Virtual Integrated Planning And Execution Resource System (VIPERS): The High Ground Of 2025

A Research Paper
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by

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2025 is a study designed to comply with a directive from the chief of staff of the Air Force to examine the concepts, capabilities, and technologies the United States will require to remain the dominant air and space force in the future. Presented on 17 June 1996, this report was produced in the Department of Defense school environment of academic freedom and in the interest of advancing concepts related to national defense. The views expressed in this report are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States government.

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This publication has been reviewed by security and policy review authorities, is unclassified, and is cleared for public release.

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Executive Summary

Effective command and control systems magnify the unique characteristics of air and space power: flexibility, speed, range, responsiveness, precision, and observation.[1] By 2025, plans, decisions, and actions will occur rapidly and with insight into a potential adversary's movements. Our ability to observe, analyze, and predict will reveal an enemy's weakness and possible intent. By extending the conceptual horizon of the war fighter, we will foster a paralyzing tempo and inhibit the enemy's ability to react or recover. This paper takes a high-ground approach concerning combat support in the future. It describes combat support in terms of people, processes, and products and posits a more descriptive name for combat support in 2025—force support.

This paper educes three core competencies for force support: information supremacy, reflexive sustainment, and precision employment. Other 2025 writing teams address the last two elements. As a means of satisfying the core competency of information supremacy, this paper proposes the virtual integrated planning and execution resource system (VIPERS). VIPERS provides commanders at the strategic, operational, and tactical levels an integrated "system of systems" that achieves information supremacy, allowing dominance of the battlespace.

VIPERS provides commanders the ability to plan collaboratively with combat and support forces. Parallel planning permits simulation of alternate courses of action using war gaming and advanced decision support systems to evaluate congruence of objectives, potential risks, and vulnerabilities. This capability improves upon and hardens the users'

observe-orient-decide-act (OODA) loop,[2] reducing "fog and friction" in executing operations.

VIPERS provides commanders a real-time bird's-eye view of the battlespace during execution. This perspective results in visibility of all logistics from factory to foxhole and improved combat identification. The information is displayed using a three-dimensional holographic projection with natural human-machine interface during planning and execution. VIPERS tailors information from the strategic to the tactical level. This paper describes operational criteria for command and control, the system and its required technologies, and a concept of operations and makes recommendations for further investigation.

Notes

1. AFDD-1, *Air Force Doctrine*, unpublished draft, 1996, 2.
2. John Boyd, "A Discourse on Winning and Losing," Unpublished briefings and essays, Air University Library, Maxwell AFB, Ala., Document M-U30352-16, no. 7791, August 1987.

Chapter 1

What is Force Support?

Force Support is that part of the military operation that provides operational leverage to the commander. As the shaft of the fighting arrow, force support provides stability and direction. The arrow metaphor illustrates how the precise movement of the arrowhead can become weighted and misguided by a tail that is too long or too unwieldy. If constructed incorrectly, the arrow is ineffective—its impact negated. Force Support (the shaft) transforms the energy of the bow (the national command authorities (NCA) or commander) into decisive operational power.

Future war fighters will find themselves involved in the full spectrum of military operations, ranging from offensive combat operations to peace enforcement and humanitarian assistance. Force Support allows military forces to skillfully perform the actions required to respond rapidly to any situation. While it does not guarantee effective use of military power, without it our armed forces are incapable of exerting a positive influence on achieving the desired end state. When force support fails to enhance the efforts of the combat arms, it becomes crippling to the operation.

The World of 2025

In order to identify the requirements of force support in 2025, we must first outline the contextual and operational elements. Futurists anticipate the year 2025's having the following attributes:[1]

1. A virtual neighborhood exists, due to global interconnectivity. As a result of the virtual neighborhood, social interaction will take on new forms. The quality of the new forms is still unknown.
2. Computer-aided design and manufacturing have made production nearly paperless and highly automated.
3. Almost every technical discipline wants to view its area of interest in three dimensions. For example, city managers want to see the subterranean view of the water and sewer system in relation to surface structures.
4. Competition for resources has become fierce due to dwindling supplies and burgeoning population. Developed nations and international organizations are constantly pressured with cries for all forms of assistance. Regional conflicts of low intensity are prevalent.
5. The economical and technical gap continues to widen between northern and southern hemispheres.
6. Nongovernmental organizations and transnational entities increase in number and power, exerting significant local, regional, and world-wide political influence.
7. United States citizens' intolerance toward casualties in conflict hardens, and technology advances increase expectations of rapid victory.
8. Though the United States remains strong, there are challenges to its political and military leadership position in the world.

Similarly, this paper asserts air forces will have the following force qualities:

1. Air forces continue to operate weapon systems procured in the twentieth century.
2. Humans remain the primary systems operators.
3. Forward operating locations are required for lodgment, presence, and tempo. US forces and influence are welcome nearly world-wide, but not on a permanent basis.
4. Forces are vulnerable to threats from a variety of approaches (land, air, and sea).
5. Deployed forces need resupply.
6. Despite technological advances in information sharing, as well as the attendant organizational and sociological changes, combatants still require a command and control system.
7. Joint and coalition warfare are the operating norm.[2]

Air forces in 2025 will operate a mix of inhabited and uninhabited combat air vehicles. The purpose of the mix is to field a capability-based force which effectively exploits new technologies. Technology will drive the convergence of commercial and military capabilities and requirements. Aircraft and uninhabited aerial and ground vehicles will project lethal and nonlethal weapons. Large mobility aircraft will provide pinpoint employment of resources via high-altitude, precision airdrop as well as retaining the capacity for more conventional emplacement of resources. Technology advances will generate modifications in many older weapon systems.[3] The latest update of the global positioning system will provide the worldwide architecture for precision operations. Aerospace control will cover the spectrum from space to information. The interconnected force will create a distributed system of databases and will have extensive commercial involvement in all systems.

Overview

This paper focuses on improving airpower's core competency of information supremacy. The study first examines information supremacy's operational requirements and key capabilities needed. This discussion provides a set of criteria to evaluate potential systems against. Next, the paper describes a system that potentially meets these criteria, including advanced technologies and some considerations in applying these technologies. A concept of operations then explains the use of this system. There follows an analysis of enemy countermeasures and strategies to overcome these countermeasures. Finally, the paper recommends what the Air Force should and should not do to attain information supremacy in the twenty-first century.

Notes

1. John L. Petersen, *The Road to 2015, Profiles of the Future* (Corte Madera, Calif.: Waite Group Press, 1994), 284–85; also see, Lt Col Robert L. Bivins et al., "Alternate Futures" (Unpublished white paper, Air Force 2025, Air University, Maxwell Air Force Base, Ala.) undated.

2. The concepts in this paragraph were extracted from USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century*, summary volume (Washington, D.C.: USAF Scientific Advisory Board, 15 December 1995), iv.

3. Lt Col James A. Fellows et al., "Airlift 2025: The First with the Most" (Unpublished white paper, Air Force 2025, Air University, Maxwell Air Force Base, Ala.) undated.

Chapter 2

Required Capabilities

Chapter 1 portrayed the world of 2025 as one filled with regional low-intensity conflicts. The lack of standing operational plans will characterize future crises as each will have unique political, economic, and social parameters. This characterization arises from the fact that bilateral economic and security interests are so prolific that standing plans are illogical—there are too many options. Military forces will mirror corporate virtual structures in that organizations are built for a specific purpose or product and disbanded when that goal is met. This chapter identifies the requirements of force support in 2025 and then discusses the capabilities necessary.

Requirements

The most important requirement of force support in 2025 is synchronized support to combatants. Force Support must sustain combatants with significantly less lift into the remotest areas of the world. Future combat forces will disperse on the battlefield because of improvements in information connectivity—demassified forces.[1] Force Support must also disperse for nonlinear, simultaneous operations to become a reality. The traditional response to increasing demands by combat forces has been "more, bigger, and faster." In

2025 the armed forces will respond with collaborative-parallel planning as opposed to today's largely stovepipe-sequential process.

The US armed forces have many years of experience with command and control systems of increasing complexity. This experience has revealed some key lessons learned from situations which continually recur—despite technology advancements. Coordinated execution with decentralized operations is possible with:

1. Simple rules,
2. Empowerment using mission type orders, and
3. Ability to adapt to local conditions.[2]

Commanders need control of operational processes, not resources.[3] This requirement means commanders cannot afford to get lost in details, but must focus on what is happening in relationship to the desired end state. Information and intelligence systems should place commanders in a position of control, not dependency.[4] Technology provides the capability for leaders to micromanage resources. Further, technology raises serious questions about the span of control in the conduct of military operations. Civilian and military leaders need to avoid these pitfalls through training, leadership, and doctrine.

In combat, commanders don’t require 100 percent solutions; they want pointed answers usually derived from relational databases, not information databases.[5] Concurrently, “real-time” information is less important than “in-time” information.[6] Capabilities should be designed so all processes are mainstreamed and everyone uses the same systems.[7] Hardware restrictions should not prevent anyone from having access to information.[8]

Redistributing mass within the battlespace and movement suggests that our forces are agile. Simple rule sets, empowerment, and adaptation to local conditions suggest largescale synchronization and awareness of objectives and end states. The succeeding section explains the methods and tools by which decision makers can achieve this level of coordination, integration, and insightful movement toward objectives.

Capability for Mission Planning and Execution

Conflicts will often occur at great distance, with minimal response time, possibly into areas with undeveloped infrastructures.[9] To respond to these challenges adequately, commanders must see the battlespace rapidly, plan with assurance, issue operational orders, and close with the proper supplies and equipment where desired.

Operational and support planning in 2025 will occur collaboratively and in parallel.[10] Commanders and their staffs will evaluate courses of action using real-time wargaming with intelligent feedback regarding adequacy, feasibility, acceptability, and consistency with doctrine.[11] The commander with VIPERS will have superior battlespace awareness and will quickly grasp the essential contextual and operational elements of a crisis. The system will be fully downlinked throughout the organization. Tailored programming will provide subordinate commanders access to the system for accomplishing all aspects of the mission. Component miniaturization will allow these people to trade their status boards, maps, and overlays for individualized, real-time products.

VIPERS will use a variety of technologies to achieve this capability. Combining multispectral sensing with real-time data fusion[12] and intelligent, decision-support systems will be essential for planning and execution in 2025.[13] Advanced display technologies will optimize human understanding by eliminating unnecessary detail.[14] Evolutionary technology developments married with revolutionary changes in command and control will provide air and space forces an enhanced core competency—information supremacy.

The need for an improved human-machine interface stresses the importance of interactive holographic display as an essential system capability.[15]

> Humans discover and understand their world through visual sensations. The first step to machine accommodation of the human user is the creation of an intuitive, yet richly interactive, visual interface that allows the user to see and manipulate all types of natural and synthetic imagery.[16]

Interactive holography allows this process to occur and is the only imaging technique that provides all depth cues.[17] When dealing with air power's three-dimensional capability, it is even more critical to plan and test in a similar medium. Leaders must be able to think three-dimensionally in the twenty-first century in order to fully exploit military forces' accomplishment of objectives. One cannot adequately describe an air or space mission in words or in a two-dimensional pictorial display.

