Teamwork for the Warrior," 24.

[32] Defense Mapping Agency, Strategic Architecture for Dissemination of DMA GGI Data (Fairfax, VA: 1996), 4-5.

must be observed. The data being reported is likely to be more accurate than the geographic reference display because of the accuracy of the geographic data sources currently deployed. Plotting a GPS derived location on a map, or digital representation can be no more accurate than the base map reinforcing the need for accuracy and fidelity in a common geospatial framework.

## 5. U.S. Strategic Command:

## Integrating Multiple Current Geospatial References

The requirement for digital geospatial information is expanding and numerous systems are emerging and interfacing at various organizations within our national military structure. U.S. European Command, U.S. Atlantic Command, and U.S. Space Command all have major initiatives underway to harness the power of spatial analysis to yield information superiority. U.S. Strategic Command (USSTRATCOM) is on the vanguard of these initiatives and through local integration efforts, has designed a system that brings together many of the concepts suggested without the benefit of a common geospatial framework. This example shows the number of separate resources and products needing maintenance in such an environment.[33]

In the USSTRATCOM Intelligence Directorate (J2), a spatial data client/server provides USSTRATCOM J2 applications the geospatial information customers require including; such as Arc Digitized Raster Graphics (ADRG), Compressed Arc Digitized Raster Graphics (CADRG), Digital Terrain Elevation Data (DTED), and Digital Chart of the World (DCW). A list of additional products scheduled for future integration consists

[33] U.S. Dept. Of Defense, Geospatial Integration Test Facility Draft (Omaha, NE: 1997), 4-17.

of; Arc Digitized Raster Imagery (ADRI), Controlled Image Base (CIB), Vector Product Format (VPF), and World Vector Shoreline (WVS). These NIMA products all require preprocessing into one of three specific geospatial data formats to include Common Mapping System (CMS) Phase I, CMS Phase II, and Oilstock, or left in NIMA standard format (i.e., CADRG). Applications have read only privileges and Network File Systems (NFS) mount the appropriate USSTRATCOM J2 spatial data server directories to access the geospatial data. Figure 6 provides a synopsis of geospatial data formats currently stored on the USSTRATCOM J2 spatial data server.

| ***Geospatial Data Format*** | ***NIMA Products*** | ***Potential Accessing J2 Application(s)*** |
|---|---|---|
| CMS Phase I | ADRG<br>DTED<br>DCW | SWS, IWS, DITDS, RAAP, TMWS, JDGW, MIDB |
| "Raw" NIMA | CADRG | SWS, IWS, DITDS, RAAP, TMWS, JDGW, MIDB |
| CMS Phase II | ADRG | IESS |
| OILSTOCK | Custom | GALE-Lite[34] |

**Figure 6. Geospatial Information on USSTRATCOM J2 Spatial Data Server**

Physically, the J2 SDS architecture incorporates a number of hardware and Commercial Off-The-Shelf (COTS) software products. Clearly, the complexity and redundancy of this system evidence the need for one common framework.

[34] The Joint ELINT Applications Processor (JEAP)/SUNSHINE together with TARTLET forms the Generic Area Limitations Environment - Lite (GALE-Lite) application. This software package provides intelligence analysts with the tools necessary to analyze/exploit installation information. Although the tools in GALE-Lite are generic and applicable to a variety of data types, emphasis is placed on the analysis and exploitation of ELINT. GALE-Lite overlays ELINT information over map backgrounds using its own mapping application known as Oilstock.

## 6. The Future

"The DoD Modernization program is multifaceted and forward-looking. To modernize combat platforms of U. S. forces, two components are being pursued. First priority goes to leap-ahead systems. These are brand new systems featuring the most advanced technologies and designed to ensure future U. S forces have the greatest possible battlefield superiority."[35] Another modernization requirement is to expand and ensure the battlespace information dominance of U. S. forces. The key goal here is to make combat leaders as aware as possible of the situation confronting them, most notably concerning the enemy's size, location, and activity. Major programs in development include: Army digitization, Global Broadcast System, Cooperative Engagement Capability, Milstar and Space-Based Infrared satellite programs.[36]

Within the next decade, environments for the geospatial reference data producer and user will change dramatically as a result of these policies. Virtual reality, with associated data management capability and real-time data simultaneously displaying ongoing operations within very high resolution descriptive geospatial information, will

---

[35] Cohen, "Defense Policies & Budget Priorities," 8.

