AIR SYMPOSIUM 2002

Sponsored by
The Chief of the Air Staff

Space in the 21st Century

Edited by

Lieutenant-Colonel Dennis Margueratt

Deputy Director Aerospace Studies

&

Dr Allan English

Canadian Forces College Collège des Forces Canadiennes

TABLE OF CONTENTS

UNDERSTANDING THE SPECTRUM OF ADVANCED ISR TECHNOLOGIES

Syndicate 5: Major Richard Foster (Chair), Major Frank Costello, Major Martin Galvin, Major Darwin Gould, Lieutenant-Colonel Stan Grabstas, Major Wayne Griffin, Major Petr Mikulenka, Major Colin Murray, Major Gisèle Royer

> "What most nations want are smarter weapons starting with sensors. Such sensors would be mounted on aircraft, drones or space vehicles, but more important they would be under the control of theatre commanders who would be able to move them around as needed and customize the information streaming in from them. This near-term future would bring together or fuse different kinds of fine-grained data, synthesize it and check it against many kinds of databases. The result would be better early warning, more refined targeting and improved damage assessments. Sensors are top priority."[1]

INTRODUCTION

In war, the value of timely, relevant and continuous intelligence on the enemy's position, movements and vulnerabilities is well recognized by commanders at all echelons. An accurate image of today's dynamic battlespace[2] leads a commander to a clear understanding of what action needs to occur. Otherwise, planning is an unfocused and wasteful exercise, and execution may result in defeat.[3] To accomplish their tasks, the commanders must develop the battlespace with the input of numerous and complementary intelligence, surveillance and reconnaissance (ISR) sensors with various capabilities that are integrated into several different platforms. According to USAF doctrine on ISR operations, "the fundamental responsibility of ISR is to provide intelligence information to decision makers at all levels of command to give them the fullest possible understanding of the adversary."[4]

Information operations and battlespace awareness are common terms engendered in the modern C⁴ISR[5] vision. Realization of this vision is perhaps more problematic than many would believe. Ensuring that Canada pursues the right technologies and makes the right choices for the future begins with an understanding of what capabilities are available. Due to the classified nature of ISR capabilities, nations that do not leverage new technology will find themselves marginalized or worse, endangering forces because of limited access to battlespace information. It is clear that a proper understanding of emerging and currently available ISR technologies is an essential first step for any nation committed to participation in future coalition operations.

This paper explores two areas which impact future choices Canada will make regarding participation in coalition ISR activities. The first is an overview of current and emerging ISR sensor technologies, including their capabilities, current developments in industry, and general limitations. The second area covered is a brief synopsis of the information architecture technologies required to enable proper exploitation of advanced sensor programmes.

SENSORS AND PLATFORMS

Gathering battlefield information to support intelligence, surveillance, and reconnaissance often depends on combinations of sensors and platforms. Evolving technology allows combinations of sensors to monitor virtually all aspects of the electromagnetic spectrum. The most effective coverage of the spectrum is achieved through a well-managed suite of sensors where the synergy of several types is able to overcome the limitations of individual sensors. This paper looks at a suite of sensor technology selected on the basis of its ability to cover much of the electromagnetic spectrum. As well, the technology selected is based on ongoing research and development in the United States and to some extent in Canada. These technologies include spectral imaging, synthetic aperture radar, electro-optical sensors, and IR sensors. The paper concludes by examining two emerging technologies that will potentially impact ISR's future on the battlefield: micro-technology and microbiological/chemical protocols.

Multispectral and Hyperspectral Imaging

Multispectral and "hyperspectral" imaging (MSI/HSI) are passive processes that allow multiple images of a scene or object to be created by capturing reflected energy from different parts of the electromagnetic spectrum. Because all materials reflect, absorb, or emit photons relative to their unique molecular makeup, reflected energy from objects on the ground appear to an MSI or HSI sensor as a "spectral fingerprint" in the visible, near-infrared, and short-wave light spectrum.[6] Targets visible in a particular spectral band may not necessarily emerge in another. All materials generate unique spectral fingerprints that can be detected and catalogued in a database.[7] Spectral images may be used to detect military equipment such as camouflaged weapons systems, vehicles, and hazardous products. In collecting data within two spatial dimensions and one spectral, the resulting product is essentially three-dimensional. Multispectral and Hyperspectral Imagery may therefore contribute to 3-D models for battlespace simulation, air attack route planning, and terrain mapping.[8]