VIPERS's integration of databases provides the commander a nexus for interactive operational planning, execution, and evaluation. Figure 2-1 shows the merging of information sources which provide input to VIPERS and specifies desired outputs from the system. As depicted, data from information systems combined with information about logistics and personnel will provide commanders with battlespace awareness, enabling them to effectively plan to employ and support their forces.

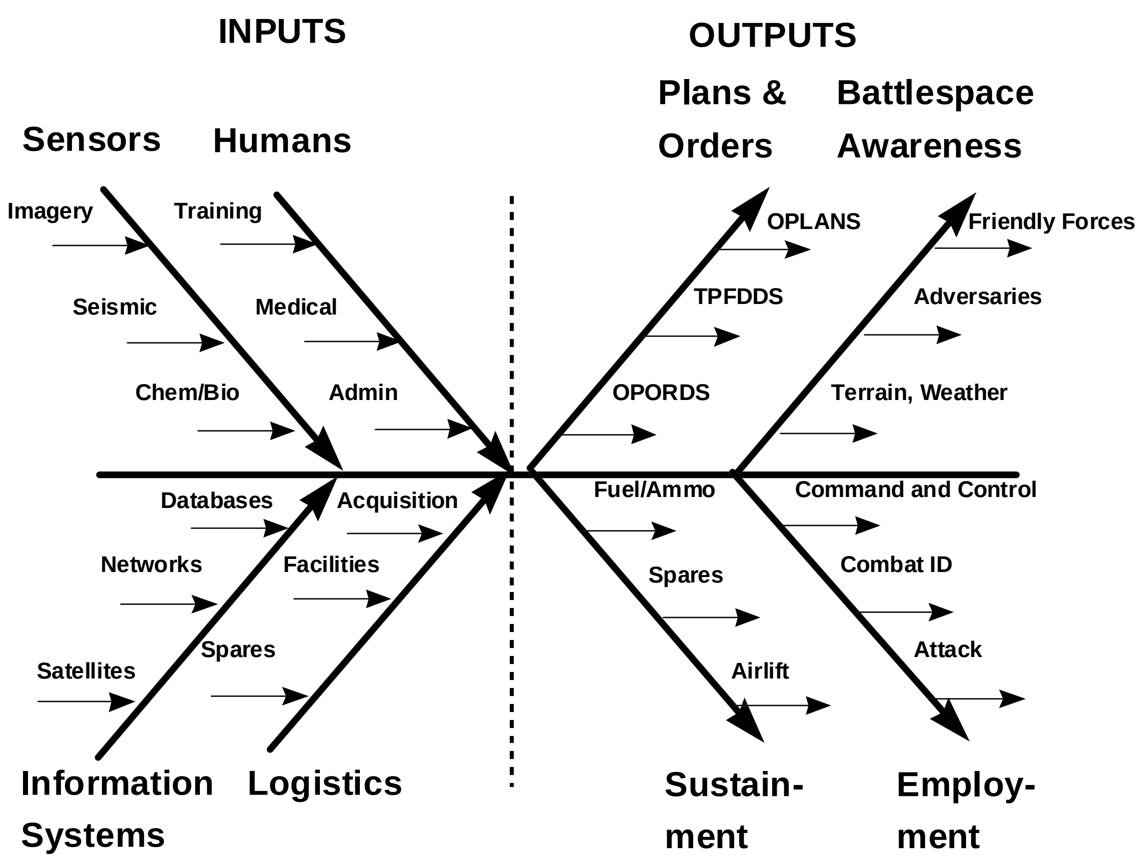


Figure 2-1. VIPERS Logic Diagram

The network of sensors and information systems generates the fused multidiscipline intelligence information.[18] The continuous input of operational data and concurrent analysis permits instantaneous response to changing conditions.

As computers are integrated more and more into the decision making-process, it is paramount that humans retain the ability to make critical judgments concerning life and death. "We . . . must never lose sight of our moral obligation to consider the human element first, and foremost, in the life-threatening arena of the battlefield. . . .Let us never forget that computers do not bleed, men and women do."[19]

Measures of Merit

In 2025 command and control systems will be judged effective in relation to their ability to

1. Survive direct and indirect attack.
2. Plan effective operations efficiently.
3. Enhance decision making.
4. Provide greatly improved connectivity, with vastly improved reliability, security, and capacity employing improved human interfaces superior to those available in 1996.
5. Integrate the battlespace view quickly with a high degree of correlation between the projected image and ground truth.
6. Finally, provide effective and efficient control of resources.

The system presented, VIPERS, will significantly improve upon each of these attributes using technologies, historical lessons, and conceptual models achievable in the next 20 to 30 years. Next, Chapter three presents a system description encompassing leading-edge technologies to show how VIPERS satisfies these criteria.

Notes

1. "Forward. . .From The Sea," Online. Available protocol: http://www.ncts.navy.mil/navpalib/policy/fromsea/fprward.txt, "Longpoles in the Sea Dragon Tent," Online. Available protocol: http://138.156.204.100/ww/cwl/cwllpls.htm, 9 April 1996.
2. 2025 advisor's meeting, Air University, Maxwell Air Force Base, Ala., 24–26 March 1996.
3. Ibid.
4. Ibid.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.

Notes

9. *Rome Laboratory FY95 Command Control Communications and Intelligence C^3I Technology Area Plan* (Headquarters Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio, June 1994).

10. USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century,* executive summary (Washington, D.C.: USAF Scientific Advisory Board, January 1996).

11. Joint Publication 5-0, (Washington, D.C.; United States Government Printing Office, 13 April 1995), I-13.

12. The concept of data fusion includes a number of combining, analyzing, and layering processes which are performed prior to user access. Databases are screened for relevance and imagery. Other visual media are combined, and an intelligent agent determines relative importance. From these, products are created to optimize human perception and support decision making requirements. Further information on intelligent agents can be found in Bill Gates, Nathan Myhrvold, and Peter Rinearson, *The Road Ahead* (New York: Viking Press, 1995), 31–34, and in multiple sources by Pattie Maes of the MIT Media Lab. Optimizing human perception of complex imagery has been studied in the Spatial Imaging section of MIT Media Lab (and other labs as well) as part of DOD-supported projects under Senior Investigator Nicholas Negroponte.

13. ***2025*** Concept, No. 200059, "Automated and Integrated Intelligence Seamless Fusion and Correlation System," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

14. Dr Mark Lucente, MIT Media Labs, on-line, Internet, 4 March 1996, available from http://lucente.www.media.mit.edu.people/lucente.pubs. ***2025*** Concepts, No. 900792, "Holographic Charged Couple Display," No. 200119, "Data Fusion," No. 900161, "Holographic C^2 Sandbox," No. 900385, "3-D Holographic Display," No. 900417, "Battlespace Awareness Holosphere," and No. 900667, "Real-Time War Status Board," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

15. ***2025*** Concept, No. 900182, "Neuro-network Computer Interface" and No. 200191, "Neural Interfaces," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

16. Dr Mark Lucente, "Imaging Sciences and Technology," IBM Research: Visualization Spaces: Imaging Sciences and Technology, online, Internet, 4 March 1996, available from http://www.research.ibm.com/imaging.

17. Dr Mark Lucente, MIT Media Labs, on-line, Internet, 4 March 1996, available from http://lucente.www.media.mit.edu.people/lucente.pubs.

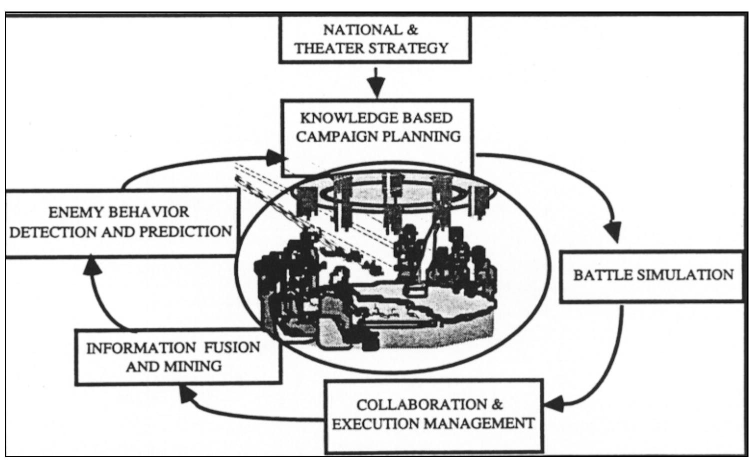
18. Multidiscipline information is the processed data collected from the full gamut of intell communities which, when married, create a usable product.

19. CWO William E. Fleming, USMC, VGMR, MAG 36, telephone interview with co-author Maj Laura J. Sampsel, 11 April 1996.

Chapter 3

System Description and Technologies

The Virtual Integrated Planning and Execution Resource System--VIPERS--enables commanders and their staffs, in conjunction with supporting commands, to collaboratively plan and execute using the process depicted in figure 3-1. Using this process, we can describe the system's elements as they relate to the whole.



Source: USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century* (unpublished draft, the information applications volume, 15 December 1995), 58.

Figure 3-1. The VIPERS's Process

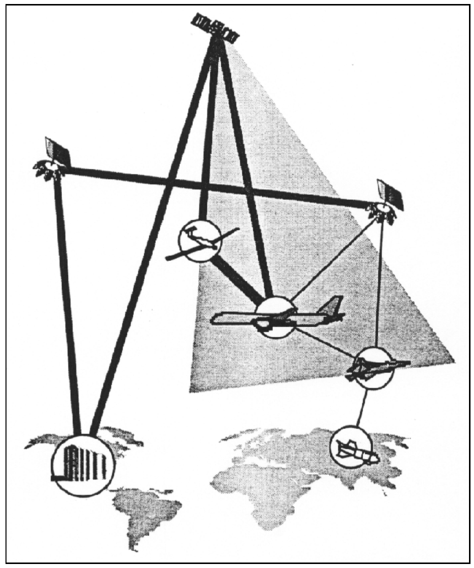
National and Theater Strategy

As crises develop, VIPERS provides visibility of ongoing events to the NCA, political leaders (elected and appointed), and theater commanders. VIPERS facilitates instant teleconferencing between decision makers, providing real-time imagery to help them assess critical situations and develop a national response using the various instruments of power. Large databases coupled with high bandwidth communication permit simultaneous access of archived information regarding history and related events. Desired end states, the purview of political and military leadership, serve as the basis for operational planning. Once the desired end state is determined, the theater commanders can provide guidance and intent for further plan development.

Knowledge-Based Campaign Planning

VIPERS enables commanders to perform knowledge-based campaign planning by using fused multispectral imagery combined with spatial data, all-source intelligence, and archived information. Knowledge-based planning enhances accuracy and improves the awareness of operational and support planners. Accuracy is enhanced because detailed data on force and equipment status is accessible in a tailored format. Awareness is improved because space and time relationships between the environment and forces are graphically depicted. Inherent in this kind of intelligent campaign planning is the extensive testing and analysis of possible courses of action through wargaming.

VIPERS integrates near-real-time, fused information regarding personnel strength, force availability, strategic transportation assets, training, and logistics via automatic up chain-of-command reporting. Information fusion is accomplished through a linked sensor network, as shown in figure 3-2.