[36] Ibid.

dominate mission rehearsals, planning and execution.[37] $C^4I$ for the Warrior describes providing real-time decision-aiding capability achieved through artificial intelligence and decision-support systems.[38]

Systems integrating the geospatial framework as a common reference will ingest and rapidly fuse multiple information sources including target status, force disposition and indications and warnings data with flexible planning tools, wargaming, simulation and multimedia technology. Now in various stages of testing and demonstration as Advanced Concept Technical Demonstrations, Joint Warrior Interoperability Demonstrations (JWID), Force XXI exercises and at the National Training Center, these applications are proliferating. A survey of JWID-97, scheduled for July of 1997 (shown in figure 7), indicates that a majority of the systems planned interact with geospatial information.

---

[37] Defense Mapping Agency, Global Geospatial Information and Services (Fairfax, VA: 1993), 6.

[38] Department of Defense, "Committed, Focused, and Needed": C4I For The Warrior, The Joint Staff, C4 Architecture & Integration Division (J6I) J6 (Washington: 1993), iii.

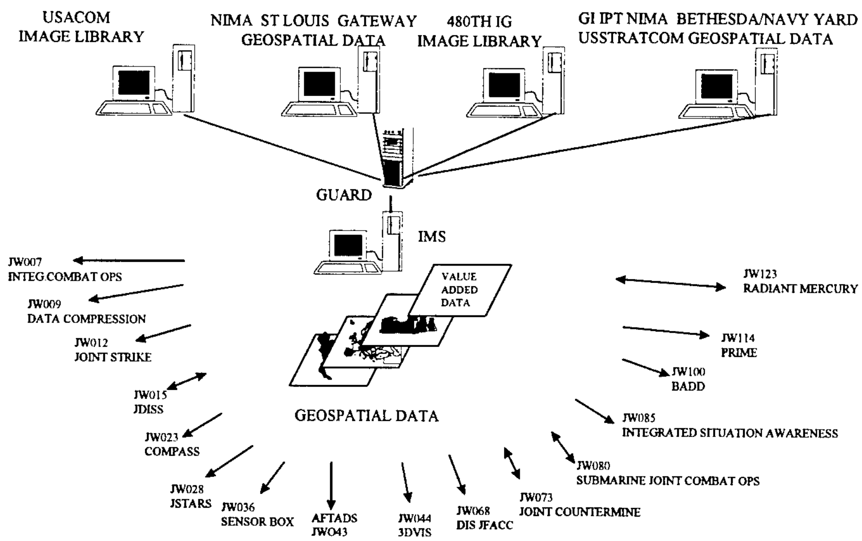


**Figure 7. JWID-97 Demonstrations Interacting with Geospatial Information**

In order to fully realize the benefits of geospatial information, while leveraging best of breed technologies in a responsive and technologically dynamic environment, certified tools require cataloging in the Defense Information Systems Agency (DISA) software reuse archives. Catalogue goals include utilities for reliable value adding of information to a national data infrastructure. Many of these applications already exist and are available through the leveraging of and licensing from coalition and commercial consortiums. Longer term, such tools must support reliable value-adding in the deployed environment by unintrusive applications. An example of such an application is the collection of precise geolocation data by a Bradley Fighting Vehicle through passive interface with an on board Global Positioning System receiver without operator involvement. This data then transmits back at mission completion, without compromising operational security.

Other dispersed sites, at the command level and below, authorized to populate, manage and distribute specific features or attributes within virtual and re-definable local databases will proliferate. Longer term, these same organizations will add value to national holdings through object oriented technologies.

Several systems are currently in development and fielding that store this kind of information, however no infrastructure has been developed to effectively exploit this resource in an organized and non redundant manner. Efficiencies in storage and redistribution of this data are jeopardized with the possible inconsistent multiple representations of features that are collected independently and merged with representations that currently exist.

A geospatial infrastructure serves a number of different customers that are both producers and users who require imagery, imagery intelligence and geospatial information. Customers rely on this information for a broad range of national security, defense, and civil missions including situation assessments, combat operations, non-combatant evacuations, diplomacy, public policy, law enforcement, disaster relief, environmental studies, etc. Consequently, a geospatial framework must support the generation of information using a common data reference model and ensure the development of interoperable mission critical applications that provide an equally broad range of functionality. The infrastructure that supports this framework, composed of operational, technical and systems architectures integrated to support responsive delivery of information, products and services, must provide common data access and services that support the community at large.[39] This approach is not without precedent. "The Defense Message System will be interoperable across multiple vendor platforms. The Defense Information Systems Agency will certify and integrate several vendors as compliant so users can choose their preferred desktop interface."[40]

[39] National Imagery and Mapping Agency, Consolidated Requirements Services Environment Draft Concept of Operations, Version 1.1 (Fairfax, VA: March 1997), 2-3.