Both MSI and HSI are passive techniques that depend on the sun or some other independent source for emission or illumination. Over and above the capabilities of Multispectral sensors, HSI systems are now able to collect data within hundreds of spectral bands across a broader cross-section of the electromagnetic spectrum. Increased data collection is therefore possible allowing greater sensitivity and finer resolution. The added capability of HSI allows many remote-sensing tasks to be accomplished that are impractical or impossible with an MSI system, including initial detection of chemical or biological weapons production, assessment of bomb damage, and detection of troops and vehicles through forest foliage.[9] Although Hyperspectral sensors may not be able to detect a missile signature, detection of the plume from the missile's effect on the atmosphere is possible permitting determination of the launch and flight path.[10]

Many HSI sensors are currently in use in commercial and military sectors.

Canadian technology features prominently in the field of remote sensing and the use of HSI sensors. An example is the Compact Airborne Spectrographic Imager (CASI) built by ITRES Research Ltd. CASI has been operational since 1988 and has provided spatial and spectral information on numerous geological materials. A unique feature of CASI is the ability to select bandwidth sets during target acquisition.[11] The Canadian Forces' lead agency for MSI/HSI research, Defence Research Establishment Valcartier (DREV), has developed an imaging spectrometer for HSI capable of "simultaneous spatial and high spectral resolution analysis."[12]

Hyperspectral systems have also been flown onboard a NASA C-130 and a US Naval Research Laboratory (NRL) P-3. The NRL project "Dark Horse" began in 1997 with the aim of validating real time data obtained from Uninhabited Combat Air Vehicles (UCAV).[13] In November 2000, the Earth-Orbiting (EO) New Millennium satellite, NASA's EO-1, was launched with a TRW-designed *Hyperion* Hyperspectral imager onboard. Although the military aspects of the EO-1 mission are highly classified, onboard HSI sensors provide resolution of surface properties many times greater than current Multispectral images offering extremely accurate classification of surface materials.[14] HSI is a proven technology that will continue to improve in capability and military application.

Current Multispectral and Hyperspectral research and development effort focuses on system integration with other information gathering sources. Hyperspectral images, when compared with a library of image banks, highlight differences in the target environment. Changes, such as a tank or other weapons system moving into a given location or disturbance of the ground, act as a cue for further investigation. Following initial detection, aerial photography, Unmanned Air Vehicles (UAV), Elint and Sigint may be directed to localise activity occurring at the area of interest. As a result, search and detection time may be drastically reduced with fewer assets required. Decision-makers gain increased confidence when more than one sensor is able to report on a specific item of interest. Dual phenomenology is a term used to describe such information or reports that are derived from multiple sensor systems and means.[15]

Limitations of HSI systems include background noise caused by atmospheric and stratospheric phenomena, such as thermal layering, propagation ducting, and false target ranges all of which affect image resolution, target detection, and positional accuracy. Another problem is that HSI systems collect large volumes of data at a much faster rate than current systems designed for the same purpose. Additional data collection increases the requirement for data storage, rate of storage, and requirements for greater downlink bandwidth. Analysis requirements needed to optimize computer algorithms cause critical delays in information distribution to operational commanders. Technological development should solve the computing problems in the near future.

Notwithstanding these limitations, the range of potential uses for this technology are almost limitless. MSI and HSI currently contribute directly or indirectly to the following:

- northern ice patrols, routing and navigation;

- monitoring of refugee migration;
- arms control and verification (WMD);
- counterterrorism - threat monitoring; and
- counternarcotics - growing, processing and transshipment.

