Worldwide Information Control System (WICS)

A Research Paper
Presented To

Air Force ***2025***

by

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Disclaimer

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Contents

Illustrations

Tables

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Executive Summary

Information is crucial to warfare. To the war fighter, the right information at the right time and in the right format can be a tremendous military advantage. When information flows correctly it can provide a clear understanding of the developing operation. This allows commanders to make effective decisions and direct forces in a manner to meet specified objectives. Maintaining this order of battle requires a system for managing and communicating information. Today, the system is called command, control, communications, computers, and intelligence (C^4I) and is often seen by those who are familiar with it as inhibiting and unresponsive. This paper develops a concept for tomorrow's system: the Worldwide Information Control System (WICS). WICS can overcome the deficiencies of today's system and can provide a revolutionary command and control capability for military operations in the possible futures of 2025. It will be capable of automatically gathering data, processing it, and presenting useful information products to the users in time for them to take appropriate actions. WICS is designed to be flexible and responsive, adapting to 2025 technologies, and providing information products that are tailored to individual users.

Chapter 1

Introduction

There has been a lot of discussion about *what* is needed in a data fusion system. This paper answers the question of *how* by presenting an architecture for an information control system that can probably be fully operational by 2025.

The Problem

A military command and control system should provide the commander with a clear understanding of the developing operation so that forces can be directed in a manner to meet a specified objective. Such a system surveys the battlespace, assesses what actions to take, and uses available resources to implement those actions. Maintaining this order of battle involves managing and communicating information.

The current command and control system is basically an inventory function; keeping track of what assets go where and what the capabilities of each are all while maintaining communications among force levels. John Boyd's OODA Loop is a standard model for the decision-making process used in the current C^4I system.[1] OODA stands for Observe, Orient, Decide, and Act, the parts of a four-step framework for command and control.

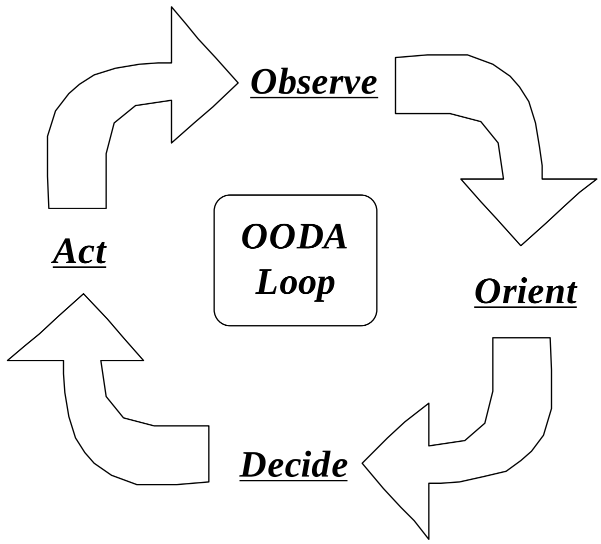

Figure 1-1. OODA Loop - A Paradigm for Command and Control

Unrestricted information flow up and down the chain of command has always been essential, as is apparent in the 1939 writings of Maj Gen J. F. C. Fuller.

> If intercommunications between events in front and ideas behind are not maintained, then two battles will be fought—a mythical headquarters battle and an actual front line one, in which case the real enemy is to be found in our own headquarters. Whatever doubt exists as regards the lessons of the first war, this is one which cannot be controverted.[2]

Even today the system is characterized as slow, incomplete, and unresponsive. Evidence of this is apparent as recently as Operation Desert Storm, where there were examples of a communications breakdown between intelligence gathering and command and control. For example, target information collected from United States intelligence systems had to be delivered to the theater by way of secure telephone.[3]

Many familiar with command, control, communications, computers, and intelligence (C^4I) procedures and capabilities view the current system as limited, unresponsive, and improperly utilized. During peacetime operations, data is poorly distributed and processed. Commanders are often forced to make decisions without access to all available data. The system is inefficient and often results in long delays in transferring vital data. During conflict, this problem is compounded because of limited communications at deployed locations and the confusion inherent in any mobility effort. C^4I channels become flooded because of the large number of sorties and special requirements for each type of weapon system. Airborne sorties in a rapidly changing environment are sometimes effectively cut off from their commanders.

Due to the present tempo of operations, a major frustration in the current C^4I arena is the knowledge that whatever information required is available but not accessible. Commanders cannot make well-informed decisions because they do not have the most current data from all possible sources. Present data networks do not allow for information to flow between all sources in a systematic and user-friendly manner. Commanders need to be able to assess any aspect of a situation they desire in a timely manner without being overloaded with extraneous data. Current C^4I systems such as the Worldwide Military Command and Control System (WWMCCS) provide decision makers with data. Commanders need to see this data after it has been processed into a logical, simple, recognizable, and complete format. Information may be defined as data that has been collected, systematically processed, and put into a format that is easily understood by the user. This process is known as *data fusion*.

The current system allows commanders to utilize only a fraction of the potential information sources. This problem exists because these systems exist as separate entities rather than as a cohesive network. The individual systems are poorly integrated and separately tasked, and their output supports separate user bases[4].

Recent improvements to the current C^4I system have expanded the type, quality, and distribution of information. At the same time, there have been dramatic advances in the speed and lethality of weapon systems. As a result, the decision maker is now forced to assimilate and act upon information in an even shorter time.

A Revolutionary Solution

As we have learned from experience, "Nearly always it is the evolutionary follow-on of a new concept that produces a revolutionary capability.[5]" In 2025, weapon systems will have advanced to the point where even today's third world countries may be capable of launching theater-range ballistic missiles and detecting aircraft that utilize current stealth technology. Access to space will be available to any country that can pay for it. Most countries will be on the same technological level in the war-fighting arena. With the technological edge diminished, the US must focus on developing ways to best gather and distribute vital information; on a global scale, in near real time.

The United States armed forces must develop a global information control system capable of automatically gathering data, processing it, and presenting the resulting information to the user in a concise manner. This system, the Worldwide Information Control System (WICS), would provide a means for global data collection, intelligent processing, and instant global communications with enough flexibility for both peacetime and contingency operations. The concepts of data fusion and a global information network may not be new, but the methods of implementing them are.

The key to implementation in the year 2025 will be to transform the current paradigm of Boyd's OODA Loop. Command and control in 2025 must go beyond the limitations of the OODA Loop. The time available to make critical decisions will be drastically reduced in the future. Fractions of a second will be critical in all aspects of a military campaign–not just the “fighter pilot scenario.” Because of this, the four-step OODA Loop must be refined into a more timely and automated process. A natural progression of the OODA Loop and the drive for in-time command and control information will require the military of the future to react faster than an opponent can operate its decision-making process.[6]

This was also discussed in “The Man in the Chair,” an Air Force 2025 white paper which describes how the OODA Loop has continuously shrunk throughout the history of warfare and will continue to shrink.[7] In the future, the OODA Loop will be transformed into a format where its four components will seem to occur simultaneously. Inherent speed and accuracy limitations in human information processing abilities point to the need for automation by a data fusion system that is capable of making decisions based on a global, cohesive information infrastructure. A human interface must remain in the loop to have a final “vote” in the decision process. However, a “smart” architecture will be essential to collect, filter, and disseminate the pertinent information in time for the war fighter to make well-informed decisions in a timely manner.

Such a system must continually perform the future equivalent to today’s “observe” and “orient” processes. When tasked, it should also be capable of expediting the “act” phase of the OODA Loop by providing in-time communications to commanders and war fighters. To the future war fighter, today’s OODA Loop will be reduced to decision making based on a condensed global representation of all pertinent information.