[40] Edmonds, "Teamwork for the Warrior," 25.

## 7. Near Term Interfaces to a Common Geospatial Framework

"Accommodating sweeping technological change and revolutionary DoD requirements is a tremendous opportunity for the Defense Information Systems Agency and its service partners."[41] With this mandate, DISA embarked on the development of the Joint Mapping Tool Kit (JMTK), a cooperative effort between DISA and NIMA. JMTK, currently part of the Defense Information Infrastructure (DII) Common Operating Environment (COE) Global Command and Control System (GCCS) family of tools, allows common, interoperable, geospatial information for viewing. On GCCS, "The system provides warfighters with surveillance, reconnaissance and the precise location of dispersed friendly forces with the ability to direct those forces within the battlespace. It has dynamic, flexible structure and provides access to global intelligence sources, which gives warriors insights into exploitable opportunities."[42]

In theory, "The Global Command and Control System uses an integration standard and migration strategy that eliminates the need for inflexible stovepipe command and control systems with expensive duplication. This ensures interoperability,

[41] Ibid., 31.

[42] Ibid., 28.

minimizes training requirements and allows efficient use of limited defense resources."[43] "The system approach focuses on developing the Defense Information Infrastructure common operating and data environments as well as shared services that enable interoperability between command and control application and data."[44]

The challenge before DISA is extending these services to the entire Joint Planning and Execution Community. The complementary task facing the geospatial community is developing and photogrammetrically, radiometrically and operationally populating a global geospatial infrastructure on a common datum with at least GPS equaling accuracy, with fidelity and resolution dense enough to evaluate independent courses of action or opportunities within a common operating environment.

JMTK envisions satisfaction of extensive geospatial application requirements for the Common Operational Picture (COP). Although this effort is in its fourth release version, the goal is unrealized as evidenced in Joint Warfighting Interoperability Demonstrations 1995 and 1996. The responsibility for this failure resides with GCCS corporate services providers as many have failed to integrate the standardized data calls provided.[45] JMTK started as a federation of existing tool kits and suffers from the incompatibility of its legacy systems. The spatial data base management portion comes

---

[43] Ibid., 27.

[44] Ibid.

[45] Telephone conversation with Mr. Mel Wagner, Chief, NIMA GCCS Project Office, Bethesda, MD, 21 March 1997.

from the Air Force's Common Mapping Tool Kit (CMTK) with visualization modules from the Navy's CHART system. The Terrain Evaluation Module (TEM), developed by the Army's Topographic Engineering Center, contributes terrain analysis modules. Unfortunately, these applications, developed for high end processors and specialized operators, lack utility for integration into tactical and maneuver unit use. If JMTK is to become viable, enhancements required include imagery and geospatial data fusion modules, use of Commercial of the Shelf (COTS) software components and standardized Application Programming Interfaces (APIs) supporting migration to changing industry and public operation environments, like Windows N. T. (as a current reference).[46]

---

[46] For the Navy, application program managers such as JMCIS, NSIPS, TAMPS, and GCSS have been directed to migrate current applications to the DII COE with an immediate objective of obtaining PC workstation access to all application data on an enterprise LAN by 1999 as stated in Department of the Navy, "Information Technology for the 21ST Century." CINCPACFLT 300944Z MAR 97.

# 8. Developing Technologies Enabling Realization of a Common Geospatial Framework

Several areas of technology are emerging from the research and development community. In some cases, the technology is not new, rather its application to information fusion constitutes evolutionary implementations. Creative and effective solutions of projected consequence to information fusion and particularly geospatial framework population, management and dissemination include collaborative computing technologies, new generations of tactical sensors and interoperable object oriented data structures.

## Collaborative Computing Tools

In the modern tactical environment, geographically separate commanders and forces need to refer to a common view of the battle space in order to effectively plan and understand the spatial context of operation execution. Technologies, becoming common to commercial applications make use of collaborative computing to support these requirements. Shared white boarding has been a utility since the initial fielding of the

Joint Deployable Intelligence Support System (JDISS), but more useful is the addition of collaborative computing tools.