Source: New World Vistas, (unpublished draft, the information applications volume), x.

Figure 3-2. Sensor Network

The network's nodes consist of space-based, air-breathing (inhabited and uninhabited) surface and subsurface sensors. Communications will rely upon various media using continuous and burst transmissions to provide a low probability of interception, detection, and tampering. Fiber, wire, and packet communication systems will help achieve the necessary connectivity.

Integrated relational databases are key to VIPERS, because they permit the worldwide distribution of knowledge-based information essential to all realistic planning and operations. To use a present-day example, the joint tactical integrated data system (JTIDS) functions as a virtual database by allowing the warrior to extract information from the bit stream at any time. Similarly, the integrated databases in 2025, as depicted in figure 3-3, will allow worldwide access to all-source intelligence, given the proper access and authorization controls.

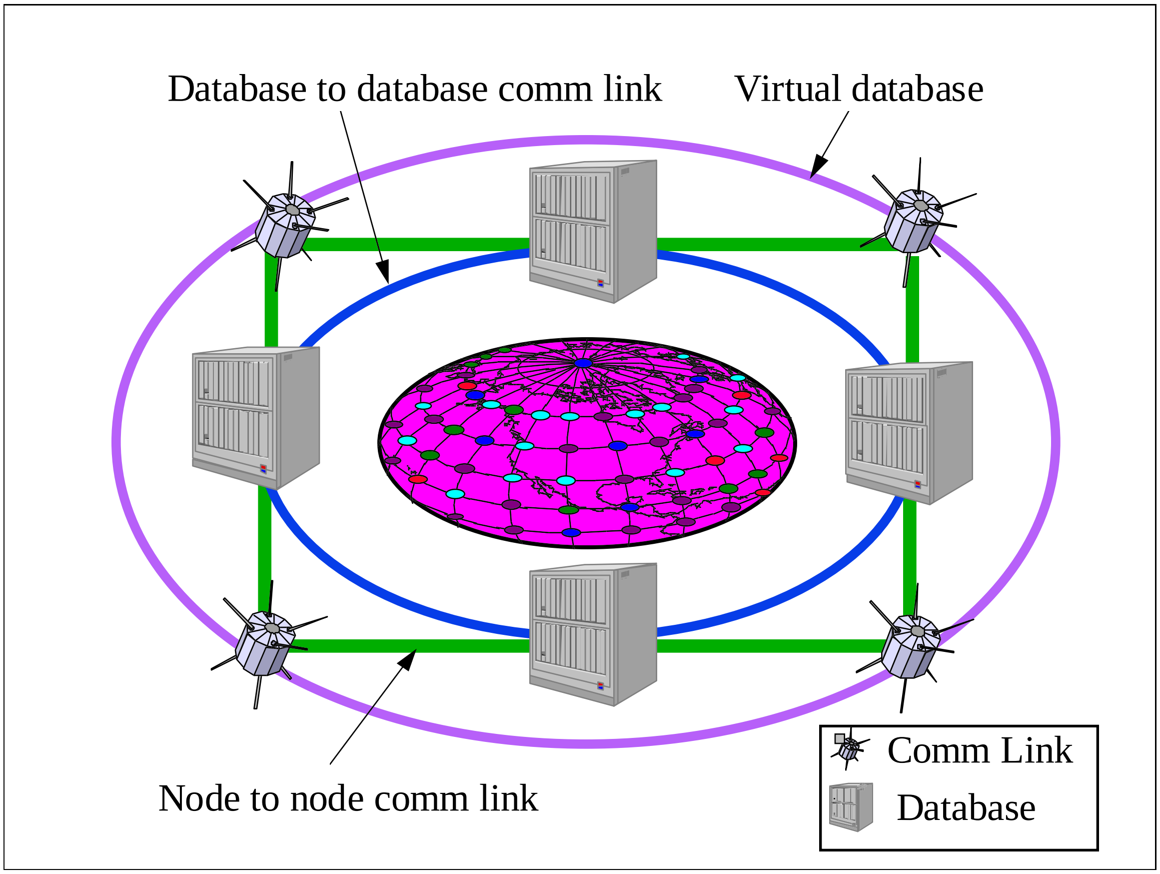
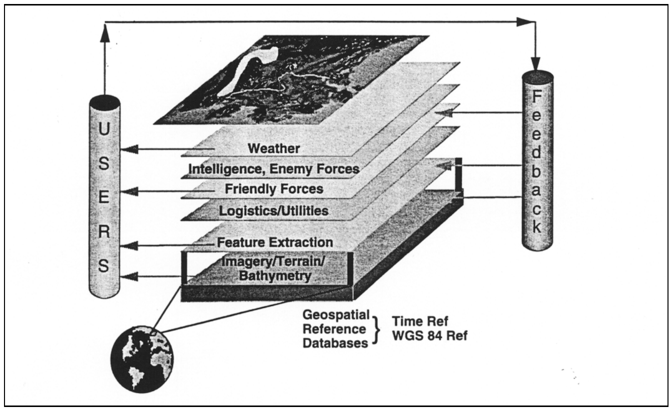


Figure 3-3. Integrated Database System

Layering of databases is a required step toward intelligent fusion. This layering reduces the amount of information the human must process, enabling faster and more complete understanding. Figure 3-4 shows VIPERS's concept for layering databases.



Source: *New World Vistas,* (unpublished draft, the information applications volume), 57.

Figure 3-4. Example of Layered Databases

The system overlays each database onto a georeference grid with location and time indexing. Data translates into relevant information via fusion once organized into a logical framework. Fusion combines useful data from the various sources and suppresses information that is unusable. The benefit of layering and fusion is that the "synthesized picture of the battlefield that emerges is better than any view that can be obtained from raw data."[1] Keys to functionality are the techniques and supporting software that allow the system to review, analyze, distribute, and archive information. Table 1 depicts a reasonable cross-section of the types of data the VIPERS will access and fuse.

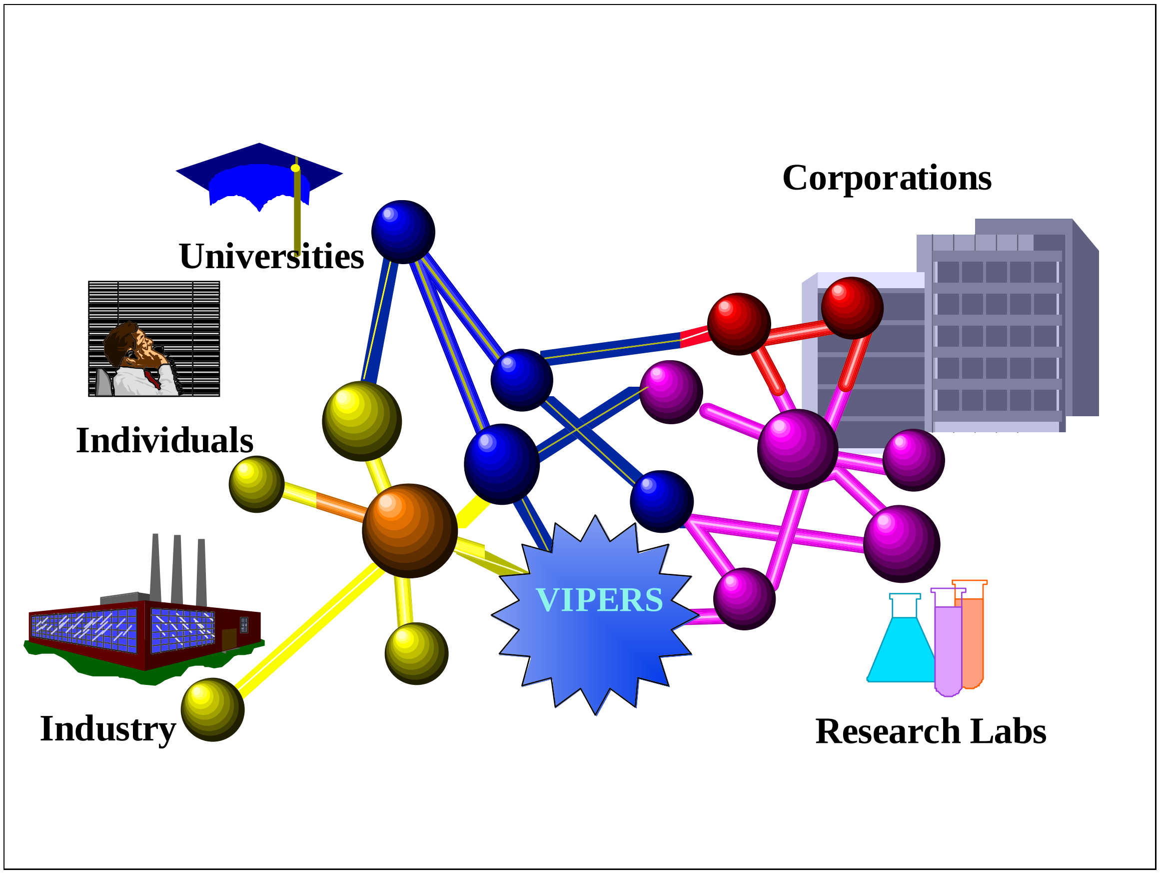
Table 1

Potential Databases

United States Government	Intelligence Databases	Geographic Information Systems	Public Information and Gray Intelligence
JOPES	Multispectral Imagery	LANDSAT	Library of Congress
LOGSTAT	HUMINT, SIGINT, MASINT, ELINT	NOAA (weather data/DMSP)	Worldwide Web
SORTS	DIA/CIA and other intel sources analysis	Demographics (Population, Age, Growth Distributions)	University Academics
PPBS	INTERPOL, FBI, Police Databases	DMA/Topographic and Geodetic	Private Corporations
PC-III/ Personnel Readiness	Indications and warning	Political, Cultural, Ideologic, Economic, Geography	Medical (WHO/CDC)
Medical		Morphology	Environment

See appendix B for acronym definitions

Although intelligence is never perfect, use of “gray intelligence” with classical intelligence expands the possible realm of insights into adversaries' cultures, intentions, motivations, and infrastructures. Figure 3-5 illustrates a sample of gray intelligence sources.



Source: Adapted from undated briefing on Air Force C^4I Visioneering and Long-Range Planning, HQ Air Force Communication Planning Directorate.

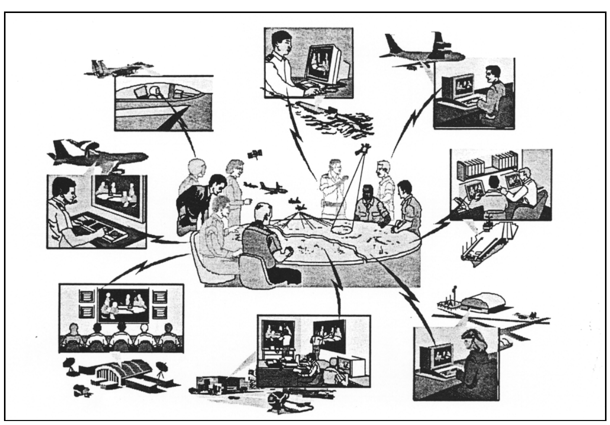
Figure 3-5. Gray Intelligence Network

Battle Simulation

By combining natural human interfaces with intelligent decision support systems (DSS), commanders will be able to war-game ongoing situations.[2] This ability permits risk and vulnerability analysis to refine force, logistic, and transportation planning. DSS are organic to VIPERS. Automatic alerting ensures that assumptions or desired activities are supportable in light of available personnel, equipment, and timing. Intelligent DSS will also offer corrective alternatives for deficiencies. Commanders retain the right of accepting computed risk or disagreeing with recommended actions; however, conditions that cause failure will not allow further progress in the plan until they are corrected. For example, a commander intends to employ a unit in a critical operation before forces are in-theater. VIPERS alerts and offers alternate forces for employment or suggests modified timing of the course of action. Intelligent software generates next-generation operational orders to turn selected courses of action into reality.