Current upgrades and improvements to the C^4I process are steps in the right direction but are evolutionary in nature and represent only a fraction of the capabilities of the system that will be needed by 2025. What is really needed is a revolutionary system that can assemble, maintain, and distribute information in time for the warfighter to make effective decisions.

The word "revolutionary" is often used when describing new or future war-fighting systems, but what does it really mean to be "revolutionary"? *Webster's New World Dictionary* defines revolutionary as "bringing about or constituting a great or radical change." When viewed in this light, few systems actually deserve to be called "revolutionary." Among these are the tank, the submarine, the airplane, the satellite, and perhaps a handful of others. Systems such as the global positioning system (GPS), while often spoken of as being revolutionary, are actually, upon closer inspection, evolutionary systems. For example, GPS evolved from the US Navy's Transit positioning satellite system, which itself is an evolution from shore-based radio navigation systems and techniques. What is revolutionary about GPS is the *capability* it unlocked. WICS itself may be considered an evolution of current C^4I efforts, but by providing the "God's eye view" commanders have always longed for, it would bring about a revolution in the manner in which forces are managed.

Notes

[1] Jeffery Barnett, *Future War: An Assessment of Aerospace Campaigns in 2010* (Maxwell AFB, Ala.: Air University Press, 1996), 6–7.

[2] J. F. C. Fuller, *Infantry in Battle*, 1939, as quoted in Peter G. Tsouras, *Warrior's Words: A Quotation Book* (London: Arms and Armour Press, 1992), 94.

[3] D. A. Fulghum, "Glosson: U.S. Gulf War Shortfalls Linger," *Aviation Week & Space Technology*, 29 January 96, 58.

[4] Barnett, 109.

Notes

[5] 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), 13.

[6] Barnett, 6–7.

[7] Clarence E. Carter, et al., "The Man In The Chair: Cornerstone of Global Battlespace Dominance," Air Force 2025 draft white paper, 11 March 1996.

Chapter 2

Information Control in 2025

> *We must remember that science and science fiction are related only superficially.*
>
> —Air Force Scientific Advisory Board, *New World Vistas*

It is very difficult to accurately predict the operational environment of 2025. The technological advantage that US weapon systems have enjoyed is decreasing due to the proliferation of technologies to the commercial sector and to other nations. Former or potential adversaries are gaining access to space and ballistic missile technologies, and they are starting to use information systems like the Global Positioning System (GPS) and commercial remote-sensing surveillance systems such as the French system probatoire d'observation de la terre (SPOT). Because information is essential to fighting wars, the upper hand in future conflict may belong to the nation that does the best job utilizing and controling the information flow.

Due to the unpredictabiltiy of the future environment, it is very difficult to determine what tools must be developed to meet information control requirements. Instead, it is more important at this stage to develop an architecture that is able to operate effectively in a number of technological scenarios. This will allow changes in the geopolitical environment, technological advances, and operational needs to dictate the specific tools that will be developed in the next 30 years.

Required Capabilities

The key system drivers for a military information control system would most likely be the demands for coverage, mobility, timeliness and security. Figure 2-1 summarizes the mission need statement for a comprehensive global information control system. Mission objectives and top-level mission requirements are then derived from the mission statement using an using an established systematic design approach as described by Larson and Wertz.[1] The mission objectives are presented in figure 2-2.

Mission Need Statement
Putting timely and accurate information in the right hands can be a tremendous advantage during war. The United States needs to develop a system to globally collect, process, and present useful information from multiple sources to the war fighter in near real time. This system should also allow for secure worldwide communications. The information products must meet the unique timeliness, mobility, and security requirements of military users at all levels, including the individual.

Figure 2-1. WICS Mission Statement

Mission Objectives
Primary Objective: Gather, process, and present "in-time" information to military users
Secondary Objective: Provide uninterrupted, secure, global communications for military forces

Figure 2-2. WICS Mission Objectives

Top-level mission requirements for WICS can be derived from the mission objectives.[2] Functional requirements define how well the system must perform to meet its objectives; operational requirements describe how the system operates and how users interact with it to achieve its broad objectives. Constraints are limitations imposed by shortfalls in a system architecture or an outside agency. These requirements will drive the system design.

Table 1

WICS Top-Level Mission Requirements

WICS Top Level Mission Requirements	
Functional	
Performance	Optimized resolution, high bit rates
Coverage	Global coverage, near continuous coverage, mobile targets will require wide area searches
Responsiveness	High percentage of users connected with “in time” updates
Operational	
Availability	100 % available
Survivability	Natural and man-made threats
Data Distribution	Mobile, wireless access from anywhere on globe
Data Content, Form, and Format	Information tailored to individual user
Constraints	
Cost	Must be affordable
Schedule	Fielded and operational by 2025
Regulations	International frequency allocations?
Interfaces	Must function with existing (in 2025) systems

Due to the vast quantity of data that will be available from many sources, commanders and war fighters will need a system capable of collecting, processing, and presenting useful information in a timely manner and of providing secure global communications. Information must be presented to a user located anywhere on the globe in time to make meaningful decisions. Advances in information collection and transmission technologies are progressing rapidly. Properly utilizing information will give forces a tremendous advantage in future conflicts. Failure to develop an information control system that includes necessary processing will likely result in information overload, where individuals will not be able to decipher pertinent information from extraneous data and it will become impossible to make rapid, well-informed decisions.

Data Collection and Processing Requirements

Data is currently acquired through many separate sources. Each source operates independently, and in-time access to worldwide, complete C^4I information is not available. There is not a comprehensive system to collect, process, and present the information. For an advanced system to be properly fielded, each individual collection source must be capable of sending information back and forth. This will require future data collection systems to include a common communications package.

Additionally, a comprehensive information control system must be capable of processing data from many different collection points simultaneously. This parallel processing will occur using data from conventional sources such as airborne platforms and space-based imagery, as well as advanced technologies that will be available by 2025. These follow-on systems must be designed to interface with the new information control system.

Artificial Intelligence Requirements

To process data in near real time, it will be necessary to field a system with artificial intelligence (AI) capabilities. Figure 2-3 shows the basic elements of AI (located on the wheel hub) and the corresponding applications (located on the wheel rim). AI is a challenge that must be overcome by a future information control system, especially when considering AI's relatively slow progess in the past 30 years. Machine vision applications could be used to automatically interpret and analyze images (e.g., automatically detecting and identifying potential targets). Problem-solving applications could be used to process multiple source redundancies by passing them through a "data divergence" filter. Conflicting data will be transformed into information, assuring confidence without redundancy. In addition, data from different sources must be compared as a validity cross-check before the redundant data is removed from the information flow. If there is a discrepancy in acquired data, the system must be capable of realizing this and either comparing the data with additional sources or judging the confidence level of the sources to determine which is likely to be accurate. Expert systems applications should be used to prioritize information (i.e., determine what information is critical). And finally, natural-language processing should be used to enhance user-machine interfaces.