These tools allow remote access to subject matter experts for creating, coding, editing, and updating information, as well as the remote sharing of software applications. Essentially, a JTF commander can realize the benefits of inorganic skills and expertise, without providing for the care and feeding of additional personnel. When applied to force projection doctrine demanding "split-based" operations, collaborative geospatial information production significantly enhances the quality and quantity of geospatial analysis available to the command, while supporting reach back requirements. The Defense Mapping Agency (pre-NIMA), in coordination with the MITRE Corporation, pioneered the use of collaborative cartographic applications in 1995 as part of the Joint Warfighting Interoperability Demonstrations. Initially DMA applied the technology to collaborative targeting and target list development and subsequently to collaborative geospatial production in 1996.

## Tactical Sensors

A promising technology for rapid tactical elevation data collection that can take advantage of collaborative production technologies is the STARTLITE, currently under investigation by the Defense Advanced Research Projects Agency (DARPA). This new objective constellation of 24 satellites configured with Synthetic Aperture Radar (SAR) allows for direct tasking control by deployed tactical commanders. The constellation provides for a very rapid revisit rate (about 15 minutes) to most areas of the earth. If funding is secured, plans are for the launch of two STARLITES in fiscal years 1999 and 2000 for demonstration purposes. An Enhanced Tactical Radar Correlator supporting the demonstration as a ground processing segment, responsible for tasking, receiving the direct down link, processing, and exploiting the data completes the system. If the demonstration succeeds and funding is approved, scheduled deployments of the additional 22 STARLITES are in fiscal years 2003-2005. The STARLITE system capabilities include generation of very high resolution elevation data (1 meter post spacings) and highly accurate radar imagery. This data merged into the common geospatial framework becomes value added data. The preliminary list of demonstration objectives includes a determination of the feasibility and utility of delegated collection management authority to tactical (i.e. joint task force) commanders.[47]

### Object Oriented Data Structures

When a change, such as value added data from a user is made to a digital vector based map feature, several items are affected to include: feature attributes, location coordinates, and topological relationships with neighboring graphic elements. While it is possible to record some of this change by the average user, updates require specialized

[47] Interview with Dr. Steve Flank, Director, DARPA Fusion Programs, National Correlation Working Group, Chantilly, VA: 2 April 1997.

processing by systems to address spatial consequences to surrounding represented features. This chain reaction renders the rapid update and redistribution of vector data on a wide scale unfeasible. The use of an object oriented data structure, on the other hand, allows the determination and export of new or updated feature data (treated as a data record with identifying values). A common framework based in an object oriented data structure allows implementation and better integration of these technologies and information. Object oriented structure designs support distribution of a stable data foundation upon which users build reliable, interoperable and tailored references. Because the structure supports seamless transition between multiple spatial data resolutions, for example more detailed information as a shoreline is approached from the sea, without redundancy, resources are more effectively employed. Additionally, time-varying characteristics of some spatial features, like tides can be calculated and displayed for synthetic mission rehearsal, course of action analysis and wargaming. Most importantly, each object's topological relationships are available to support efficient decluttering and generalization. This supports the use of a single data set across multiple echelons for tailored display while maintaining interoperability throughout the organization. With such an interface to larger data repositories, users interactively update and redistribution of extremely current data is possible.

Several differing technologies are competing under sponsorship of different agencies to meet this need. According to Dr. Steve Flank, Director, DARPA Fusion Programs, "Too many correlation engines, using too many information types to finish products for situational awareness applications are being developed [and fielded]. The only certainty is fusion confusion."[48] Fortunately a standard interface is emerging.

The Data Integration and Synergistic Collateral Usage Study (DISCUS) is U.S. Government research and development software that provides a baseline capability upon which to build a distributed, object oriented system using an open system architecture. DISCUS uses Common Object Request Broker Architecture (CORBA). CORBA provides the mechanisms by which objects transparently make requests and receive responses. It is an application framework that provides interoperability between objects, built in possibly different languages, running on potentially different machines in common distributed environments.

Essentially, CORBA is a very flexible facility for building distributed object oriented data structures for highly interoperable systems. This architecture recasts the distributed system as a collection of cooperating objects with alternating client roles and server roles. Any application making a request through an object request broker is acting in a client role and any application responding to a request is acting in a server role. "By eliminating these difficult issues from client programming, new levels of distributed software interoperability are possible."[49]

---

[48] Ibid.

[49] The MITRE Corporation 1996, DISCUS Developer's Guide 1.3 (*FINAL DRAFT*) (Reston, VA: 1996), 3.

# 9. Integration of and Transition to a Common Geospatial Framework

The commitment to produce a truly common interoperable framework for information fusion supporting the entire Joint Planning and Execution Community is not without challenge, nor can such a framework immediately replace current products. Once again the Army provides an excellent example, having recently conducted a warfighting experiment in which a digitally equipped Brigade-sized task force executed tactical maneuvers.