Collaboration and Execution Management

The capabilities of VIPERS extend to all levels of warfare (strategic, operational, and tactical) across the spectrum of conflict to execute operations. Commanders will direct, coordinate, and reconstitute their forces while seeing the battlespace in real-time. This system will further serve the commander by allowing him to "process control" via alert functions and command by negation. The primary human-machine interface is voice.[3] Conversational language, properly interpreted for context and inflection, is the principal mode of operating VIPERS. As shown in Figure 3-6, the battlespace will be projected as a three-dimensional holographic image.



Source: Mona Toms and Gilbert Kuperman, "Sensor Fusion: A Human Factors Perspective," research report (Wright-Patterson AFB, Ohio: Armstrong Laboratories, Air Force Systems Command, 1991), 48.

Figure 3-6. Illustration of Projection System

Domes best accomplish projection for full visual understanding of air operations. Commanders will use table-top projections where domed projection suites are not available. VIPERS's flexibility, due to large memory capacity, permits individual tailoring of the projected image.[4] Specialized glasses or hand-held projectors can be used for image viewing in remote locations.[5] Field use of VIPERS requires nonverbal system control as well as projections visible only to the user. Small units and individuals have adaptive access to the system's many capabilities, as authorized.

Information Fusion and Mining

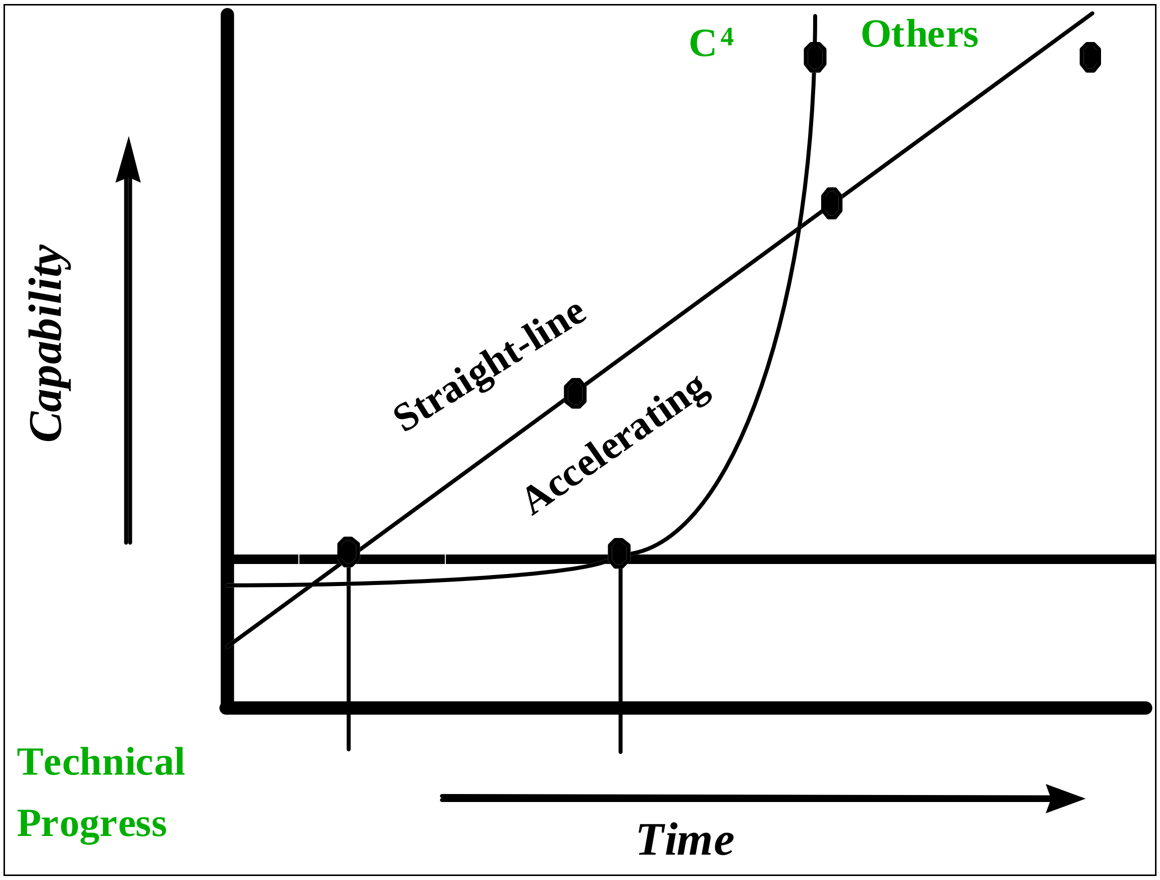
The sheer volume of data flowing in from the multitude of distributed sensors and collectors will require intelligent software to rapidly process data into knowledge-based information. An intelligent assistant best achieves this capability. The agent knows what its goal is, strives to achieve it, learns from experience, and responds to unforeseen situations with a repertoire of methods.[6] "It should be autonomous, so that it can sense the current state of its environment and act independently to make progress toward its goal."[7] The agent acts as a guardian to prevent leaders from trapping themselves into mirror imaging or habitual tendencies.

Enemy Behavior Detection and Prediction

Surveillance systems provide the necessary capacity for enemy detection. Prediction flows from real-time observation and capability analysis coupled with historic behavior. The system continually "pushes" every action and reaction to the commander as it updates archival data. The ability to map the earth to one meter will allow modeling of enemy actions, to a degree only dreamed of before.[8] For example, before starting an air campaign, an entire nation's terrain, infrastructure, and fielded forces can be mapped as links and nodes. This mapping reveals vital connections between systems. As combat assessment and field reports are generated, planners and operators can analyze the effects of targeting. Today's 32 layers of information in metropolitan geographic information systems (large relational databases) will be replaced by 100 layers of data which can accurately predict how damaging a specific node will have cascading effects throughout various political, economic, social, and military systems.

Technology Progress

Studying the pace of technology development is helpful in understanding what VIPERS may achieve in 30 years. Figure 3-7 portrays the differences in advancement of electronic systems compared with other technological endeavors.



Source: Air Force C4I Visioneering and Long-Range Planning Briefing, HQ Air Force Communications Planning Directorate, undated.

Figure 3-7. Technological Progress in C4I Systems

The accelerating curve is indicative of advances in the microelectronics industry from memory capacity to processing speed. The transistor was invented in the late 1950s but did not achieve substantial growth until the mid-1970s. This nonlinear growth also applies to lasers and other advanced technologies. Similarly, today's new technologies will show little advancement in the next 10 to 20 years (points 1 and 2), but will experience explosive growth in the third decade (point 3). The following table depicts technological progress of today compared to projections for 2010 and beyond.

Table 2

Growth in Capabilities of Information Technology

Capability	1990	2000	2010
Software	10 MB/User	100MB/User	10 GB/User
Computer Speed	1–25 MIPS	25–100 MIPS	100–1000 MIPS
Software	Serial	Serial & Parallel	Massively Parallel
Network Bandwidth	1–150 Mbps	.1–10 Gbps	10 Tbps
Data Volume	100 Megabytes	1 Terabyte	1000 Terabytes
Response Time	Hours	Minutes	Seconds
Reports	10,000/Day	1,000,000/Day	1,000,000,000/Day
Geopositioning	5 Points/Hour	50 Points/Hour	500 Points/Hour

Legend: MIPS- millions of instructions per second, Mbps-megabytes per second, Gbps-gigabytes per second, Tbps-terabytes per second

Engineers refer to the fact that processing and memory capacity double every 18 months as Moore's Law.[9] Moore's Law predicts this exponential growth will continue for at least the next 20 years. This pace of development is necessary to create VIPERS, and there are specific thresholds technology must achieve before the system becomes feasible outside a laboratory setting.

Technology Thresholds

For VIPERS to become reality, certain technologies must attain a minimum level of performance. For instance, holographic projection needs data storage capacity of no less than 1,000 terabytes.[10] Today, to produce a smooth VHS-quality projection, data transfer rates must be at least 1.2 million bits per second.[11] In 2025, seamless three-dimensional projections will require data access speeds of no less than a million bits per millisecond. The data transfer rate to produce a two-dimensional broadcast-quality image is 30 million bytes per second[12] which requires greatly increased bandwidth. Lucente asserts, "There are no technical limits to bandwidth. Bandwidth is limited only by cost."[13] This opinion is largely supported by history. In 1961 computer memory cost $8 per byte. Three megabytes of computer memory cost $60 or 0.00002 dollars per byte in 1995; therefore, the computer memory cost for complex graphics in 2025 is insignificant.[14] These historical trends indicate that the following technologies, vital to VIPERS's operation, are not only possible but feasible given fiscal adequacy.

Promising Technologies

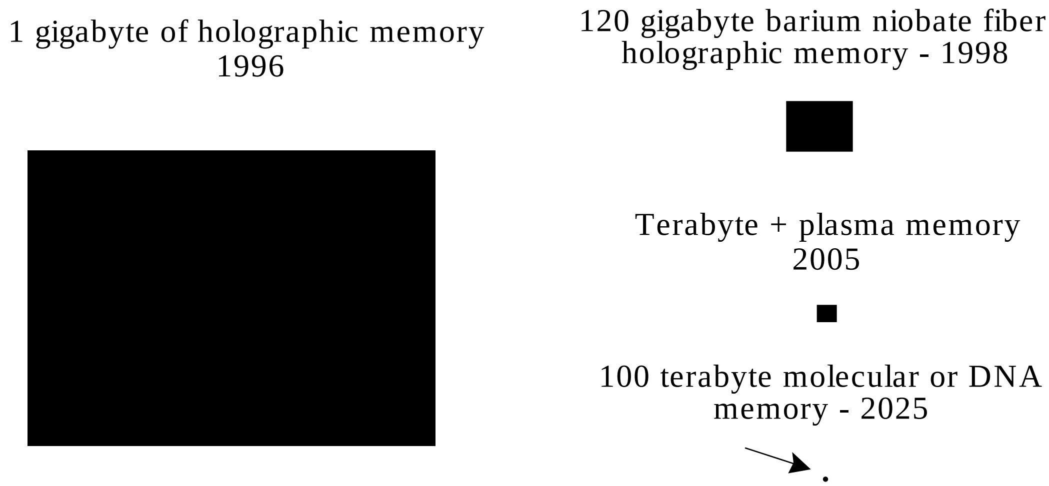
VIPERS results from combining several advanced technologies. Flexible, "anytime-anywhere" battlespace management requires an array of sensors to provide continuous coverage of areas of interest.[15] Use of miniaturized sensors provides the capability for monitoring the physical environment and enemy operations.