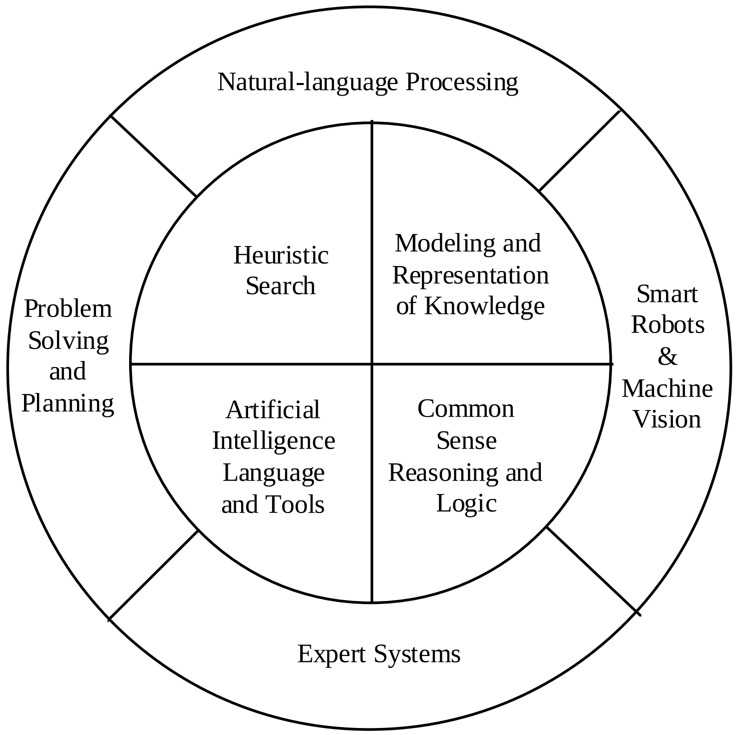

Figure 2-3. Elements of Artificial Intelligence

Once data is filtered, it must be automatically sorted by level of interest. All users of an intelligent information control system will not require the same fidelity of information. Clearly, theater commanders and troops in the field will have vastly different demands for the system. To work efficiently, a system of this type must be able to recognize the user and determine what level of fidelity is required. The system must be able to automatically adjust the data product to meet the needs of particular users. At the same time, the user must retain the ability to customize data requests. Giving the system the ability to sort data is vital if individuals at various levels are to avoid "information overload."

The white paper "Information Operations: Wisdom Warfare for 2025" discusses the "models, simulations, software agents, predictive decision aids, planning and execution tools, and archival methods" that must be incorporated in a WICS architecture.[3] Methods such as Markov chains, the fuzzy cognitive map, and chaos theory are on the leading edge of research in the data-processing arena. Advances in these fields must occur and will define the information processing algorithms for WICS.

Presentation Requirements

After data has been collected and processed, it must be effectively presented to the user. This will likely be one of the most difficult technological aspects of the information control system. A challenge for future computer systems will be transferring the burden of interaction from the user to the computer[4]. Every user has unique requirements. As a result, it will be necessary to present information in many different ways. At the highest levels, national command authorities (NCA) must be able to access a database of worldwide information. The database should provide a virtual-reality representation of any geographic region of interest. Additionally, it must be suitable for in-time decision making and for war gaming a number of possible scenarios. Ideally, this should be coupled with war simulation capabilities to allow commanders to see the likely outcomes of their decisions, based on historical data, before they issue a tasking order.

The system for theater and battlefield commanders should essentially be a specialized subset of the capabilities at the NCA level. Information must be condensed to allow for adaptation to dynamic local conditions. The greatest benefit will be derived by using this information to create a virtual battlefield. The theater-level, data-collection system should allow joint task commanders to view a battlefield in near real-time with a high level of fidelity. By being able to visualize the compilation of immense quantities of information, commanders will be able to make well-informed, time-critical decisions.

A very different type of information presentation system will be required for the unit level C^4I operations. The operational information control system must be capable of providing information on many different levels. For instance, a unit based in the continental United States may need to see a projected worldview to determine where airborne sorties are located on an overseas flight while simultaneously showing a virtual image of the local traffic pattern to another local user. The output device may not appear very different from the Global Command and Control System (GCCS) that is now being phased in. In fact, this epitomizes what should be a key goal in designing a new C^4I system: The infrastructure of the system and its data-processing techniques must remain transparent to the user.

Additionally, units must have a user station that is portable and can be used reliably in a combat environment. The system must be capable of operating from many different platforms, including aircraft, ground assault vehicles, naval vessels, and the individual user. It must be durable, secure, lightweight, and simple to use. This will require additional data-processing and refinement techniques beyond those required at the NCA and theater levels. WICS must be able to tailor information at the receiver end to satisfy individual needs and preferences.

Communications Requirements

Data collection, processing, and presentation do not constitute a complete information control system. The other component needed is communications. An effective future information control system must give military users the ability to receive and transmit vital information anytime and anywhere. Regardless of the method, the system must satisfy obvious needs for global, mobile, secure, and redundant coverage must be satisfied. Without a comprehensive, reliable communications system, the rest of the information control network will be useless.

Notes

[1] W. J. Larson, and J. R. Wertz, *Space Mission Analysis and Design*, 2d ed. (Microcosm, 1992), 12.

[2] Larson, 14.

[3] "Information Operations: Wisdom Warfare for 2025," Air Force 2025 draft white paper, 11 March 1996.

[4] Nicholas Negroponte, *Being Digital*, (New York: Vantage Books,1995), 92.

Chapter 3

System Description

The best way to describe WICS is to separate the system into its functional components. There are four basic components to WICS: *Data Collection*, *Data Processing*, *Information Presentation*, and *Communications*. Data collection involves all activities where data is collected. Processing is the element of the system that transforms data into useful and recognizable information. Information presentation involves the military user's ability to access information; it is the interface between the processed information and the user. The communications element involves all chain-of-command communications, the transmission of information from the system to the user, and feedback from the user to the system.

Data Collection

The timely access and global coverage advantages of space-based platforms will be particularly important in satisfying the demand for "in-time" information. WICS will use a constellation of low earth orbit (LEO) satellites, called ***LEO Harvesters***, to gather and preprocess the data from a number of existing (in 2025) space- and ground-based data-collection sources. The sensors themselves could be commercially developed and operated as predicted by *New World Vistas*,[1] or they could be owned and operated by the government. In 2025, data-collection systems will most likely be some combination of military and commercial.

The individual data-collection systems will be operated and controlled independently of WICS but they will be "plugged into" WICS by dumping the data they collect to the LEO Harvesters. It is anticipated that in 2025 these individual systems will include the general categories of weather, navigation, surveillance, and reconnaissance. Additionally a "self awareness" system could be implemented that would function as a space-based military traffic and logistics control system and would keep track of all friendly systems. An "enemy tracking" system could keep track of enemy assets, activities, and maneuvers.[2] The basic concept of WICS data collection is summarized in figure 3-1.