Plans are now underway to equip an Army division with digital exploitation capabilities however, neither the warfighting experiment nor the planning for the first digital division allows for the complete replacement of paper maps and charts with digital terrain data. The Army intends for digital information's use as a supplement to and not a replacement for paper products. While the Army of the future may be able to transition away from an extensive need of paper maps and charts, it is unlikely that this capability will exist in the total force for the next 10-15 years.[50]

[50] Department of Defense, "Army Response to NIMA Reductions Proposed by the Quadrennial Review," 071030Z APR 97.

While results of the initial stages of digitization are encouraging, and steps being taken to move from experimentation to a fielded capability progress, digitally equipping the Army will require time and resources. The current intent is for a totally digital division by 2001, followed by a digital corps by 2006. Considering the success (and expense) of these efforts, the Army will determine how fast to completely digitize the total force. After 2006, there will still be 5-7 active Army divisions as well as reserve and national guard forces that will not have full digital capability.[51] Although, traditional hardcopy products no longer meet the broad range of new mission requirements sufficiently, hardcopy maps and charts the military still requires them to support technology constrained users and potential coalition partners.

Initially, customers with the potential capability to exploit large geospatial data sets will be limited by available hardware, software and communications resources.[52] This situation is changing rapidly by the increasing power of personal computers, driven by previously focused software vendors to expand markets through commercialization of technologies and expanding communications capacities.

---

[51] Ibid.

[52] National Imagery and Mapping Agency, Consolidated Requirements Services Environment, 8.

To have the requisite information foundation available when the digital force deploys requires commitment and resources. Major General King, Director for Intelligence, Joint Staff suggests an approach to transition. He points out that the intelligence cycle is out of balance with more assets directed at collection than can be used. He stated, "Fully seventy percent of information collected is never used,"[53] and suggested the need for a total cycle encompassing budgeting resources against collection, processing and dissemination simultaneously. Major General King adds, "Information collection exceeds analytic capability by more than 400 per cent, while only nine percent of resources focus on data integration."

A rebalancing of these resources can provide opportunity to enhance framework population without reducing current mission critical standard geographic products. With information fusion tools proliferating, interoperability and the resources for cognitive tools development are lacking. The current products, be they hardcopy or softcopy, digital or analog, raster or vector, cannot provide the capabilities needed to ensure information superiority in the future. Tailored information that rectifies ambiguities in knowledge of the battlespace must be the goal. A goal achievable only through provision of smart tools that fuse information at the decision makers' level and also maintain a common reference to the thousands of similar processes going throughout the infospace. That common reference is the geospatial framework.

[53] Interview with Major General James C. King, Director for Intelligence, Joint Staff, National Correlation Working Group, Chantilly, VA: 1 April 1997.

Lieutenant General John A. Gordon, Associate Director of Central Intelligence for Military Support, stated, "Human intelligence is not definitive and difficult to assess. Warfighters are challenged to integrate this information within its context and appropriately value it."[54] Yet, often this information is critical to force protection. A more effective approach to the analysis of this information can be achieved by spatial analysis methodologies. When aggregated and placed within a geospatial framework, relationships between disparate information sets often become apparent and new perspectives of situations emerge.

Merely populating a database with common references does not guarantee information superiority. An education process instituted at all echelons of national service training is also needed. "Common support like mapping and weather applications will be **overlaid** on a computer screen that can access all information and applications users need"[55] is a common concept in the information fusion literature. This perception is perhaps the basis for a lack of emphasis and resourcing for geospatial infrastructure. Information tends to be more highly valued than the framework in which it exists. However, without the ability to analyze information within (and not just merely overlay it) its environmental reference, the true synergy of the information does not support

[54] Interview with Lieutenant General John A. Gordon, Associate Director of Central Intelligence for Military Support, National Correlation Working Group, Chantilly, Virginia: 1 April 1997.

[55] Edmonds, "Teamwork for the Warrior," 29. (Emphasis added).

dominant battlespace awareness. It is this perspective that has led to intelligence expenditures skewed to the collectors and not the power of information fusion as a focus for analysis within a common reference environment.

## 10. Opportunities

The community is rapidly approaching a crossroads. Resources allocated to support legacy systems divert investment from information superiority enabling technologies. The result will likely be an endless attempt by information providers to catch up to fielded systems. A worse scenario presents itself as numerous projects, left without recourse, simply grow, or contract, for their own data. In this event, data standards proliferate and interoperability is unachievable. There are evolutionary measures available to assist in transition but, the greatest returns will come from revolutionary approaches.