Operation Allied Force offered several applications for HSI sensors at the operational level. The potential existed to use HSI technology to identify targets and follow-on bomb damage assessment. Battlespace hazards including environmental and weapons of mass destruction might have been classified and highlighted in near-real time with HIS technology. Potential hazards to KFOR personnel, including land mines and chemical / biological weapons could also have been identified with this technology. Finally HSI sensors could have detected regular patterns of recently disturbed soil making it possible to isolate mass graves and determine the location of minefields. MSI and HSI as ISR technologies are potentially available for use today. Indeed, it is possible the US exploited these technologies during Operation Allied Force. MSI and HSI are examples of technologies currently available for Canadian development with coalition partners. Increased Canadian involvement in this realm may, therefore, improve CF opportunities related to either the provision of, or access to, ISR on the battlefield.

Synthetic Aperture Radar (SAR)

The defining characteristic of Synthetic Aperture Radar (SAR) is its ability to detail an extremely fine azimuth resolution without the large antennae normally required for comparable sharpness in beam focus. This resolution is accomplished through a synthetic array, a "single moving antenna to simulate the function of all the antennae in a real linear antenna array."[16] The polarized radiation is transmitted along the route of the SAR vehicle enabling received signals to be collected, stored, and subsequently processed. These signals can subsequently be collated with other data sets to produce high-resolution images.

SAR is an active system, which operates in the microwave band of the electromagnetic spectrum. Unlike spectral, purely optical, or infrared systems, the longer wavelength microwave energy of SAR is able to penetrate cloud, fog, mist, smoke, and rain. SAR provides all weather, day-night imaging with the capability of spatial resolutions up to one foot making it an invaluable military classification and identification system.

Recent developments and techniques to enhance the utility of SAR include interferometry, moving target indication (MTI), and inverse SAR (ISAR). Interferometry, or three-dimensional SAR, is another imaging technique that uses triangulation of two radars to develop very accurate high-resolution topographic maps with a level of detail approaching the wavelength of the microwave radiation employed.[17] Techniques have also been developed to allow SAR to detect the doppler shift of received microwave signals created by moving targets, including land vehicles, aircraft, and ships. By filtering background returns, moving targets can be identified and categorized in accordance with their respective velocities and size. While SAR is appropriate for imaging most types of targets, the rotational component of aircraft, ships, and satellites tend to deflect the microwave energy resulting in blurred images.[18] ISAR exploits modified algorithms to measure and evaluate the doppler shifts resulting from this rotational movement thereby allowing the generation of high-resolution images of these target types. These enhancements make SAR an effective detection and tracking tool for ISR assets in all weather conditions.

SAR systems are currently employed on various platforms including manned aircraft, unmanned aerial vehicles, and satellites. Each platform category offers varying performance capabilities in the areas of resolution, spatial and temporal coverage, mission flexibility, and vulnerability. Of the airborne SAR platforms, the E-8 Joint Surveillance Target Attack Radar System (J-STARS) and the U-2 are the most capable.

The J-STARS is a modified Boeing 707/300 that serves as an "airborne battle management and C2 platform which conducts ground surveillance to develop an understanding of the enemy situation and to support attack operations and targeting." Its radar suite includes SAR with MTI that can cover 50,000 square kilometers while detecting targets out to 250 kilometers. It can detect and track numerous ground vehicles, moving and stationary, and possesses a limited capability to track helicopters, low velocity fixed-wing aircraft, and rotating antennae.[19] This battlefield information is collected and transmitted in near-real time to supporting ground stations.

The U-2's ISR suite includes the Advanced SAR System (ASARS-2) capable of the highest resolution currently available for radar ground mapping permitting detection of stationary and moving ground targets out to 180 kilometers.[20] The collected data is formatted and transmitted to an Enhanced Tactical Radar Corelator (ETRAC) providing a new generation processing system for ASARS-2 information. The ETRAC digitizes the data, produces softcopy imagery and, to a limited extent, interprets this imagery for intelligence products that can be disseminated to users via ground stations.[21]

Other users of SAR include the United Kingdom, which is planning to fulfill its Airborne Standoff Radar battlefield (ASTOR) surveillance requirement with a variant of the ASARS-2 system mounted on a Bombardier Global Express jet airframe. Expected in-service date of ASTOR is 2005. Development is also continuing on a NATO Alliance Ground Surveillance (AGS) system. The American/Belgian/Canadian/Danish/Norwegian proposed solution incorporates a SAR and MTI, with functionality and resolution superior to that now available on J-STARS.[22] Installation of the suite on an Airbus A320 airframe is projected, with an in-service date of 2008.