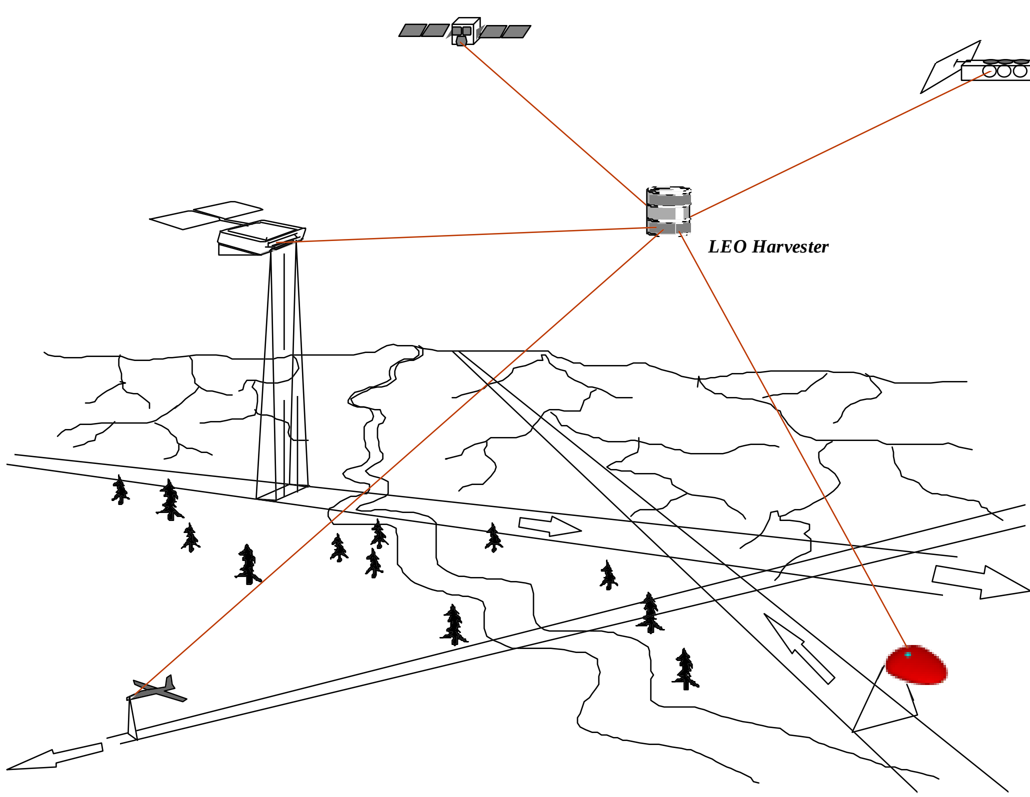

Figure 3-1. WICS Data Collection

The LEO Harvesters will receive periodic data updates from the individual collection systems via secure laser communications links. A laser communications system will be used because of its potential for increased bandwidth and security.[3] Lasers can offer increased data rates on the order of billions of bits per second. The increased security is a consequence of the smaller beam divergence angles, which make the signal more difficult to intercept.[4] Also, communicating at optical frequencies will inherently involve smaller components.[5] For transatmospheric links, one of several infrared (IR) wavelength bands can be chosen that fall within "spectral windows" that have a reasonably high atmospheric transmissivity (see table 2). Spectral windows also exist at other wavelengths. Visible bands (0.4-0.7 µm) will be avoided to maintain options for covert operations. Low-frequency signals should be avoided because they correspond to lower energy levels, resulting in an increase in atmospheric attenuation.

Table 2

Infrared Spectral Windows

Window	Percentage Transmission
1.1 - 1.2 µm	84
1.2 - 1.3 µm	80
1.5 - 1.8 µm	77
2.0 - 2.4 µm	80
3.5 - 4.0 µm	85
4.6 - 4.9 µm	40
8.0 - 13.0 µm	72

The type, quality, and quantity of data collected will depend on the capabilities of the individual collection systems. It is also possible that data-collection systems that exist today as independent systems could be combined in 2025 to form a multimission sensor (e.g., weather and reconnaissance combined). Regardless of what the individual collection systems look like, they will need to be only modified slightly to be compatible with WICS. They will each need to be equipped with a laser transceiver system, and each must be programmed to periodically "dump" their data to the LEO Harvesters via the laser link. When new collection systems come on line they can easily be "plugged into" WICS.

Remote-sensing satellites will not be the only means of acquiring information. Other data-collection sources will include standard intelligence operations (e.g., human intelligence, communications intelligence, etc.), unmanned aerospace vehicles (UAV) and remotely piloted vehicles (RPV), unattended ground sensors (UGS), sensors on weapon systems, and possibly other systems, depending on what is available in 2025. A summary of possible 2025 data-collection systems is given in table 3. Data collected from terrestrial systems may be periodically uplinked to the LEO Harvesters via a laser communications link.

Table 3

2025 Data Collection Systems

SYSTEM	DESCRIPTION
Weather Satellites	Terrestrial and space weather
Navigation Satellites	Near-real-time-accurate position information on all military craft and weapons (bombs, etc.)
Surveillance/Reconnaissance Satellites	Intelligence collection
Self-Awareness System	Space based system that provides craft information (location, fuel, ordinance, health, maintenance records, etc.) and crew information (casualties, supplies, morale, etc.)
Enemy Tracking System	Enemy ship, aircraft, and troop movement, launch detection, target identification.
Terrestrial Data Collection	UAV, RPV, intelligence operations, UGS

Data Processing

On-orbit data processing is needed to quickly reduce, analyze, and format the vast amount of data that will be collected and to transform it into information that can be distributed and used. Processing data on-orbit will save much-needed time. Given sufficient technological advances (see chap. 5), ground-based processing, storage, and analysis will not be needed in 2025. Satellites today are used in a "bent-pipe" fashion in which data is collected and transmitted to ground stations for processing. This takes time. In 2025 this bent-pipe paradigm will be eliminated and processing will be done on board the satellites for faster delivery to the user. Basically the processors used by WICS will transform all of the collected data into information, the distinction being that information is the usable subset of the data (fig. 3-2).

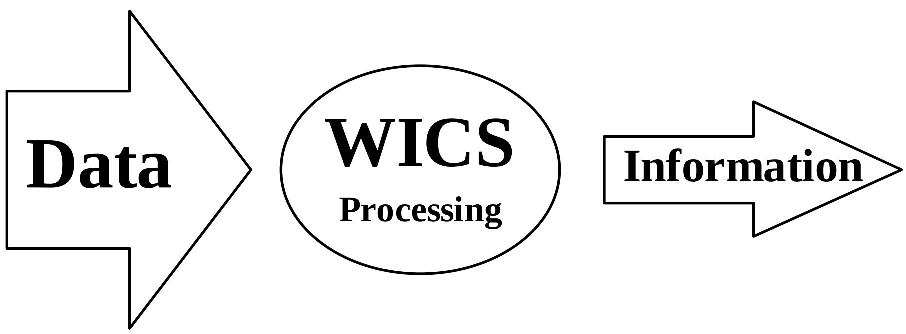

Figure 3-2. WICS Processing - "Data in and Information Out"

WICS has two options for the processing: geosynchronous orbit (GEO) processing or low earth orbit (LEO) processing. GEO processing will occur in the following manner. After the LEO Harvesters gather and preprocess the data from the individual collection systems, they will uplink the data via a secure laser communications link to one of a number of GEO processing satellites, called ***GEO Processors*** (fig. 3-3). The GEO processors will have massive computing capabilities, and their positions in GEO will give global coverage with only a small constellation of satellites.