Microelectromechanical System (MEMS)

Microelectromechanical system (MEMS) technologies are developing rapidly to provide a relatively low-cost, robust sensor for various purposes. These technologies allow creation of active sensors to monitor seismic, chemical, and environmental signatures.[16] Dr Kaighm Gabriel predicts MEMS technologies will reach full maturity within the next 50 years.[17] Rapid exploitation of MEMS in the commercial sector allows the military to capitalize upon these advances. The Advanced Research Projects Agency (ARPA) is playing a strong role in MEMS and should continue to develop its already strong ties with the private sector by funding those areas of research which will most benefit the military.

Data Storage and Processing

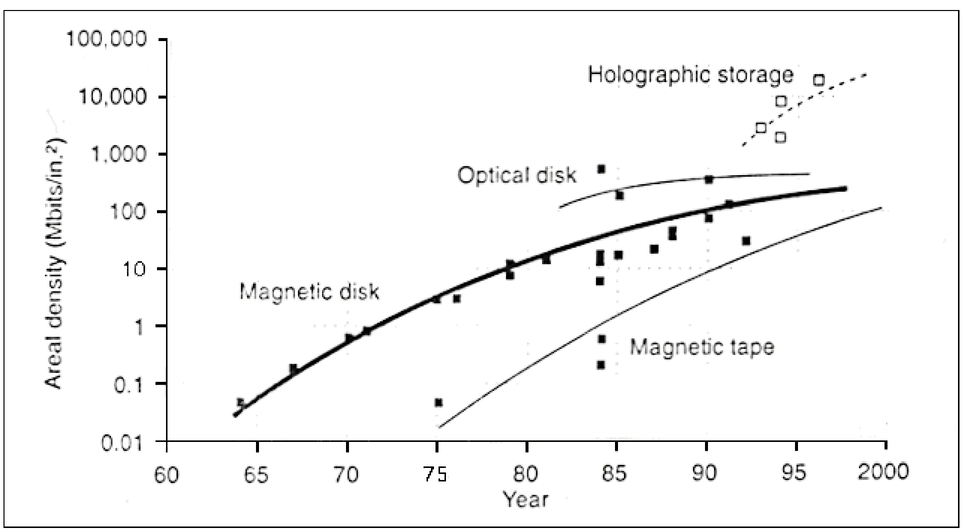
Real-time information fusion is impossible without several orders of magnitude improvement in data storage capacity and processing speed. Exponential increases in both these domains of computing power continue in the commercial sector. Rome Laboratory's C^3I Technology Area Plan articulates the issues of storage and speed as a thread in virtually all of its thrusts.[18] Reliable holographic storage media using a stacking system and photoreactive polymers are creating one gigabyte in a 2.5-square inch-area.[19] Professor Lambertus Hesselink's work with optical fibers of strontium barium niobate suggests that one million bits of data can be encoded on a rod smaller than a straight pin.[20] He plans for an array that handles 120 gigabytes in one square centimeter within the next few years.[21] Supercooled plasma memories are predicted to provide multiple terabytes in one-square- millimeter-size storage units while theorists suggest that molecular[22] or deoxyribonucleic acid (DNA)[23] memories and processors will put a terabyte in an area the size of a grain of salt.[24] Negroponte and Gates argue that growth in memory is driven today by the commercial sector, and society (military, government, and education) will ride upon their coattails, gaining virtually unlimited memory storage capacity in miniature form.[25]



Note: 1 Terabyte is equivalent to 1,000 gigabytes or 1,000,000 megabytes

Figure 3-8. Comparison of Data Storage Capacity and Size

Achieving high levels of areal* density is a key component of both storage and speed, as shown in figure 3-9.[26]



Source: John Stockton, "Portable Electronic Storage Systems," *IEEE Micro* 14, no. 1 (February 1994). Reprinted with permission ©1994 IEEE Micro.

Figure 3-9. Advances in Areal Density

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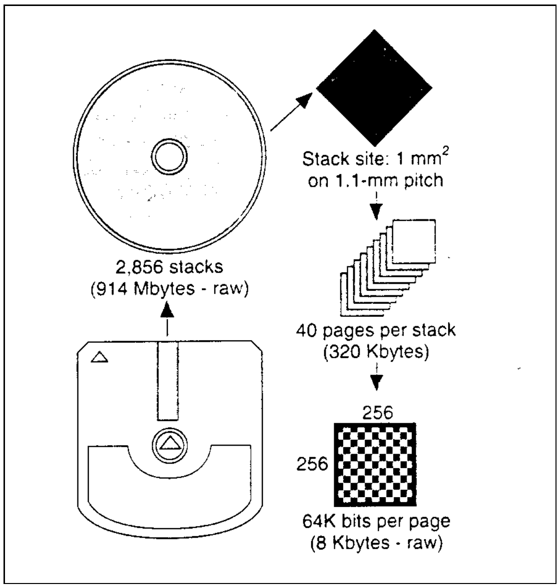
* *Areal density* is a term which relates to the amount of data that is stored in close proximity. The more that is "packed" into a two-or three-dimensional space, the more efficient and effective the memory system.

Holographic media are most efficient in maximizing this feature, using optical storage and retrieval systems. Simultaneous reading and writing of "pages" of data and multiplexing[27] allows storage of large numbers of pages in the same location.[28] Consequently, saving and accessing data is much quicker.[29]



Source: John Stockton, "Portable Electronic Storage Systems," *IEEE Micro* 14, no. 1 (February 1994). Reprinted with permission. ©1994 IEEE Micro.

Figure 3-10. Example of Holographic Memory Array

Holographic design not only improves speed, it also allows processing within memory.[30] Given the delays experienced when accessing a large spreadsheet or database and the processing time needed to make changes, it is understood that processing within memory means that calculations and modifications occur continuously and are totally transparent to the user. Random access memory (RAM) is freed up so transitions, by virtue of their speed, are seamless. A further advantage is that optical data storage creates physical changes in the medium and, therefore, holographic memory systems are more resistant to electromagnetic pulses than magnetic memory.[31] The Air Force's Rome

Laboratory is actively pursuing advanced holographic memory designs while Tamarack Industries is the leading-edge commercial developer today.

Real-time Decision Support/Artificial Intelligence (AI) Software

Turning mountains of data into usable "point" information drives the ability for complex analysis and application of highly advanced artificial intelligence architectures. These systems must combine inputs from multiple sources; identify significant changes and anomalies; determine critical indicators for alert reporting; and generate highly reliable products. Rome Lab, in collaboration with the Advanced Research Projects Agency and other Department of Defense (DOD) laboratories, is addressing this area through multiple product lines, and has fielded some limited systems (e.g., the advanced planning system installed as a component of the contingency tactical air control systems automated planning system [CTAPS]).[32] Advanced technology demonstrations are ongoing with the joint strategic targeting and reconnaissance system (JSTARS) for cueing and correlation and for several other data- and image-processing and display programs.[33]

While this work is important, a great deal of artificial intelligence and processing design can be culled from the civilian sector and then adapted for military use. The current military literature on data fusion is still speaking of improving the "blips" on radar screens,[34] but the war fighter of the future needs fully articulated visuals and an intelligent, interactive machine interface which alerts and advises, not one that just reports. Monte Zweben's processing and scheduling control system for National Aeronautics and Space Agency's (NASA) Kennedy Space Center optimized the complex parallel tasks of shuttle launching and maintenance, generating substantial savings in time and money. Using multiple sensors and applying proactive data processing, analysis, and artificial intelligence (AI) modeling to the business world, his Response Agent™ system optimizes manufacturing processes based on changes within the system.[35] This decision-support software uses a theory of constraints approach[36] and has become the "smart" expediter for diverse manufacturing processes. Although Lenat indicates that AI progress has been disappointing since its inception in 1956, he believes that "artificial intelligence stands on the brink of success."[37] Software modules for military simulations still require military investment.[38]

Image Understanding Software

The ARPA has created the Image Understanding Program for the Department of Defense; two projects within the program are Radius (Research and Development, Image Understanding Systems) and UGV-RSTA (Unmanned Ground Vehicle-Reconnaissance, Surveillance and Target Acquisition).[39] The former is focused on image intelligence, and the latter is an enabler for unmanned aerial vehicles in targeting. Image recognition programming advances are currently inadequate in the commercial sector. The advanced fractal analysis and complex algorithms required for the highly accurate, multimodal system envisioned for VIPERS are not yet available and require continued development.[40]

Human Machine Interfaces

Commanders access VIPERS through a natural human interface. Their voice, eye movements, and gestures are interpreted by VIPERS's communications sensors and directly integrate with its functions.[41] The commercial sector already recognizes voice, and language systems have a strong market demand. According to Lucente, "This is the year of commercial speech recognition and commands"; dramatic improvements will be seen by the year 2000.[42]

Researchers at the Massachusetts Institute of Technology (MIT) Media Lab are working on the gesture and eye-movement components of a natural human-machine interface; working in conjunction with their ARPA/Rome Laboratory sponsored C^3I battlefield project they have successfully fielded a system which uses a glove to pick up hand motion and a camera for eye movement.[43] Several military labs, including Rome and the Naval Research Lab, have projects on line while the intelligence services are taking systems a step farther by adding translators.[44]

The Naval Research Laboratory's Intelligent M^4 Systems Group is examining the linguistics of spatial relations when a user interacts with a computer-based map display. The testbed for this so-called InterLACE (Interface with Land Air Combat in Eric) project is Rome Laboratory's LACE (Land Air Combat in Eric) combat simulation system. It is combined with a natural language processor to allow querying of routes and directional orders for a simulated tank unit as it traverses three-dimensional terrain.[45] This militarily focused effort begins to link some of the key technologies for VIPERS as it integrates a geographic database with an artificially intelligent medium and offers verbal order execution in a three-dimensional simulation.[46]

Three-Dimensional Holographic Display

For commanders and their staffs to interactively plan and execute, they will rely on a system which ties a number of technologies to the holographic engine. This involves wargaming software, verbal tasking order generation coupled with automated resupply, and other support functions based on mission requirements.

The essential technologies for the holographic component of VIPERS include portable projection devices, which have greatly increased capability for generating large, complex images and eliminating need for display media. In 1994 Dimensional Media Associates generated full-color moving images which appeared suspended in the air outside a building. Current technology allows 120^{o} view angle and image size from a few inches to 20 feet. A 360^{o} projection capability is expected in the near term.[47] Although current technology limits real-time, interactive three-dimensional holograms to 150 mm wide by 75 mm high by 160 mm deep, developers are predicting "big as an elephant" displays in the lab setting by 2020.[48] These projections will incorporate the desirable AI features without the restrictive trappings of today.