Augmenting the contemporary manned aircraft options are UAVs, such as Predator and Global Hawk. UAVs represent a low-cost alternative to manned airborne ISR vehicles, and are especially relevant to high-risk, dynamic missions. The Predator UAV incorporates the TESAR strip-mapping SAR, which provides "continuous variable-resolution imagery from 1 meter to 0.3 metre."[23] The data is translated into imagery through on-board processing and then compressed for down link to a ground control station. The radar can operate in strip mode with swath widths of up to 800 metres aligned with either the aircraft track or a predetermined terrestrial line, or in pseudo-spot mode where a target area is continuously imaged while the aircraft travels through the region.[24]

Global Hawk's SAR operates in either strip mode, providing one-metre resolution, or spot mode providing thirty centimetre resolution that can support GMTI on targets with speeds as low as four knots. On a 24-hour mission, Global Hawk's SAR can provide coverage of just over 74,000 square kilometres in wide mode, or 1,900 two-kilometre square spot images.[25] By 2004, the USAF plans to replace Global Hawk's SAR with the same ASARS-2 system that is currently employed on the U-2.[26]

Space-based SAR (SBSAR), in addition to providing overlapping coverage with manned and unmanned aerial vehicles, provides an effective means to monitor remote land and oceanic areas through wide-area surveillance without the limitations imposed by airspace restrictions and national boundaries. Currently there are two commercial SAR satellite systems in operation: the European Resource Satellites (ERS) and Canada's RADARSAT. Because of the similarities, only RADARSAT will be discussed.

Canada currently has one RADARSAT satellite in orbit. A second satellite (RADARSAT-2) is planned for launch in 2004 and is predicted to achieve resolutions as refined as three metres. RADARSAT can image an area of over one million square kilometres per orbit.[27] The data received by RADARSAT is digitized and encoded by on-board processors, and can be downloaded in real time to a ground network. Originally developed to support scientific research, RADARSAT has been used extensively in such fields as oceanography, including ice flow patterns, forestry, geology, and agriculture. RADARSAT has also been used as a military ISR asset with its imaging capability being exploited in peace support operations and humanitarian missions.

The major limitation of SAR is its significant cost and support infrastructure associated with highly complex imaging technologies. SAR can be affected by atmospheric phenomena, that may cause false targets in MTI and obscure mapping that may make real-time targeting difficult. Nevertheless, SAR offers a very capable ISR sensor that complements HSI and other spectral sensors in that it provides an all-weather capability.

Electro-Optics and Infrared

Traditional electro-optical (EO) and infrared (IR) sensors have a number of limitations that are slowly being overcome by advances in EO/IR technology. In the case of EO sensors, the ability to provide an image with good resolution depends on the availability of electromagnetic energy or illumination from sources such as stars or solar light. As well, traditional EO systems are unable to penetrate fog or clouds and work poorly in the rain. They also provide limited resolution over long ranges. IR systems are dependent on thermal energy and are only effective if the desired target exhibits thermal contrast characteristics. Recent advances in EO and IR technology have overcome or minimized the effects of many of these limitations.

The current fourth generation of EO technology offers several advantages. New EO sensors, based on the digital camera concept, use new digital

charge-coupled devices (CCDs) that operate in a large spectral bandwidth. As well, EO systems that have been traditionally dependent on ambient light sources are now able to operate using laser illumination. These modern technologies provide EO systems with the ability to penetrate haze, and significantly improve image resolution, albeit for relatively short distances (three miles). EO systems that are coupled with new array aperture technology can provide images of large areas with high resolution in a digital format that may be transferred to commanders at all levels in near real time.[28]

Modern EO technology can have a significant impact on the strategic, operational, and tactical level theatres. For strategic and operational employment, modern EO technology is integrated into a variety of manned and unmanned airborne platforms. Space-based platforms employ EO sensors to provide images for reconnaissance, targeting, and meteorology to all levels in the command and control networks. EO systems are also integral to the payload of modern UAVs, such as the Global Hawk. Manned platforms, such as the Joint Strike Fighter (JSF), will also employ an EO sensor for targeting. This sensor will have a field of regard extending above the horizon and will operate continuously during flight to monitor the battlespace. The digital processing capabilities of these newer EO systems significantly enhance the survivability of the surveillance system. For example, an aircraft flying at 450 knots at low-level with a traditional EO system would take twelve seconds to photograph a complete 10,000 foot-long runway for battle damage assessment. With a modern EO camera this can be achieved with two frames in 1.8 seconds thus minimizing the exposure time of the aircraft over the hostile target.[29]