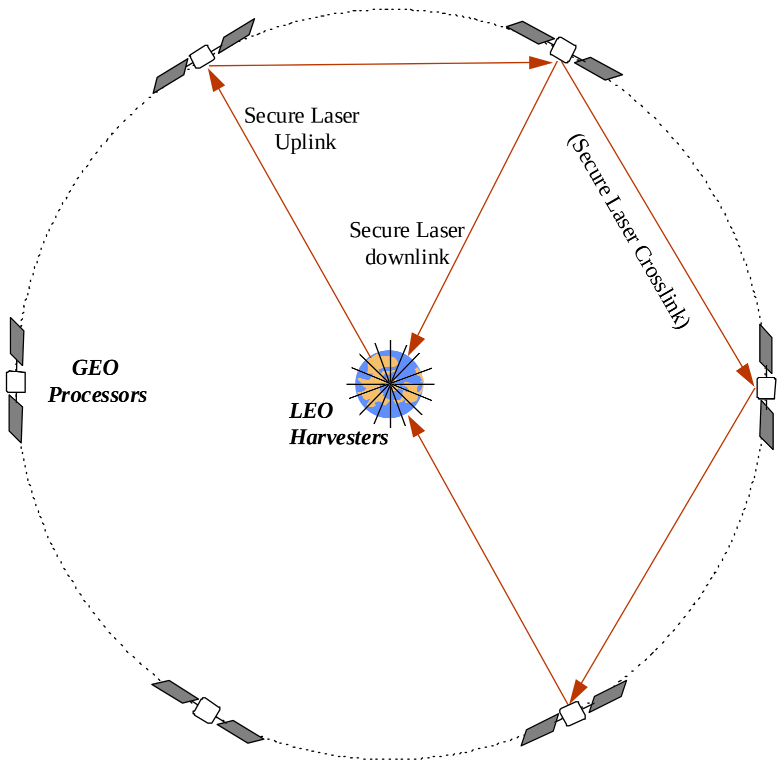

Figure 3-3. GEO Centralized Processing Alternative

With sufficient advances in distributed processing technology, the LEO Harvesters could be used in a networked fashion to process the data and transmit the information product to the user base. To maintain coverage, many more satellites will be required for LEO-based distributed processing. This alternative is demonstrated in figure 3-4. One disadvantage of processing at GEO is the introduction of about a quarter second time lag for the signal to travel there and back. Regardless of the location of the processing, software updates to space-based processing satellites can be made easily, but it will be more difficult to replace hardware as it fails or becomes outdated. A cheaper and more responsive satellite development and launch system, therefore, will be necessary to provide the ability to easily and cheaply field and replace satellite systems as the hardware fails or becomes outdated. A summary of some of the trades associated with processing at LEO or at GEO is provided in table 4. The direction chosen will largely depend on the state of the art in processing technologies and also on the responsiveness and economy of spacelift capabilities in 2025 (i.e., our ability to field, support, and replace space systems).

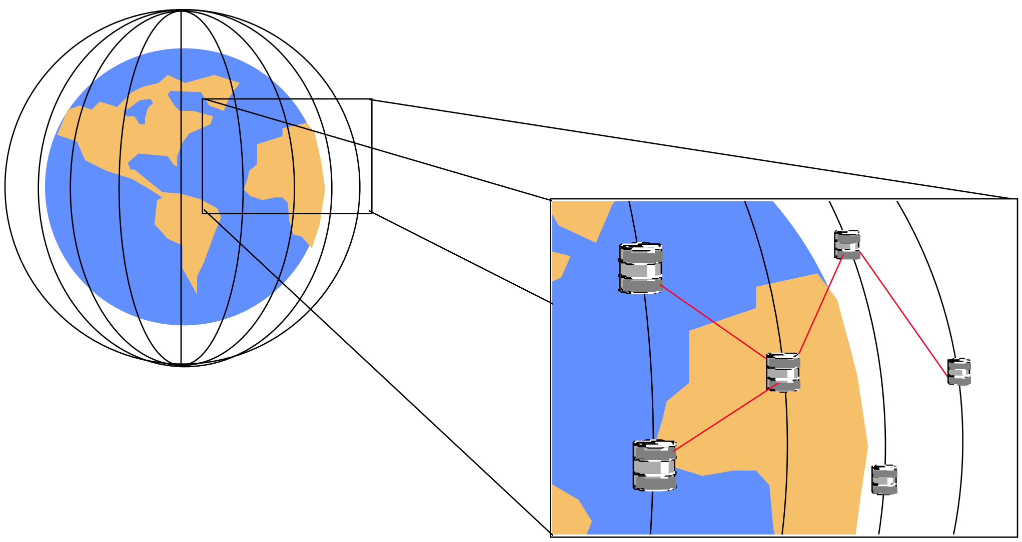

Figure 3-4. LEO-Distributed Processing Alternative

Table 4

LEO-Based versus GEO-Based, On-Orbit Processing

LEO Distributed Processing	**GEO Centralized Processing**
Advantages • Shorter transmission time • Negligible range loss • Easier to replace hardware as it becomes outdated • Faster processing • Greater processing capacity • Large network provides system robustness	Advantages • Fewer satellites needed for coverage • Easier to control • Easier to integrate data[6]
Disadvantages • More satellites needed for coverage • Complicated cross linking • Larger, more complicated LEO Harvester	Disadvantages • 1/4-second time lag • Larger transmission losses (1/Range) • Need more powerful transmitters

Artificial intelligence (AI) will be used by the processing satellites to decipher duplicate or erroneous information; it will also act as a smart switchboard to determine and relay critical information to critical assets and to ground centers for further processing. AI will be used to create and prioritize information structures from the synthesized data. This will give WICS the ability to automatically determine what is critical and "tap" the user on the shoulder when there is trouble. An example of critical information would be updates on the positions and velocities of enemy aircraft or ballistic missiles. This information would be downlinked to the appropriate defensive systems.

A challenge for WICS will be to process the data from each individual system while keeping track of the separate applications and user requirements. Processing is very application dependent. Surveillance systems, for example, will require image processing to automatically detect and track potential targets. Here, a spectral "directed vision" concept could be used that would combine a low-resolution rapid area search to detect targets and a higher-resolution secondary system to interrogate reported target locations.[7]

In addition to the processing done on-orbit, more in-depth human analyses may also be required. For this reason the data from the processing satellites will be downlinked periodically, or upon request, to ground-based processing centers for further analysis. Also, the system will be flexible enough so that the format of the processed data can be easily modified to meet changing user requirements.

The next step is to get the information from the processors to the users. There are two ways that WICS can make this happen. The first is a direct link from the processing satellites (either LEO or GEO) to critical assets to update critical data as it becomes available. The second way the information will be presented to the user is through the battlenet, a streamlined, computer-based, networked information data base similar in concept to the internet. Battlenet will manifest itself in different forms depending on the type of user. All users will have free and open access to the information. Information deemed critical will be updated automatically. Other information can be accessed on a self-serve basis.

Information Presentation

Different types of users will have different kinds of information and mobility demands. The main user classes will be the NCA, theater commanders, battlefield commanders, and the troops. A common attribute of popular information systems is that user appetite often exceeds the system capacity. The result is often an overburdened, unresponsive, and clogged system. To avoid this problem battlenet users will access the system through one of many distributed “mirroring sites.” These sites will be located at the battlefield level. Because they would be maintained in a distributed manner, there would be less demand on a single transmission path, thus minimizing bottlenecking. Stationary sites can be connected by fiber optics, which can provide extremely high bandwidth. Mobile platforms and individuals can tap into the WICS communications network that will act as an “internet in the sky.”[8]

At the NCA level the information flowing into the battlenet will be part of a larger war room environment. Battlenet information will support a number of activities including strategy development, battle management, keeping track of foreign and enemy capabilities, getting the latest in strategic intelligence updates, offering the means for secure worldwide communications. The battlenet will also give the NCA the ability to conduct high-fidelity war simulations and the capability to watch the war as it happens using a combination of real and virtual data.

At the theater commander level, battlenet will be an integral part of command center operations. Here, theater and battlefield commanders will use its information resources to select targets, conduct near-real-time battle damage assessment, track enemy maneuvers, and keep tabs on the weather. A virtual battlespace will be automatically updated to let commanders “watch” the conflict, make decisions, and implement them as necessary. Data collected and processed by WICS will be used to update terrain maps, targets, and structures in the virtual battlespace.

At the troop level the battlenet will be implemented as the personal interface card (PIC), a do-it-all credit-card-sized computer similar to the “wallet PC” envisioned by Bill Gates.[9] It can also be plugged into a weapon system, much like an automated teller machine (ATM) card, effectively making the weapon system an extension of the user, which will customize the weapon system to meet the individual user's needs and capabilities. PIC will update airmen, sailors, soldiers, and marines on their positions, update their weapon systems on the locations of targets, locations of service support (e.g., close air support), and provide a communications link. The layered information access requirements are summarized in table 5.