The key need to generate interactive holographic images in near real time is also partially addressed by emerging holographic movie technologies. The technology is currently constrained by short projection times, monochrome images, and the need for supercooled (7K) operating temperatures. Nippon Telephone and Telegraph designers are predicting storage capability of 10 million still pictures/100 hours of broadcast with a recording system able to capture one frame per nanosecond.[49]

The recreational market for virtual-reality systems is bearing fruit with potential application to the holographic battlesphere. Dr Pattie Maes of MIT Media Labs, while working without DOD sponsorship, has focused on ALIVE (Artificial Life Interactive Video Entertainment), a "no wires" virtual world with smart, sensing, autonomous agents that interact with visitors.[50] In 1996, virtual-reality interfaces also help stock and commodities traders perceive changing markets in a way that lets them make faster, more accurate judgments on trends and relationships.[51] Fully holographic media may not be desirable in the field setting, and hand-held devices which use a variant of the master system are likely to be both cheaper and easier to deploy.[52] Image projection may employ transparent holographic visors, similar to head-up displays.[53] The commercial applications for these devices include automobile designs and medical systems.[54]

Negroponte claims that in the future we will watch in our living room football games played by small holographic figures who run around on the carpet.[55] This level of commercial development and broad application of holographic technology is not likely to occur by 2025 without large infusions of capital.[56]

The following chapter reveals systems operation, the concept of operations, and the absolute utility of the proposed system. For now though, what do we know about VIPERS? VIPERS provides decision makers, at all levels of command, with a knowledge-based tool enabling rapid operations and support planning.

VIPERS allows decision makers to integrate political conditions and end states with the required intelligence information and force structures to achieve it. Along the way, sophisticated technologies allow operations and support planners to visualize the relevant environment, consider wargame options, and issue logical logistical, deployment, and operations orders to those charged with mission accomplishment. The end result is an overarching, fully integrated plan that is entirely feasible, within whatever constraints relevant decision makers have placed upon it.

Notes

[1] David Hughes, "MITRE, Air Force Explore Data Fusion for Joint-STARS," *Aviation Week and Space Technology* 140, no.10 (7 March 1994): 47–48. The table in Appendix A summarizes the methods of fusion and integration for various databases. Further, the table illustrates the ways and means to provide useful information by critical analysis.

2. ***2025*** Concepts, No. 900182, "Neuro-network Computer Interfaces" and No. 200191, "Neural Interfaces," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

3. ***2025*** Concepts, No. 901148, "Voice Command Systems," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

4. ***2025*** Concepts, No. 900161, "Holographic C^2 Sandbox," ***2025*** Concept database (Maxwell AFB, Ala.: Air War College/***2025***, 1996).

5. Bill Gates, Nathan Myhrvold, Peter Rinearson, *The Road Ahead* (New York: Viking Press, 1995), 73–77. Gates discusses the wallet computer, which can display maps, communicate, and perform a multitude of other functions, plus is capable of sending and receiving fully encrypted material.

6. Dr Pattie Maes, "Intelligent Software," September 1995, n.p.; online, Internet, 11 March 1996, available from http://pattie.www.media.mit.edu/people/pattie/SciAm-95.html.

7. Ibid.

8. USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century*, executive summary (Washington, D.C.: USAF Scientific Advisory Board, January 1996).

9. "Milestones," Online. Available protocol: http://www.nanothinc.com/cgi-bin/imagemap/navigationbar?186,18., 24 June 1996.

10. Dr Mark Lucente (lucente@watson.ibm.com), "Subject: Air Force/Air Power 2025, E-mail to Maj Barbara Jefts (bjefts@max1.au.af.mil), 23 March 1996.

11. Nicholas Negroponte, *Being Digital* (New York: Alfred A. Knopf, 1995), 29.

12. Tim Stevens, "Holograms: More than Pretty Pictures," *Industry Week*, 4 October 1993, 37. Broadcast-quality video requires 30 video frames per second. In each frame there are approximately 922 kilobytes of data. Multiplying 922 kB per frame by 30 frames per second yields 27,660 kB per second (John F. Stockton, "Portable Electronic Storage Systems," *IEEE Micro* 14, no. 1 [February 1994]: 71); therefore, 30 MBPS data-transfer rate is rational basis for forecasting broadcast video requirements.

Notes

13. Dr Mark Lucente (lucente@watson.ibm.com), "Subject re: Air Force/Air Power 2025," E-mail to Maj Barbara Jefts, (bjefts@max1.au.af.mil), 21 March 1996.

14. Negroponte, 107.

15. "Personnel Identification Friend or Foe (IFF)," Concept 200021, 17 November 1995; "Gnat Threat Detector," Concept 200231, 11 October 1995; "Surveillance Swarm," Concept 200023, 20 November 1995; "Electronic Grid Throw Away Sensors," Concept 900518, 27 November 1995; and "Space AWACS Concept," Concept 900678, 5 December 1995.

16. Dr Kaigham J. Gabriel, "Engineering Microscopic Machines," *Scientific American* 273, no. 3 (September 1995): 119.

17. Ibid., 118.

18. *Rome Laboratory FY95 Command Control Communications and Intelligence* C^3I *Technology Area Plan* (Wright-Patterson Air Force Base, Ohio, Headquarters Air Force Materiel Command, June 1994).

19. Ibid., 72.

20. "Untangling the Data Traffic Jam," *USA Today* 121, no. 2577 (June 1993): 8.

21. Philip E. Ross, "The Hologram Remembers," *Forbes* 54, no. 7, (26 September 1994): 170.

22. Gates et al., 21–34.

23. The complex genetic codes found on DNA are actually memories. The chemical structure can be replicated and thus is a reproducible, "readable" memory. Genetic engineering advances may allow DNA creation in the future as they allow "gene splicing' and chromosome repair today.

24. Sunny Bains, "Plasma Holograms Pack in the Memories," *New Scientist* 145, no. 1968, (11 March 1995): 22. The *New World Vistas* paper discusses petabyte capacities for computation.

25. Gates et al., 31–34; and Negroponte, 208.

26. John F. Stockton, "Portable Electronic Storage Systems," *IEEE Micro* 14, no. 1 (February 1994): 72. If high density is achieved, minimal time is lost accessing and transferring data from memory to application for processing. Literally packing the bits of data in a three-dimensional array, it reduces this time significantly as well as allowing other unique functions.

27. Multiplexing is a process of optically storing data by changing the angle of the laser used to write the data into the memory and then literally stacking the memory crystals

28. Ross, 173–74.

29. Stevens, 37.

30. Ross, 174.

Notes

31. Maj Greg H. Gunsch, Air Force Institute of Technology, telephone interview with Maj Barbara Jefts, 3 April 1996.

32. *Rome Laboratory FY95 Command Control Communications and Intelligence C^3I Technology Area Plan*, 5–6.

33. Ibid., 6. Appendix A also provides a reference table which presents the multitude of fusion approaches being used in the development of these systems.

34. The status of current fusion projects for the airborne warning and control system (AWACS) and JSTARS is addressed in two articles by David Hughes. "AWACS Data Fusion under Evaluation," *Aviation Week and Space Technology* 140, no. 10 (7 March 1994): 62–63 and "MITRE, Air Force Explores Data Fusion for Joint-STARS," *Aviation Week and Space Technology* 140, no. 10 (7 March 1994): 47–48.

35. John Teresko, "Red Pepper Software—Bringing Real-time Planning and Scheduling to Manufacturing," *Industry Week* 244, no. 23 (18 December 1995): 27. Monte Zweben's work at the NASA Ames Research Center was directly responsible for improvements in the shuttle maintenance and repair which translated to shortened periods between launches.

36. Theory of Constraints process modeling allows you to identify those subprocesses or whole processes which, if improved, will directly impact overall system performance. The user defines the outcome measures which are most important (e.g., profit, time, quality of product, etc.), and the model will expose the components of the system which play the biggest role in achieving those goals. Once a constraint is overcome, the model reveals any new constraints which may have developed because of the change in the system and highlights other process choke points.

37. Douglas B. Lenat, "Artificial Intelligence," *Scientific American* 273, no. 3 (September 1995): 62.

38. USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century* (unpublished draft, the information applications volume, 15 December 1995), 9.

39. Oscar Firschein, "Defense Applications of Image Understanding," *IEEE Micro,* October 1995, 11.

40. Peter Wayner, "Machine Learning Grows Up," *BYTE* 20, no. 8 (August 1995): 63.

41. "Neuro-network Computer Interface," Concept 900182, 25 September 1995; and "Neural Interfaces," Concept 200191, 4 January 1996.

42. Dr Mark Lucente (lucente@watson.ibm.com), "Subject: Air Force/Air Power 2025," E-mail to Maj Barbara Jefts (bjefts@max1.au.af.mil), 6 March 1996; and "Voice Command Systems," Concept 901148, 1 February 1996.

Notes

43. Mona Toms and Gilbert Kuperman, "Sensor Fusion: A Human Factors Perspective," Research Report (Wright-Patterson AFB, Ohio) Armstrong Laboratories, Air Force Systems Command, 1991, 63.

44. *Rome Laboratory FY95 Command Control Communications and Intelligence (C^3I) Technology Area Plan*, 17–19; Stephanie S. Everett, Kenneth Wauchope, and Manuel Perez, "A Natural Language Interface for Virtual Reality Systems", online, Internet, available from http://www.nrl.navy.mil, 4 March 1996; and 2025 concept, no. 900341, "Universal Translator," 2025 concept database (Maxwell AFB, Ala.: Air War College/2025, 1996).

45. Kenneth Wauchope, Navy Center for Applied Research in Artificial Intelligence, InterLACE project, online, Internet, available from http://www.aic.nrl.navy.mil/~wauchope/interlace.html, 4 March 1996; and "LACE", Rome Laboratory, online, Internet, available from http;//www.rl.af.mil:8001/technology/summary/summary.html, 7 April 1996.

46. Charles Arthur, "Holographic Movies Come in from the Cold," *New Scientist* 142, no. 1931 (25 June 25 1994), 21.

47. Ron Goldberg, "How Much Is That Image in the Window," *Popular Science* 246, no. 2 (February 1995), 42.

48. Lucente, "Subject re: Air Force/Air Power 2025," 6 March 1996.

49. Arthur, 21.

50. Pattie Maes, "Artificial Life meets Entertainment: Interacting with Lifelike Autonomous Agents," *Communications of the ACM* 38, no.11, November 1995, n.p.; on-line, Internet, 11 March 1996, available from http://www.acm.org/pubs/cacm/ and Maes, "Intelligent Software".

51. David Baum, "Assets in Wonderland," *BYTE* 20, no. 7 (July 1995): 111–12. The system described vrTrader™ operates on a Windows PC; uses live data feeds from Cable TV, FM, or satellite; and generates a 3-D color display with optional voice recognition and spatial sound capability .

52. Lucente, "Subject re: Air Force/Air Power 2025," 6 March 1996; and Nicolas Negroponte and Dr Richard A. Bolt, "Advanced Concurrent Interface for High-Performance Multimedia Distributed C^3 Systems," Research Report, (MIT Media Lab, March 1993), 34.

53. Robert Langreth, "A 2-D Display is Better Than 3," *Popular Science* 244, no. 5 (May 1994): 53; and "Tactical Information Display Helmet," Concept 900317, 27 October 1995.