At the tactical level, progress is being made to overcome EO/IR surveillance limitations characteristic of traditional forward looking infrared (FLIR) and night vision goggle (NVG) systems. Many of the limitations inherent in FLIR and NVG technologies are overcome by a new technology called Laser Range-Gated Imaging (LRGI). LRGI technology employs a pulsed laser and a gated image-intensified camera. The process begins with a short intense laser-light pulse directed towards a target of interest. As the light travels it is absorbed and scattered by obscurants in the atmosphere such as smoke, dust, rain or fog. The camera shutter remains closed, or gated, to avoid the backscatter caused by such obscurants. The pulse illuminates the target and reflects back to the image-intensified camera. The camera shutter opens at the time the reflected laser light is calculated to return from the target, and remains open for the duration of the laser pulse. The desired range is defined by the time the shutter remains open. The depth of field is controlled by adjusting the length of the laser pulse and the duration the shutter is to remain open.[30]

LRGI technology overcomes many of the limitations of traditional NVGs and FLIR systems by using a laser to generate its own source of illumination. This active technology gives it an advantage over NVGs and FLIR systems that are dependent on external ambient light sources or thermal contrast. Second, the range-gated technology is able to eliminate the negative effects of backscattering. This means LRGI can "see through" obscurants such as fog, rain or dust. Third, LRGI technology reduces the "blooming effect" of artificial light that degrades the image contrast and seriously degrades the functionality of traditional NVGs. Unlike conventional sensors, LRGI sensors can operate day or night, with no ambient light, in degraded weather conditions.[31]

Although EO/IR technology is improving rapidly, it still has limitations. Good resolution over long ranges must still be improved. Atmospheric conditions continue to degrade EO/IR effectiveness. Dense moisture, such as heavy rain or cloud will obscure the intended image. The sensor capability may also be reduced depending on temperature variations affecting the near infrared spectrum such as during crossover times between night and day when temperature contrast becomes less. As well, those systems dependent on lasers for illumination are neither covert nor eye-safe. This is a problem when conducting clandestine operations.

Despite several limitations, EO technology provides an excellent, low-cost sensor alternative that can be easily integrated with a variety of platforms and other ISR sensors. Advances are being made which will further minimize the impact of atmospheric conditions on EO/IR technology. Research and development is ongoing in an effort to minimize or perhaps eliminate the eye-safe hazard associated with LRGI technology. EO/IR sensors will continue to play a dominant role in future operations and will provide a highly capable complement to the ISR equipment arsenal. Canadian-developed EO/IR technologies, such as DREV's LRGI sensors, offer Canada the ability to leverage this technology in exchange for access to other ISR capabilities in a coalition environment.

Microtechnology

The predominant ISR platform in future military conflicts may consist of large numbers of smart micro-sensors carried on micro-air vehicles (MAV) all tied into a global aerospace surveillance network. The war zone could see tens of thousands of flying, crawling or hovering insect-sized vehicles designed to seek out enemy forces and attack or designate them for long-range precision strike weapons.[32]

Development of MAVs began in 1997 with a US government initiative to develop the new vehicles. Specific performance and environmental specifications dictated that MAVs be capable of traveling up to 20 kilometres, remain airborne for up to two hours, and be capable of vertical take-off and landing.[33] The design parameters set by government were those of a semi-independent flying vehicle not to exceed six inches in length, width and height, and to be no heavier than fifty grams.[34] The primary payload carried by MAVs will be a visual imaging system consisting of a camera and data transmitter.[35]

Other capabilities of MAVs may include a digital datalink derived from wireless local-area networks and an imaging sensor by digital camera. The sensor is expected to provide recognition of a squad-sized target, day and night, which would be transmitted to a notebook computer. From these concepts two types of missions are derived: standoff sensing to observe, and close-in operations to fly beneath tree canopies or inside buildings. Other potential roles include service as a fixed, unattended surface sensor, detection and identification of biological or chemical agents, communications relay, and for placement of lightweight weapons.[36]