Table 5

User Information Requirements

NCA	Theater CC/ Battlefield CC	Troop
• Strategy • Battle Management • Enemy/Foreign Capabilities • Intelligence Information • Secure Communications • Virtual Battlefield (Simulation)	• Target Selection • Battle Damage Assessment • Enemy Tracking • Weather • Imagery • Near-Real-Time Battle Plan Updates • Virtual Battlefield (Simulation/Training) • Secure Communications	• Navigation • Situational Awareness • Targeting • Troop/Craft Management • Enemy Tracking • Secure Communications

PIC will add to the tailoring WICS gives to different user classes by acting as an *interface agent*. A concept described by Nicholas Negroponte, interface agents are located at the receiving-end computing platform and will have the ability to recognize and present the data product in a manner that is most effective for a particular user.[10] The user and interface agent will have a symbiotic relationship that will build with each new shared experience. The use of interface agents is different from today's paradigm. The situation today is characterized by "dumb" computing systems that do not recognize or understand the needs of a particular user. In 2025 computers will know you much better. The agents will remember a user's specific needs and recall how those needs change under different circumstances.

Communications

WICS will handle data/information and voice communications differently. As previously mentioned, the transfer of information between collection systems and the LEO Harvester satellites, between satellites, and from satellites to the mobile users will be done through secure laser communications links. Voice communications up and down the chain of command will be handled through the use of commercial telecommunications satellites. There are many LEO communications systems currently being developed that should be operational by 2010. By 2025 these systems should be fielding their "block II" systems. Also, negotiations are under way today to equip these space-based networks with capabilities for laser communications.[11] The Defense Department could negotiate to have secure military communications compartments on board. Near-real-time, two-way secure communications are needed at each user layer to communicate up and down the chain of command.

The idea of incorporating a commercially owned and operated communications satellite system into a military architecture raises the problem of the satellite system's becoming a potential target for an enemy antisatellite (ASAT) weapon. The "blackhull versus grayhull" problem, as it is commonly called, is neither new nor unique to space systems. There is a real possibility that the owner of a commercial or civil "grayhulled" satellite system, fearing its destruction, would not allow it to be turned into a "blackhulled", -- thus targetable–military asset by placing a military payload onboard. WICS could avoid the problem by employing a dedicated system, identical to the commercial system but owned and operated by the military. Not having to share the system with the commercial/civil community has obvious advantages in terms of available capacity and communications security. The drawback to a government-owned communications satellite system is that the military would incur system operations and maintenance expenses rather than merely paying for the development of a military payload and a "user fee." Another option is to take the opposite approach. The military could utilize the commercial system "as is," without relying on separate satellites or specialized payloads. This approach--the "hide in the weeds" option assumes the level of secure communications a commercial company would require is good enough to satisfy military requirements. While this is probably the least expensive option, the problem arises of maintaining the integrity of a secure network used concurrently by nongovernment entities. In addition, if knowledge of military use of the system reached an ASAT-capable enemy, it may become a target regardless of whether the system is wholly, partially, or not at all owned by the government.[12]

Table 6 provides a summary of the revolutionary capabilities that the Worldwide Information Control System provides in contrast to the evolutionary path currently being pursued.

Table 6

WICS System Summary

C4I Evolutionary Path	WICS Revolutionary Path
Collection • Improved individual systems • Multispectral imaging • Improved spatial resolution	**Collection** • Harvest data from existing (in 2025) systems • Hyperspectral imaging • Spatial and spectral resolution
Processing • Terrestrial centralized processing • Human filter • Smaller computers	**Processing** • On-orbit distributed networked processing • Directed-vision target detection and ID • Credit-card-sized computer (PIC)
Presentation • Dumb receiver • User friendly	**Presentation** • Interface agents • User-computer symbiosis
Communications • Less than 10 Gigabits per second • Radio Frequency communications	**Communications** • 40 Gigabits per second • Laser communications (data, images, video) • Commercial telecommunications (voice)
Operations • Joint force operations • Condensed OODA loop	**Operations** • Fully integrated operations • OODA point

Countermeasures

Like every other major advance in military technology, from the flintlock musket to the supersonic fighter, opposing countries will tend to develop similar systems in parallel and also look for ways to exploit the weaknesses of their enemy's systems. One possible countermeasure for WICS is an enemy ASAT that could take out satellites, ground segment, and/or satellite-to-ground links. ASAT tactics can take on many different forms, including active shoot/downs, jamming, communications interference, laser blinding of sensing platforms, and induced electromagnetic anomalies. ASATs are a concern because

WICS will depend heavily on the use of satellites for data collection and processing. The use of large constellations of microsatellites would diminish the effectiveness of any type of practical ASAT weapon. The large number of satellites would provide redundancy and replacements could quickly be launched (given a responsive launch system). A ground-based backup system for processing the data will allow the flow of information to continue if the processing satellites fail or are attacked. The information baseline provided by the battlenet will not be affected except in the frequency of its updates. The satellites themselves can be protected through signature-reduction techniques, maneuvers, and other options to make them difficult to find, and/or an active threat-mitigation system (e.g., a space-based laser follow-on to airborne laser). Link disruptions will be mitigated because of the small beam divergence angles inherent with laser communications. This will allow for pinpoint delivery of the message (uplink, downlink, or cross-link). Additional message interception mitigation techniques like frequency hopping could also be used. On-board processing, autonomous satellite operations, and distributed user terminals will reduce the need for a centralized (i.e., exposed) ground system.

Another countermeasure facing WICS is an adversary's use of the system to enhance its own war-fighting capabilities. Because the side that best controls information in 2025 will have a distinct advantage, an adversary may be more interested in using the system than in disabling it. Undeterred access to the data from a fully functional database may be far more valuable to an enemy than disabling the system. Information-control technologies must rapidly evolve with the system as an answer to this threat. The key will be to design a system that can easily be adapted to negate countermeasures. Employing denial tactics can introduce errors or completely deny use of the systems to all who attempt to access the information without the proper access codes or keyed terminals. The use of laser communications will also help to prevent unwanted users from tapping into the system.

Notes

[1] 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), 10.

[2] Collectively these two systems will solve the friendly-fire problem. For example you could incorporate a system in a fighter that would (through the use of WICS) automatically be able to distinguish friendly assets from enemy assets and restrict fire mechanisms when a friendly asset is targeted.

[3] J. Frascinella, "Laser Bridge Across the World," *New Scientist*, 17 June 1995, 25.

[4] Morris Katzman, ed., *Laser Satellite Communications*, (Englewood Cliffs, N. Jersey: Prentice-Hall Inc., 1987).

[5] R. M. Gagliardi and S. Karp, *Optical Communications*, 2d ed. (New York: John Wiley& Sons, Inc., 1995), 3.

[6] *New World Vistas*, summary volume, 43.

[7] M. R. Whiteley, "Non-Imaging Infrared Spectral Target Detection", Air Force Institute of Technology, masters thesis, 1995.

[8] Carol Levin, "Competition Intensifies for Satellite Networks," *PC Magazine*, 12 March 1996. Available from http://www.zdnet.com/pcmag/issues/1505/pcm00011.html

[9] Bill Gates, *The Road Ahead*, (New York: Viking, 1995), 74.

[10] Nicholas Negroponte, *Being Digital*, (New York: Vantage Books,1995), 150.

[11] Frascinella, 25.