As the primary geospatial information producer, NIMA can lead this transition by canceling its vector map programs in favor of production resources allocated to the development and production of a common global geospatial framework. This framework (supporting generation of paper products, as well as digital products), with an object oriented structure, allows remote value adding and distributed collaborative production for more rapid population and user enhancement. As the user community expands, the value adding enhances the fidelity of the information available to all. The vector map products do not provide the geospatial accuracy and currency requirements needed to support the Joint Vision 2010 force.

The Joint Planning and Execution Community should follow the Navy's lead and aggressively transition to PC environments, promoting interoperability and reducing information friction as the Defense Message System is doing. Additionally, a DII/COE PC based version of GCCS with a user friendly Joint Mapping Tool Kit, able to operate in a stand-alone environment when necessary, requires extension to U.S. embassies and consulates throughout the world. To provide the necessary reach, DISA should institutionalize the Joint Broadcast System in all theaters to support emerging contingencies and simplify the requirements process to reduce lead times for new information and services, striving for near real time response for planners, negotiators and warfighters.

The National Correlation Working Group, which brings together members of the C4ISR community, while productive, must be expanded to incorporate the operations community and the rest of the Joint Planning and Execution Community (our National Security Strategy team). This is unlikely to occur unless the operations community in consort with the Department of State takes a leadership role in sponsorship of open dialogues to demand recognition and satisfaction of their information requirements.

Developing a geospatial framework for a common operating environment, connected by transparent user links, with common analysis and exploitation tools, can accelerate the attainment of ensured information superiority. The evolution of a distributed, Internet-like architecture that uses geospatial databases as its foundation and involves end users to locally add value enhances this process. True realization of the power of information superiority however, cannot be achieved until principles of information fusion are fully understood by the entire community.

VADM Dennis C. Blair, USN, Director, Joint Staff, prescribes five principles for information fusion that benefit from a common geospatial framework that seem apparent but deserve reiteration:

- Every user involved in the same problem must draw from the same data. Data available to separate fusion systems working the same problem must be the same. Consistency in distribution and flexibility in display are key.
- Fusion systems should be designed to support decision makers.
- For military operations, fusion systems should present a single picture using electronic display technology with an ability to tailor the display and replay previous situations.
- Responsibility for the integrity of the fused picture must be clearly assigned and accepted.
- The solution to a fused picture must be affordable with systems either migrating to a joint standard or discarded.[56]

[56] Interview with VADM Dennis C. Blair, USN, Director, Joint Staff, National Correlation Working Group, Chantilly, VA: 1 April 1997.

To achieve true information superiority the United States must follow a revolutionary path. Despite higher risk and the smaller probability of immediate success, the potential payoff is great. Breakthrough technologies for information superiority include on demand world wide web like access for signals intelligence and imaging with tailored response in near real time.[57]

Overall, the intelligence and operations community (DoD and non-DoD organizations) must:

- Appropriate resources and plan for a smooth transition from geographic products (discrete bounded information like a map or chart) to a geospatial information focused environment as user needs require and technologies allow.
- Establish a consolidated process that encompasses requirements for imagery, imagery intelligence and geospatial information that will effectively and efficiently drive geospatial infrastructure population, while supporting near term needs with reduced resource levels. This will offset a resource set aside to focus on long range infrastructure population and enhancement.
- Build a distributed, interactive process and the supporting tools for user access to the global geospatial framework (input and output).
- Identify, collect, manage and maintain a national geospatial infrastructure.

[57] Interview with Mr. Keith Hall, Director, National Reconnaissance Office, National Correlation Working Group, Chantilly, VA: 1 April 1997.

- Develop and implement a means to provide timely and meaningful feedback to customers on the production of required data and information that may not yet be part of the geospatial infrastructure, maintaining transparency in this process for "collection opportunity" value adding by that same clientele.

## 11. Conclusion

Geospatial information should be made easily accessible to our worldwide representatives through a global communications architecture. The key element of this geospatial framework vision is a blurring of the traditional roles of producer and consumer. As the community migrates from a product oriented focus (maps, charts, and discrete data sets) to an information fusion perspective, producers and consumers need the capability to perform either role as needed. At any point in time, members of various mapping, CINC, service, intelligence, policy, law enforcement and commercial communities will be browsing, collecting, producing, collaborating, sharing, and value adding information. The resulting common operational view of the infosphere references a Common Geospatial Framework.