Current program developments include the Aero-Vironment Black Widow, the Sander's MicroStar and Lutronix Kolibri. The Aero-Vironment Black Widow can travel one kilometre in twenty minutes. It is powered by lithium batteries and is launched pneumatically from a shoulder pack with view goggles for the operator to view live video images. The expected flight time is 1 hour. The Sanders' Microstar is a fixed wing MAV with a 20-60 minute range of five kilometres, and is considered best suited for over-the-hill reconnaissance. It is powered by an electric motor and will cruise at altitudes of 50-300 ft. The Microstar should be available in September 2001. The Lutronix Kolibri, is a rotary wing vehicle that has a vertical take-off capability and an endurance of 30 minutes. It is powered by a diesel engine and designed to carry imaging sensors for both day and night. It is best suited for reconnaissance and surveillance missions in urban operations.[37]

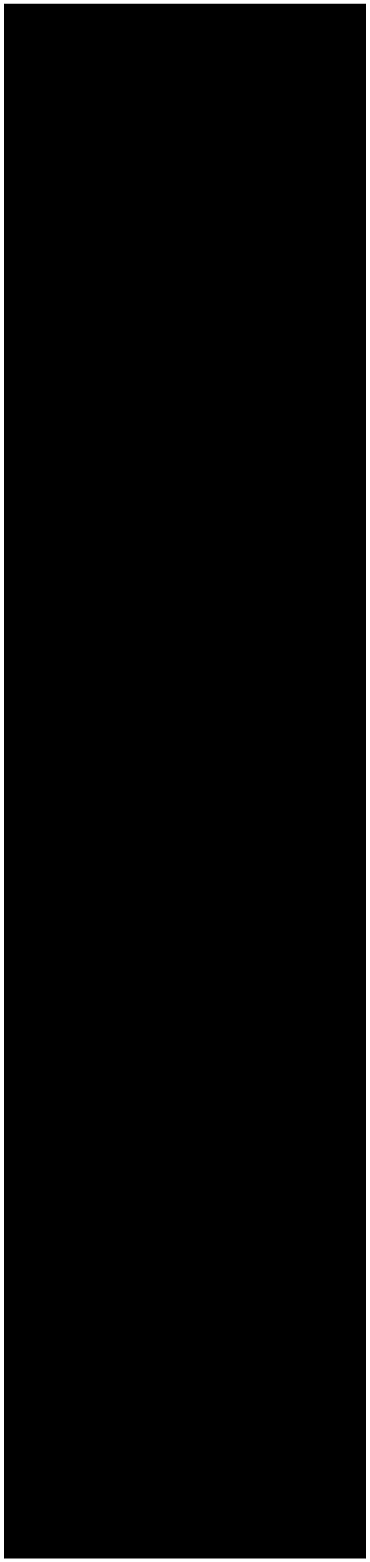
There are many challenges to be addressed in MAV construction and operation such as navigation, propulsion, energy and aerodynamics. In addition, concerns with battlefield control, data-link capabilities and full ISR integration need to be addressed. Nevertheless, this emerging technology could drastically change the use of ISR on the battlefield.

Early successes of the MAV programs indicate that the technology is feasible. As stated by one engineer, "we may optimistically anticipate a rapid evolution of MAVs to militarily useful and flexible systems in the not-too-distant future."[38] Eventually MAVs will be providing the operational commander with surveillance and reconnaissance required for operational awareness, the ability to detect biological and chemical agents, and direct communications to any part of the combat zone. MAVs, once perfected, could be an effective ISR technology.

Microbiological and Chemical Protocols

One of the newest technologies designed to deal with an evolving asymmetric threat to forward-deployed air or land forces is automated detection of nuclear, biological or chemical agents. The field of microbiological and chemical protocols has developed and expanded significantly in this century, particularly in the past 15 years. This developing technology has permitted significant improvements in the detection and identification of various compounds. The Defence Research Establishment Suffield (DRES) has used this new technology to develop the latest generation detection system that integrates biological and chemical protocols in the Canadian Integrated Bio/Chemical Agent Detection System (CIBADS). CIBADS uses two complex applications to detect and identify biological agents consisting of a Fluorescence Aerodynamic Particle Sizer (FLAPS) and Chemical Agent Detection System (CADS).