[12] The "blackhull versus grayhull" problem was initially brought to the team's attention during the 2025 Advisors' briefing on 25 Mar 96.

Chapter 4

Layered Access

In its broadest sense, WICS will be employed as a three-tiered command, control, and communications system. Each fundamental tier is configured to the user level. At the top tier, the “strategic” level, the users will be the senior authorities based out of Washington, D.C. At the middle, the “operational” level, the users are the theater and battlefield commanders. At the lowest, the “tactical” level, the users are the smaller, division/ship/aircraft wing-sized units and their components. This in no way means the system is restricted to operating at specific levels of command. The strategic, operational, and tactical labels are used merely to describe, in the broadest sense, the type of information available. WICS will be, to the greatest extent possible, an open system, accessible to all legitimate users. Even if current titles and organizational structures such as “national command authorities,” “theater commander in chief,” and “joint force component commander” no longer exist in 2025, the fundamental strategic, operational, and tactical levels of command will continue to exist.

For purposes of system control, WICS can be divided into three components: the LEO Harvesters, the battlenet, and the communications system. The satellites that make up the constellation of LEO Harvesters will, for the most part, operate autonomously of traditional, ground-based satellite command and control. This is not to say that satellite controllers will have no role in WICS operation. Rather, tasks such as station keeping, momentum dumps, and other routine tasks will be self-initiated. The LEO Harvesters will transmit periodic "state of health" reports, but will continuously monitor their own health and will be able to compensate automatically for common anomalies. WICS will alert ground controllers when unusual events occur; for instance, when a satellite is nearing the end of its life and needs to be replaced. If GEO processors are used to process the data, they will be controlled in a similar manner. The battlenet will be managed by a team of information management specialists. These individuals will not have direct control over what information is sent to whom. Their purpose will simply be to monitor and maintain the battlenet's operational status and make changes as necessary. The third component of WICS, the communications system, will be controlled by its commercial owners, or if a military-adapted version is procured, in a manner similar to its commercial counterpart.

Tactical Layer

At the tactical level, all personnel will carry a standard-issue personal interface computer (PIC). This device will link every soldier, sailor, airman, and marine, and give them access to a wealth of information via the battlenet. Through the PIC, all personnel will have access to basic information such as position, digitized maps, locations of nearby friendly and enemy forces, and the like. The PIC will also be a personal communications device, enabling individual troops to remain in contact with each other, their superiors, and their subordinates. In an emergency, the device could be used as a beacon to facilitate search and rescue operations. The PIC could be voice activated, use a miniature alphanumeric keyboard, or both. The idea is "to put one in every soldier's pocket, in every pilot's flight vest."[1]

In addition to the standard-issue PIC, commanders at the tactical level will be equipped with a larger and more capable version. These units can be carried by individuals or mounted inside command vehicles. This device would have all the capabilities of a standard PIC, but would allow commanders access to a greater variety of information, such as battle plans and logistics information. Commanders could request supplies, transmit unit status, report on the progress of operations, and so forth. By incorporating AI-based learning algorithms and common-sense reasoning and logic, WICS could automatically filter information gleaned from the battlenet and tailor it to suit the commander's needs. For example, by knowing its precise location, the device would screen out troop movements that are not within a certain radius of its position. This avoids the commander's having to wade through irrelevant information to get to what they really need. Of course, the commander would be able to query the battlenet for information not automatically provided.

In the air, WICS would be an integral part of the aircraft's communication and navigation system. A transceiver mounted in the aircraft's electronics will automatically and almost continuously transmit the aircraft's coordinates to its controlling air operations center. WICS would also be wired into the aircraft's health-monitoring systems. Data such as fuel stores, weapons stores, on-board cargo, and so forth, would be transmitted as well. Unmanned Aerospace Vehicles (UAV), both combatant and noncombatant versions, would be continuously and automatically fed navigation information, targeting data, and anything else they need to complete their mission. Simultaneously, WICS would monitor the status of aircraft systems, automatically alerting ground facilities of the presence and nature of any trouble so a fix could be prepared in advance and implemented as soon as the aircraft lands. In the case of manned aircraft, WICS will prevent information overload by selectively filtering and reducing data to give the pilot exactly what he or she needs in terms of targeting data, nearby threat updates, weather conditions, and so forth. The pilot would have the capability to query WICS for any supplemental information. Vocal requests for information will be enabled through AI-driven natural-language processing. Just as important as a pilot's being able to query WICS vocally, WICS will be able to respond vocally, allowing the pilot's eyes and hands to remain focused on flying. Nicholas Negroponte predicts that, through speech storage and synthesis, machines with humanlike conversational capabilities will be in use.[2] As an example of a new capability enabled through WICS, *New World Vistas* noted future cargo aircraft should have "point-of-use delivery capability through precision airdrop as a routine process."[3] WICS will, through continuous and automatic position updates to both the airlifter and the intended target, enable this capability for both stationary and mobile drop targets.

Operational Layer

At the operational level, in addition to having all the capabilities of tactical units, WICS will be able to conduct battle damage assessment, receive and process raw imagery from satellites and other collection sources, transmit and receive battle plan updates, and conduct near-real-time battle simulations (refer to table 5 for a listing of information requirements at each level). Commanders would be linked to WICS through the battlenet, but also through direct satellite-to-ground laser downlinks. This provides a degree of redundancy, and allows the commander to directly task WICS to look for particular information that may be of unusually high value. WICS would operate in a "war room" setup at the theater/battlefield commander's headquarters. Large cinema-like viewscreens would display the overall strategic view (i.e., the "God's eye view") in a virtual environment, providing all of the information necessary to give the commander, at a glance, an overall situational awareness. This includes, but is not limited to, enemy positions and strengths, the locations and status of friendly forces, and natural and man-made landmarks. Battlestaff personnel would be seated at consoles, each responsible for and continuously monitoring a particular functional area of responsibility (logistics, intelligence, etc.). Each staff officer would receive continuous updates, as well as have on-demand access to all information affecting the area of responsibility. By assigning one or more staff officers to a particular area of responsibility, information overload can be avoided. In addition to overall situational awareness, WICS would continuously conduct battlefield modeling and simulation exercises. One of the 2025 concept papers spoke of a system that would

> not only consider current battlespace information, but would also have access to past historical information about the key political and military leaders involved and their decision-making histories and tendencies. In addition, the system would include information from key, successful political and military leaders. The system would be able to fuse this information and provide the commander or decision maker with possible outcome scenarios based on various actions the commander might take . . . and suggest alternate courses of action with their potential outcomes.[4]

WICS would perform this mission, acting as a knowledgeable advisor to the commander. Furthermore, information would not only be tailored to meet the commander's needs but automatically presented in a format to his or her liking. In *Being*

Digital, Negroponte introduces the concept of a "digital butler," a computer that possesses a body of knowledge about something and about the computer user in relation to that something (tastes, inclinations, etc.).[5] *New World Vistas* discusses a concept called "dynamic planning and execution control," in which planning and operations tempos are increased and plans can be easily changed while maintaining consistency throughout the battlespace.[6] WICS would easily facilitate this. Overall, WICS would provide the theater commander with "dominant battlespace awareness,"[7] greatly reducing the decisionmaking and implementation timeline and increasing by leaps and bounds the efficiency in the way forces are employed.

Strategic Layer

At the strategic level, WICS will be employed in a nearly identical manner to the operational level. The major difference would be that WICS will be a global system. WICS will be used to monitor events and control forces on a global scale. Global military and political events and strategies will be incorporated into the near-real-time planning, modeling and simulation, and execution processes. WICS will afford national authorities near-real-time situational awareness and control.