The quality of the planning process for negotiation, marketing or military operations depends directly on the substance, completeness, accuracy, and timeliness of external data feeds. Geospatial data is a structural building block of the planning process. Since so much of the planning process depends upon external information, a key observation is appropriate concerning data availability: plans produced use the best **available** information. If critical geospatial data is unavailable or cannot be provided within the timeframe of the deliberate or crisis planning process, a less than optimum plan results. Regardless, the plan is produced. The development process of a plan is not impeded, but the quality of planning is affected by the lack of requisite information, potentially negating U.S. information superiority investment and technologies.

Joint Vision 2010 mandates;

> "Long-range precision capability, combined with a wide range of delivery systems, is emerging as a key factor in future warfare...Improvements in information and systems integration technologies will also significantly impact future military operations by providing decision makers with accurate information in a timely manner...The fusion of all-sources intelligence with the fluid integration of sensors, platforms, command organizations, and logistics support centers will allow a greater number of operational tasks to be accomplished faster. Advances in computer processing, precise global positioning and telecommunications will provide the capability to determine accurate locations of friendly and enemy forces, as well as to collect, process and distribute relevant data to thousands of locations. Forces harnessing the capabilities potentially available from this system of systems will gain dominant battlespace awareness, an interactive "picture" that will yield much more accurate assessments of friendly and enemy operations within the area of interest. Although this will not eliminate the fog of war, dominant battlespace awareness will improve situational awareness, decrease response time, and make the battlespace considerably more transparent to those who achieve it."[58]

[58] Chairman of the Joint Chiefs of Staff, *Joint Vision 2010*, undated, p. 13.

Unfortunately, none of this precise recognition and location will be possible to maintain multi-echelon and multi-discipline situational awareness without investing in a common geospatial framework in which to fuse the information.

In the "Emerging System of Systems," Admiral Owens postulates, "As this broad concept [of a new system of systems] emerges over the next decade, it will carry with it the new revolution in military affairs and a new appreciation of joint military operations, for this revolution depends ultimately on contributions from all the service."[59] However, the true revolution reaches beyond the confines of the military as decision, policy makers and implementers throughout government must participate. Admiral Owens suggests, "In short, the system of systems is fundamentally a joint military entity."[60] Should this entity not extend to other tenants of the National Security Strategy and benefit all aspects of international relations?

The National Security Strategy directs the diplomatic, economic and military organizations to increase mission performance with decreasing resources resulting in demands for increased system efficiencies. Increased computer and communication system capabilities enable decision makers and operators alike to visualize and create technological opportunities for the transfer of information in huge quantities and at speeds revolutionizing international relations. This flow of digital data opens a

---

[59] Owens, "The Emerging System of Systems," 37.

[60] Ibid., 38.

globalization of situational awareness, which in turn increases the demand for framework data. Warfighters, Foreign Service Officers and economic analysts demand more flexibility in the data they receive in order to tailor information displays locally. While increased flexibility enhances their options, it challenges interoperability without a common reference. That common reference constitutes a global geospatial framework supporting information fusion across the full spectrum of national security strategy. Ultimately, the application of a common geospatial infrastructure will substantially improve the effectiveness of our National Security Strategy, highlighting options available to decision makers in all branches of government through the application of geographic information and spatial analysis.

# Selected Bibliography

## Literature


Air Combat Command. Air Combat Command Intelligence Support to the JFACC Concept (3rd Edition). Langley Air Force Base, VA: 1996.

Bunker, Robert J. "Advanced Battlespace and Cybermaneuver Concepts: Implications for Force XXI." Parameters, Vol. XXVI. No. 3. Autumn 1996, 108-120.

Cohen, William S. "Defense Policies & Budget Priorities." Defense 97, Issue 2. American Forces Information Service. Washington, DC. 4-8.

Defense Mapping Agency. Global Geospatial Information and Services. Fairfax, VA. 1993.

Defense Mapping Agency. Strategic Architecture for Dissemination of DMA Global Geospatial Information. Fairfax, VA: 1996.

Defense Mapping Agency. Strategic Architecture for Dissemination of DMA GGI Data. Fairfax, VA: 1996.

Defense Mapping Agency. Geospatial Information Infrastructure Master Plan. Fairfax, VA: 1996.

Dept. of Defense. Geospatial Integration Test Facility. Draft. U.S. Strategic Command. J2. Omaha, NE. 1997.

Dept. of Defense. Joint Vision 2010. Chairman of the Joint Chiefs of Staff. Washington: undated.