54. "Disc Drivers," *The Economist* 335, no. 916 (27May 1995): 74; "3-D CT," *Discover* 13, no. 8 (August 1992): 10; and Andrew A. Skolnick, "New Holographic Process Provides Noninvasive, 3-D Anatomic Views," *JAMA* 271, no. 1 (5 January 1994): 5.

Notes

55. Negroponte, 107.
56. Lucente, “Subject re: Air Force/Air Power 2025”, 6 March 1996.

Chapter 4

Concept of Operations

A way of visualizing VIPERS is to think of it as the "holodeck" of *Star Trek: The Next Generation* married to the offspring of the global command and control system (GCCS). Since the full range of VIPERS's capabilities is difficult to convey in the print medium, this chapter presents a fictional scenario as an aid to understanding how the system might operate and follows with a discussion of how VIPERS's attributes compare to the measures of merit identified in Chapter 2. Finally, the chapter enumerates possible countermeasures and strategies to overcome them.

Operation Zion

Dateline: 7 Mar 2025 0300Z Jerusalem

The peace established in 1999 by Yasser Arafat and President Peres broke sharply today when an insurgent group called the New Palestinian Liberation Organization seized temples throughout the Holy City. This well-armed group has infiltrated all the major cities in Israel, taking numerous hostages, and is occupying parliamentary buildings in Tel Aviv. The group claims to have chemical and biological weapons ready to detonate if the standing forces of Palestine or Israel try to intervene in either city. This unprecedented action has stymied the Mossad. The current presidents of both Israel and Palestine have appealed to the United States for help; additional pressure for immediate action is being generated by special interest groups within the United States.

071300Z MAR 25 (Vicenza IT) - Commander-in-Chief Mediterranean region, General Miller, receives an urgent tasking from the NCA to prepare alternate courses of action in dealing with this crisis. His plans must be sensitive to the cultural and religious interests of the parties, consider use of ad hoc coalition forces, and *be ready for discussion at a special meeting of the National Security Council (NSC) 1800Z.* The formal operations plans for his region do not address this contingency, but he is unflustered as he brings his planning staff together.

071400Z MAR 25 - General Miller joins the group in the VIPERS's Planning Center. The lights dim; the holodome automatically responds to the J-2's description of the events in Israel by creating a 3-D image of the eastern Mediterranean region. Glowing icons show the location of all friendly air, sea, and ground forces within 200[1] miles of the area of operations (AO). Real-time imagery displays the known locations of insurgents' action and their order of battle as General Miller walks around his theater. At his request, VIPERS provides an audio-video review of current national security strategy for the Middle East and highlights pertinent political objectives and constraints of the present administration.

The planning group works through four courses of action (COA) in two hours. VIPERS has analyzed each one for adequacy, acceptability, feasibility, and compliance with joint/combined doctrine. By wargaming the options through the medium of holography, the team has been able to see the phases unfold and gauge the resultant end states for each. VIPERS artificial intelligence warrior function has also suggested alternatives and allowed simultaneous imbedding of branches and sequels. General Miller quickly evaluates each COA on its merits while VIPERS objectively rates them on probability of success, casualty figures, supportability, and expense factors. VIPERS concurrently generates command and unit taskings, optimizes deployment and combat scheduling, and completes the transportation planning needed for the operations. General Miller asks the VIPERS Planning Center to contact Chairman, Joint Chiefs of Staff, General Sterling, so he can be briefed on the situation and military options for action.

071600Z MAR 25 (Washington, D.C.) Within minutes, Chairman Sterling is ready in his holosuite along with a few key members of his staff. General Miller has VIPERS present the current situation with selected imagery and real-time force estimates. The chairman asks for, and immediately receives, additional details on biologic and chemical munitions countermeasures. Both staffs see the same images and move through them as the suggested courses of action play out. The entire process takes less than an hour. The chairman concurs with General Miller's suggested approach, but wants to give Secretary of Defense Pidgeon an opportunity to fine tune objectives, constraints, and possible rules of engagement (ROE) prior to the National Security Council (NSC) meeting.

071715Z MAR 25 (Washington, D.C.) - Secretary Pidgeon reviews the plan through a 3-D desktop display monitor while looking over the president's most recent foreign policy guidance. After the secretary dictates a few ROE changes and suggests an alternate deployment day, VIPERS gives an updated assessment of the merits of each COA and cost estimates for the operation. Satisfied, Secretary Pidgeon heads for the NSC meeting room.

071845Z MAR 25 (Washington, D.C.) - The meeting went well; the White House press are demanding a statement as soon as the president leaves the room. She doesn't even pause in her stride as she continues on her way saying, “We’ve already downloaded our official position to your servers, including statements from the presidents of both Israel and Palestine. You can expect daily updates from General Miller’s office as well as the White House situation room on Operation Zion.”

071900Z MAR 25 (Worldwide) - Tasked units from all services are receiving their orders for deployment. Logistics plans are complete and plans to phase into the theater are set. Host nation support capabilities have been factored in and basing requirements established. Final training recommendations have accompanied the orders so units/individuals can visit their simulators for AO familiarization training and joint/combined training, techniques, and procedures review.[2] Secure video links with the Israelis and Palestinians have allowed full discussion of the coalition effort, and they too are readying their forces with the help of VIPERS. Operation Zion is underway.

101300Z MAR 25. (Tel Aviv) - Seventy-two hours later, Colonel Dautry, 366 WG/CC, is moving toward the expeditionary wing operations center in Tel Aviv. The colonel, accompanied by the group commanders, intends to review the wing’s mission and the various adversary orders of battle. VIPERS quickly provides the required data and information as the wing intelligence officer talks. Lacking the holographic projection dome, the system formats the presentation for wall-mounted display. Colonel Dautry is instantly shown the location of the wing’s aircraft as they close on the isolated, recently constructed, airbase in the Negev Desert. Additionally, the progress and location of air- and sea-borne supplies are monitored via a real-time moving map. The system also pinpoints the location of the security police forces that will provide air base defense. Having reviewed all the relevant data, Colonel Dautry directs the air tasking order (ATO) be transmitted to the base in the Negev. The ATO completed, Colonel Dautry and staff prepare to move forward to join the wing on arrival at the deployment location.

Across the base, Lieutenant Colonel Lance uses VIPERS to evaluate the security sphere surrounding the airbase in the Negev. She reviews the location and disposition of her security forces and then requests a detailed report on all personnel located at the airbase, ensuring that all deployed individuals have their personal transmitters. VIPERS compares the real-time data uplink with its archived personnel deployment data and generates a display that positively identifies the location of all assigned personnel. The addition of physiological parameters and fitness-for-duty estimates in the display allows Colonel Lance to detect a sentry on the west perimeter asleep on duty. She uses VIPERS to alert the area supervisor to the condition and links back to her stateside judge advocate general (JAG) to assure correct Article 15 procedures are followed. Further, she calls up a subterranean schematic of the base’s sewer system to ensure all access routes to the base are observed and defended.

121500Z MAR 25 (Negev) - Combat operations commenced at 1300Z. VIPERS detects an attempted incursion 500 meters outside the northern base perimeter by three unidentified personnel (UP). It immediately alerts the ground defense operations center and the sentries in the affected sector. The system provides precise location, equipage, and direction of movement of the UP and then assesses the threat based on localized sensor observation.[3] Following this engagement, VIPERS provides Colonel Lance with an updated evaluation of the base security posture reflecting the current threat assessment and recommends three additional sentries be added to the northwest perimeter.

If the scenario continued, it would merely add more detail regarding VIPERS's specific processes and outputs. The powerful system has integrated and automated the majority of planning, execution, and evaluation of military requirements. VIPERS freed human decision makers and empowered them to think creatively, unencumbered by the myriad of details which accompany complex operations. Some critics might argue that using artificial intelligence to assist in planning inherently creates a vulnerability because the machine is predictable. An alternate view is that humans are as likely as machines to have predictable decision-making and response patterns. Intelligent agents may help overcome this weakness. VIPERS's incorporation of AI does not subsume creativity, but instead improves the commander's capability by reducing or eliminating other taskings. VIPERS also adapts to the user's eccentricities rather than requiring the user to adapt to the system, as in today's systems.

As discussed in Chapter 2, synchronized support to combatants is critical to success. VIPERS generates this capability, puts commanders in control of processes, and is designed to avoid dependency on a separate "push" type intelligence/information architecture. VIPERS produces the type of "point answers" [4] commanders require during crisis planning.

All of VIPERS's users accessed the same "system of systems," but its displays and products were individually tailored. The NCA viewed Operation Zion from the strategic level; the theater CINC focused on operational concerns for planning, deployment, lodgment, and employment; while the security police commander used both tactical and administrative functions, in response to quickly changing conditions. VIPERS provided a comfortable human–machine interface in the overall process for all users.

The system supports demassifying the battlespace through its robustness at all levels of command. When fully operational, it should allow simplification of command structures and effectively reduce the number of planning and support personnel required. Coupling VIPERS's capabilities with new force structures allows information supremacy and addresses a significant constraint of the world envisioned in 2025. By using VIPERS, we will place fewer forces in harm's way: the system allows effective military action and deals with US citizens' intolerance of casualties. It also makes rapid victory possible in this high-tech environment.

Attributes and Measures of Merit

Why VIPERS? First, the observing and analysis feature of the system hardens friendly forces' OODA loop.[5] Plans, decisions, and actions occur rapidly and precisely with insight into the adversary's movements. In similar fashion, the observation, analysis, and prediction features of VIPERS reveal an enemy's weaknesses and possible intent. Finally, VIPERS removes safe havens from the enemy by extending the sensory and conceptual horizon of the war fighter, fostering a paralyzing tempo and inhibiting the adversary's ability to recover. VIPERS aids friendly forces in imposing chaos on the opponent.[6]

Throughout this paper, we have shown how VIPERS, using new conceptual frameworks and advanced technologies, will provide a significant improvement over the system of systems developing today. VIPERS is not just an omniscient system or a sophisticated war-gaming system; it is an architecture that uses common standards across intelligence, surveillance, and reconnaissance (ISR) and C^4I systems. It melds these systems with technology advances to produce uncommon capability. Some may argue that VIPERS may be a reality within 10 years; however, experience has shown that technology promises are rarely accurate. Given the fiscal constraints of today, as Negroponte argues, cost and funding will drive progress more than technological feasibility will.[7]

Measurable improvement is realized in the ability to survive, plan, decide, communicate, control, and integrate. VIPERS demonstrates survivability in terms of the percent of the network surviving after attack as well as the survival of any single node.

Planning is measured by effectiveness and efficiency. Effectiveness speaks to how the system enables the commander and staff to generate a plan in terms of congruence with objectives, feasibility of courses of action, and required logistics support. The effects of course of action simulation provide rapid feedback that allows anticipation on the battlefield. Effectiveness of operations improves through war gaming and automated "what if" analysis. Efficiency refers to how the system aids planners in accomplishing the planning task (i.e., time required, man-hours, etc.). VIPERS's visibility of assets and display of all-source intelligence reduce the time and effort consumed in chasing information essential for detailed planning.

Timeliness and quality are the defining measures of merit for decision making. VIPERS improves any decision with regard to speed, accuracy, and risk through the integration and inclusion of capabilities previously discussed.