The flexibility of WICS to different situations can be illustrated by applying the system to the alternate futures envisioned in the 2025 study. Four of the alternate futures described are "Gulliver's Travails," "Zaibatsu," "Digital Cacophony," and "King Khan."[8] In all four futures, but particularly in the "Gulliver's Travails" and "Digital Cacophony," knowledge of global events and near-real-time command and control of forces is critical.

In all four futures described, WICS provides global command and control, and situational awareness greatly enhances national security and capabilities.

Notes

[1] 2025 Concept, no. 900585, "Global Location and Secure Comm," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/**2025**, 1996).

[2] Nicholas Negroponte, *Being Digital,* (New York: Vantage Books,1995), 144.

[3] 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), 10.

[4] 2025 Concept, no. 900386, "Computer-Assisted Battle Decision System," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/**2025**, 1996).

[5] Negroponte, 149–52.

[6] *New World Vistas,* summary volume, 26.

[7] B. R. Schneider and L. E. Grinter, *Battlefield of the Future: 21st Century Warfare Issues* (Maxwell AFB, Ala.: Air University Press, 1995), 91–94.

[8] "2025 Alternate Futures," videotape of briefing to MAJCOM vice-commanders, January 1996.

Chapter 5

Enabling Technologies

New World Vistas identifies several primary technologies that will be required in 2025.[1] Those that are applicable to WICS are presented in table 7.

Table 7

***New World Vistas* Technologies Applicable to WICS**

- High bandwidth laser communications for satellite and aircraft cross and downlink (*)
- Distributed satellite vehicles and sensors
- Precision station keeping and signal processing for distributed satellite constellations
- Continuous simulation
- Secure operations across large networks having secure radio frequency components (*)
- Information protection (*)
- High speed processors
- Data compression systems
- Networking technologies
- Direct downlink broadcast equipment
- Fiber optic and satellite communication services

(*) indicates technologies that will be pursued in both commercial and military forms

These and other key enabling technologies can be grouped into five areas. First, advances in *data-collection* technologies are needed so that we can collect data sufficient in quality and quantity. Second, advances in *data-processing* technologies are needed to handle that data. Third, advances in *presentation* technologies are required that will dramatically improve the human-computer interface. Fourth, advances in *communications* technologies are needed to transmit large volumes of data "in-time" to multiple users simultaneously. Finally, *information-control* technologies must be advanced so data-gathering and communications activities can proceed undetected and uninterrupted.

Data-Collection Technologies

Before we can collect enough data of the quality and fidelity required by WICS we need a big increase in satellite spatial coverage and a big decrease in satellite revisit times. Current satellite design concepts focus on developing highly-redundant systems with long design lifetimes. These vehicles are extremely expensive and generally require large, complicated boosters for launch. A better approach may be to develop the data-collection system around a large constellation of relatively simple, inexpensive, and expendable microsatellites. These microsatellites depend heavily on advancements in microminiaturization technologies. Each space-based individual collection system could include several dozen such satellites. Because they would be expendable by design replacements could easily be launched on a relatively cheap booster system. This also would provide operational flexibility because, given a more responsive spacelift capability, spare satellites and boosters could be prepared for short-notice launches to orbits providing additional coverage of specific geographic regions during conflict.

Data collected from all available sources, including weather, navigation, and imaging satellites, must become more refined. Improved resolution and target-identification capabilities could be provided through spectral sensing rather than current spatial imaging techniques.

Data-Processing Technologies

Improved data-processing capabilities could possibly be the key technological challenge facing WICS. Processing speed must continue to improve. Because of the immense quantities of data that will be processed by this system, it will be necessary to utilize artificial intelligence as part of the onboard processing system. Current satellites are "dumb systems" that do little more than serve as high-altitude transceivers. Instead, it is necessary to develop the next generation of "smart satellites." These will use artificial-intelligence techniques to process and filter the data and prioritized information before it ever reaches the user. This will greatly reduce the user workload and, because extraneous data will be removed from the information flow, will improve the rate at which data may be transmitted. The filtered data will be transmitted to users at fidelity levels determined by the requirements of a particular user.

Data-Presentation Technologies

The usefulness of the information will only be as good as the presentation format. This will require advances in software and smart user interface technologies, including virtual reality and interface agents.

Communications Technologies

A major technical challenge that must be met to make WICS a reality is the improvement in communications technologies for voice, images, video, and data. Improved bit rates, data compression, and higher bandwidths are essential to this effort. Developments in laser communications are needed. Satellites must be standardized so that all of the space-based platforms are compatible and data cross-link can occur. Standard radio frequency signals are not practical for minimizing unfriendly access to data; their signals tend to spread over wide areas. One attractive alternative is the use of lasers to pass information. Lasers are attractive because of their higher data rates and smaller beam divergence angles. The use of laser communications will necessitate major improvements in pointing and tracking capabilities (systems will need to find and point to each other before they can transfer information). Also, methods are needed to mitigate the signal-degrading effects of atmospheric turbulence.

Information-Control Technologies

In addition to improved pointing and tracking capabilities, several other steps must be taken to protect friendly access and deny unfriendly access to the system. Secure communications capabilities will be essential due to the sensitive nature of the information. Standard cryptographic and jamming techniques must be improved. Communications and access redundancy will be essential. As information warfare becomes more of a standard procedure, countermeasures must be developed and employed in WICS. As a result, defensive counterinformation tactics must be developed to protect the system and restrict its access to unauthorized users.

Notes

[1] 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), 52–53.

Chapter 6

Cost, Schedule, and Implications

One of the prominent features of WICS that will reduce costs is that it will function with existing (in 2025) collection and communications systems. A partnership with the commercial space sector will give opportunities for cooperative relationships that have the potential to reduce costs. For example, a program similar to the Civil Reserve Aircraft Fleet (CRAF) can be used to augment military space capabilities, particularly in the area of communications satellites. Cost elements will include LEO Harvesters, interface costs associated with plugging the existing systems into WICS, data-processing hardware, communications infrastructure, and personal interface computers.

There is a high probability a system like WICS could be functioning in 30 years. The commercial sector is currently driving the market for advances in computing and communications technology because of the public's growing appetite for information access and mobile portable communications. Potential military applications cannot be ignored.

The layered implementation of WICS will serve several purposes and alleviate many concerns. First it will assure military campaigns are conducted under the principles of centralized control and decentralized execution. Second, it will maintain the compartmentalization (i.e., need to know) character of the information security. Third, it will avoid information overload by presenting only necessary information in a recognizable and usable format.

Another possible concern is the reliance on space systems for military command and control. Space is a difficult and hazardous place to do business. Reliance on the LEO collectors and GEO processors raises several concerns. For example, what if they fail or what if the space environment interferes? Two things can be done to counter this concern. First, develop a backup system that can be utilized in the event of satellite failure. Basically, the data could be processed on the ground instead of on-orbit. This will reduce the timeliness of the data. Second, push for micro (throw-away) satellites and cost-effective, responsive space lift. If satellites fail or if they are attacked, they can be easily replaced with a responsive launch system.

Chapter 7

Conclusion

At first glance, the Worldwide Information Control System (WICS) appears to be "just another information system." However, a closer look at WICS quickly discounts this notion because of the revolutionary capabilities it will bring to warfare. By 2025 technological proliferation will likely even the playing field to a level where only those who best control information will rise above their adversaries in war-fighting capabilities. If the necessary technological challenges are overcome, WICS can provide an adaptable architecture, leveraging 2025's data collection systems and satisfying the information needs of war fighters. WICS will provide the essential framework to give the United States a revolutionary operational capability by 2025.

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