Edmonds, Albert J., Lt. Gen., USAF. "Teamwork for the Warrior." Defense 97, Issue 2. American Forces Information Service. Washington, DC. 24-31.

Lenczowski, Roberta A. "Global Geospatial Information and Services." 05 September 1994. <http://164.214.2.57/>. (14 September 1996).

Mogren, LTC Eric T. "Engineer Force XXI." Unpublished Research Paper, U.S. Army War College, Carlisle, PA: 1995.

Morrison, Dan. "Ancient Worlds." SPIRIT. May 1997, 70-71.

National Imagery and Mapping Agency. Consolidated Requirements Services Environment Draft Concept of Operations, Version 1.1. Fairfax, VA: 1997.

National Imagery and Mapping Agency. Consolidated Requirements Services Environment Draft Concept of Operations. Version 1.1. Fairfax, VA: 10 March 1997.

Owens, William A., Admiral, U. S. Navy. "The Emerging System of Systems." U.S. Naval Institute Proceedings. Vol. No. 106. May 1995, p. 37-39.

Sun Tzu. The Art of War. trans. Griffith, Samuel B. London: Oxford University Press, 1971.

The MITRE Corporation. DISCUS Developer's Guide 1.3 (FINAL DRAFT). Reston, VA: 1996.

The White House. A National Security Strategy of Engagement and Enlargement. 1996.

U. S. Dept. of Defense. "Committed, Focused, and Needed": C4I For The Warrior. Joint Staff. C4 Architecture and Integration Division (J6I) J6. Washington: 1993.

U. S. Dept. of Defense. Requirements for Global Geospatial Information and Services (GGI&S). CJCSI 3901.1. Washington: 1996.

U. S. Dept. of the Navy. "Battlespace Information, Command and Control(C2), Operational Intelligence and Systems Integration." Naval War College. Joint Military Operations Department. Newport, RI: 1996.

U.S. Congress. House. Defense Authorization Bill for FY 1997. 104th Cong., 2nd Sess., H.R. 3230 (30 July 1996)

U.S. Congress. Senate. Select Committee on Intelligence. *National Imagery and Mapping Agency: Hearing before the Select Committee on Intelligence.* Director of National Imagery and Mapping Implementation Team Statement for the Record. 104th Cong., 2nd Sess., 27 March 1996.

U.S. Congress. Senate. Select Committee on Intelligence. *National Imagery and Mapping Agency: Hearing before the Select Committee on Intelligence.* Director of National Imagery and Mapping Implementation Team Congressional Witness Books, Sample Questions and Answers. 104th Cong., 2nd Sess., 27 March 1996.

U.S. Dept. of Defense. C4ISR Handbook for Integrated Planning. Washington: 1996.

U.S. Dept. of Defense. Report of the Defense Science Board Task Force on Defense Mapping for Future Operations. Washington: 1995.

U.S. Dept. of the Army. "Army Response to NIMA Reductions Proposed by the Quadrennial Review." Washington: 1997.

U.S. Dept. of the Army. Intelligence and Electronic Operations. Army Field Manual 34-1. Washington: 1994.

U.S. Dept. of the Navy. "Information Technology for the 21ST Century." Pearl Harbor, HI: 1997.

**Interviews, Public Statements And Telephone Calls**


Interview with Vice Admiral Dennis C. Blair, U.S. Navy, Director, Joint Staff, National Correlation Working Group, Chantilly, VA: 1 April 1997.

Interview with Dr. Steve Flank, Director of Fusion Programs, Defense Advanced Research Projects Agency, National Correlation Working Group, Chantilly, VA: 2 April 1997.

Interview with Lieutenant General John A. Gordon, Associate Director of Central Intelligence for Military Support, National Correlation Working Group, Chantilly, VA: 1 April 1997.

Interview with Mr. Keith Hall, Director, National Reconnaissance Office, National Correlation Working Group, Chantilly, VA: 1 April 1997.

Interview with Major General James C. King, U.S. Army, Director for Intelligence, Joint Staff, National Correlation Working Group, Chantilly, VA: 1 April 1997.

Interview with Rear Admiral (Upper Half) Daniel March, U.S. Navy, Retired, National Correlation Working Group, Chantilly, VA: 3 April 1997.

Press conference by William S. Cohen, Secretary of Defense, Department of Defense Press Conference, Washington: 28 March 1997.

Telephone conversation with Mr. Mel Wagner, Chief, Global Command and Control System Project Office, National Imagery and Mapping Agency, Bethesda, MD: 21 March 1997.