The ability to communicate is measured, in order of importance, as reliability, security, connectivity, capacity, user friendliness, and human interaction. Reliability or data accuracy is the percentage of data received correctly from the sender. Security is the amount of data, as a percentage, protected by the system. Connectivity or interoperability is the percent of relevant knowledge. Capacity is defined as the size of the "pipes" in gigabytes per second. User friendliness describes the ability of the human to interact naturally with the system; further, user friendliness encompasses an element of human-to-human contact that is facilitated by the system. Interaction may take the form of the written word, voice, video conferencing, or mental telepathy.

Control speaks to the system's ability to track and task personnel and materiel. It is measured as the percent of assets visible to the commander. VIPERS significantly improves process control because it seamlessly integrates tracking of assets using MEMS technology, archived information, and high bandwidth communications between databases.

Integration combines speed, battlespace view, and correlation. Speed is judged with regard to arriving in time for integration into the decision process. Battlespace view refers to the percent of relevant data displayed. Correlation is the degree of agreement between the system and historical norms. VIPERS compares favorably with these criteria because of capabilities previously discussed.

System Countermeasures

VIPERS will be a natural center of gravity for a potential enemy and is susceptible to attack at the distributed databases, transmission sources, and projection/display system.

While we recognize that any inventive enemy can discover numerous ways to attack, what follows is a sample of what an enemy might do. First, the enemy can attempt to corrupt archived data, making the data incorrect or inaccessible. In addition, an enemy could attack the links between the databases, also denying access.

Secondly, false data can be interjected (deception), compromising our ability to observe and understand. For example, an enemy might cause VIPERS to provide an indication of no air threat when an enemy strike package is actually ingressing; insert information identifying enemy forces as friendly; or cancel orders for critical logistical support. Undetected false data would also be archived, further corrupting system integrity.

A third method of attack is exploitation. An enemy could surreptitiously intercept information of our plans or operations and use it to counter our actions. A historical precedent for this is the Allies' use of broken codes to help defeat the Axis powers during World War II.

A fourth avenue of attack would be the system's physical destruction. An enemy could attack a VIPERS node or selected nodes with a variety of weapons platforms, including precision guided munitions, ballistic or cruise missiles, or directed energy weapons.

Strategies to Counter Enemy Attack

Continued focus on education, leadership, and doctrine is paramount for the successful implementation of VIPERS. If allowed, VIPERS will tend to produce cognitive dependence in our future leaders. Leader training and education must counter this dependency, sustaining the capacity for decision making in the absence of VIPERS's capability.

VIPERS's integrated sensor architecture, as shown in figure 4-1, and distributed databases would require any enemy to possess the capacity for massively parallel and simultaneous attack. VIPERS, as a complex system, has no single-point failure and is inherently self-adapting. The expected low cost of bandwidth coupled with widespread massive databases prevents a single shot or a few attacks from crippling the system. This counter is similar to the capability of today's publicly switched network to reroute phone service throughout the nation.

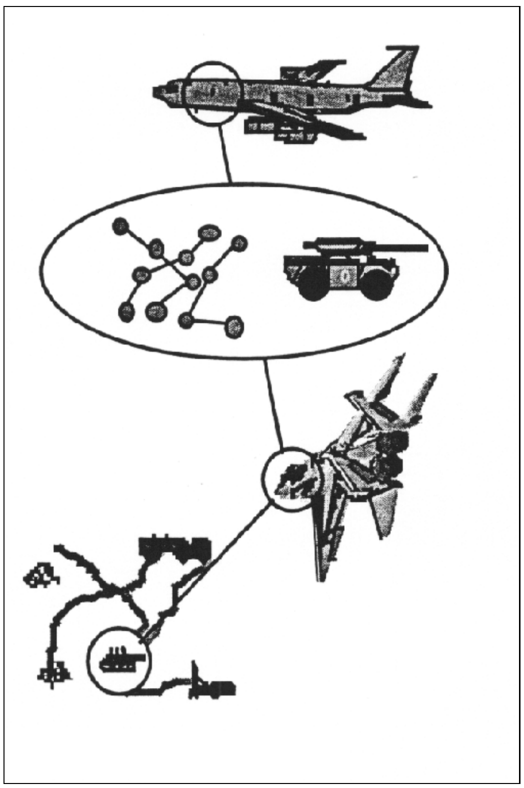


Figure 4-1. Integrated Sensor Architecture

Central to VIPERS's capability is the connectivity between distributed databases. In addition, VIPERS integrates and archives the output of numerous broadcast sensor networks. For example, MEMS programmed to sense seismic activity over a broad area would be difficult to interdict, due largely to the numbers employed relative to their very small size. Destruction or disruption of any sensor in the sensor field will alert the system that an attack or activity is in progress. Attempts to navigate the sensor field would also be detected, forcing the adversary to bypass known sensor fields, thereby producing yet another detectable signature.

The layering of VIPERS's databases produces a natural comparative environment within the archive. Each database must maintain a logical relationship over time and within historical, logical parameters. The intelligent assistant features of VIPERS assist and alert users to deviations from the chronicled or time-indexed norms.

Real-time data will also be compared: observation to observation and observation to archive. Comparative analysis minimizes the opportunity for an adversary to interject meaningless or false data into the OODA loop.

Use of fiber-optic links and cellular-packet technology, combined with the multiple frequencies and transmission mechanics between nodes and databases, will make it difficult for unauthorized users to extract information from the bit stream. Logical encryption will further complicate the extraction effort. Some data will come to the user naturally encrypted. Examples are SIGINT, photographic intelligence, intelligence analysis, logistical status, force status, and orders of battle.

By logical encryption, we are describing the encryption of the value-added portion of the decision cycle. There is no reason to encrypt data that is universally available, such as National Oceanographic and Atmospheric Agency weather data, or topographic and geodetic data. Under most imaginable circumstances, encryption of the output will be a necessary precaution. Encryption, a by-product of commercial enterprise, will form the backbone of military information security methodologies. Very large prime numbers provide the encryption basis for secure financial transactions in the future.[8] Systems using these very large primes--RSA 129 and greater--will likely safeguard military communications in 2025.

The last security topic is physical security. Recall that each individual will have a personal monitoring chip. Physical security to prevent unauthorized use of the projection devices or access to the VIPERS's databases will be a combination of personal status reporting (are you alive and still authorized?) and voice and thumb-print recognition. This capability will allow multiple authorized users access to the databases and projection capabilities of a single device. New user access (the operations officer, because his broke) will be accomplished by way of personal status reporting and iris/retina scan recognition to validate user authorization.

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4. 2025 advisor's meeting, Air University, Maxwell AFB, Ala., 24–26 March 1996.
5. John Boyd, "A Discourse on Winning and Losing," August 1987, Unpublished briefings and essays (Air University Library, Maxwell AFB, Ala., document M-U 30352-16, no. 7791), 5.

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6. Maj Glenn James, “Who Needs Chaos Theory,” in *Theater Air Campaign Studies Course Book* (Maxwell AFB, Ala.: Air Command and Staff College, 1996), 31.

7. Nicholas Negroponte, *Being Digital* (New York: Alfred A. Knopf, 1995), 31–35.

8. Bill Gates, Nathan Myhrvold, and Peter Rinearson, *The Road Ahead* (New York: Viking Press, 1995), 65.

Chapter 5

Investigation Recommendations

To fully develop the virtual integrated planning and execution resources system, further research and funding of key technologies is essential. The Air Force is aggressively pursuing many of the necessary technological advances for VIPERS. The problem is getting the various systems, which are currently developed in stove-piped manners, to integrate into a single whole. The commercial marketplace is driving the technological advancement of the future. The military must be more proactive and knowledgeable of commercial developers who provide the tools of tomorrow. It is more important for the armed forces to use emerging capabilities than to develop the technologies. In other words, the military must spend more effort in massaging commercial developments than in creating its own.

The Air Force needs smart, user-adaptive interfaces, supported by appropriate software agents, and display technologies such as large screen display and three-dimensional holographic systems. Intelligent agents must aid the human-machine interface. Research is being aggressively pursued by MIT, IBM, Navy Research, and Rome Labs in these areas, but requires further funding to foster long-term development. Image-understanding programs which will allow timely, seamless integration of intelligence into the system need a significant push in the military realm. More than anything else, though, we must integrate information system components into a system of systems that will support the goals, objectives, and missions of the armed forces.

Appendix A

Automated Analysis and Summary of Fusion Techniques

Method	Kernel Process	Character of Input	Character of Output	Range of Application
Classical	Pr (OBSV H_o)	Empirical probability population distribution for static	Pr (error declaration on H_o)	Relatively broad for single event (subjective Prob)
Bayesian	A posteriori Pr (evidence) (updates belief on H_o given new data)	Empir./Subj probability exhaustive definition of causes "A Priori" Pr (causes)	Updates likelihood of the occurrence of an event	Relatively broad but difficult when many casual factors, good for event analysis
Dempster/ Shafer	Pr (H_o mult. evidence) and Pr (and	Empir./Subj. probability exhaustive (Include. disj) Pr (H_1 evidence)	Updates likelihood of the occurrence of an event and level of uncertainty	Same as above
Fuzzy Set Theory	Set algebra where set elements have membership function	Subjective membership functions for all set elements	Profile of goal set elements and membership function	Decision analysis expert systems
Cluster Analysis	Sorting of observations into "natural groups" based on "similarity measure"	Parametric, subjective	Cluster elements and similarity measures	Broad but for vague category structures
Estimation Theory	"Best" state estimate for given observations (least squares)	Quantitative observations state/observ. model	State vector	Tracking, geolocation
Entropy	Computes measure of information content	Empirical or subjective probability	"Optimal" Pr	Relatively broad
Figures of Merit	Computes degree of similarity between two entities	Two attribute vectors	Numerical value of similarity	Broad
Expert Systems	Computer program to mimic human inference process	Observation data to support inferences	Declaration of inference	Broad for heuristic problems
Templates	Pattern matching technique for complex associations	Observed data records	Declaration that data supports (matches)	Situations, assessment, association

Source: Mona Toms and Gilbert Kuperman, "Sensor Fusion: A Human Factors Perspective," Research Report, (Wright-Patterson AFB, Ohio: Armstrong Laboratories, Air Force Systems Command, , 1991), 48.

Glossary of Terms:

Pr Probability of recognition

H_o Null Hypothesis

H_1 Positive ID Hypothesis

A Priori Evidence From cause to effect, deductive reasoning, decision made before full examination

A Posteriori Evidence From effects to cause, inductive reasoning, determining general principles from facts

Appendix B

Acronyms

CDC	Center for Disease Control
DMSP	defense meteorological satellite program
ELINT	electronic intelligence
FBI	Federal Bureau of Investigation
HUMINT	human intelligence
INTERPOL	International Criminal Police Organization (ICPO)
JOPES	joint operations planning and execution system
LANDSAT	land satellite (and earth imaging satellite system)
LOGSTAT	logistics statistics
MASINT	measurements and signals intelligence
NOAA	National Oceanic and Atmospheric Administration
PPBS	planning, programming, budgeting system
SIGINT	signals intelligence
SORTS	status of resources and training system
WHO	World Health Organization

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