Fluorescence Aerodynamic Particle Sizer technology is based on flow cytometry, and enables the measurement of the physical and chemical characteristics of individual compound cells at high speeds. The continued development of improved signal-to-noise ratios in new flow chambers (in the 1980s), the use of laser-based systems with closed flow chambers (in the 1990s) plus the advanced computer processing



Protocol standardization is one of the current weak links in developing a robust and integrated ISR capability. Many legacy systems, such as the U-2, have stove-piped communication protocols that are not compatible with other existing systems or technologies under development. The US has developed the Joint Technical Architecture as a means of outlining standards to complement both the C^4ISR architecture and the Defense Information Infrastructure Common Operating Environment.[43] One of the primary objectives of this development is to move away from stove-pipe legacy systems towards a single, scaleable, modular architecture that can be adapted to meet unique system requirements within a joint or combined environment.[44] Consideration of future ISR sensor equipment and their platforms must include protocol standardization to ensure interoperability.

Data fusion is defined as an "adaptive information process that continuously transforms the available data and information into richer information through the continuous refinement of hypotheses or inferences about real-world events."[45] The core process of data fusion involves computer algorithms that correlate and present information received from various sources such as fighters, ships and UAVs. A good example of data fusion is the final integrated picture resulting from Link-16 processing. Data fusion technology, however, has been focused on the refinement of track data between sensors, on sharing this information with C2 nodes, and on correlating tracks at the C2 nodes. The expanded capability of true data fusion to enable decision support capabilities to commanders is still in the early stages of development.[46]

The use of interoperable sensors and platforms must be paramount in any national decision to develop an organic ISR capability. Shrinking defence budgets and escalating technology costs have made the feasibility of pursuing service-specific ISR solutions, designed around unique standards and protocols, a thing of the past. From a Canadian perspective, future operations will likely be coalition efforts. Most ISR assets are likely to be maintained at the operational level; therefore, national contributions cannot consist of unique technologies or equipment. Common sensors and platforms are essential components in the effort to simplify the existing C^4ISR architecture, and would provide the best economy of scale in coalition efforts by reducing logistics, maintenance and training efforts.

Development of common battle management tools is another important aspect for integration of ISR assets into a common and useable picture. The Ad9(ces suati Td)49.7aectsca WA919.8TW)e
orrls is hfig-openformuatl
cm
lany(pr)19.7(oces(orintandedtosu)34.8(pporost
i m -
r
t r n s m i t i s

prefind film-
eors
management toog T at enablsn the eff

prevent unwanted persons from translating information received during transmissions of data on tactical links such as Link 16. Although military systems employ encryption techniques ten times stronger than current civilian applications, the gap is narrowing as demand for electronic banking security increases.[48] As commercial systems become more sophisticated, the threat to military security will increase. The second security issue is the provision of jam-resistant transmissions over the link to ensure that the required information is received. Space-based transmissions from Global Positioning System (GPS) satellites are likely to be jammed at the ground site where the link occurs. The G-STAR is an emerging technology that eliminates jamming signals prior to sending data to a satellite. This type of capability will eventually be available for many tactical GPS systems that are likely to be used on ISR sensor platforms. Security against electronic warfare will become increasingly important as modern forces become dependent on ISR links to manage the battle.

CONCLUSION

Conflicts of the past decade accompanied by the dynamic advances in ISR technologies have positioned intelligence, surveillance and reconnaissance at centre stage as an instrument of combat in future joint and multinational conflicts. Military success in future conflicts will be based on the ability to acquire timely, relevant and continuous ISR information and effectively integrate the multiple information sources into the commander's battle plan.[49] For a nation that is committed to participation in future coalition operations, it will be necessary to establish a proper understanding of emerging and currently available ISR technologies.

ISR encompasses a wide range of

provide automatic detection of nuclear, biological or chemical agents.

Despite the incredible capability available in modern sensor technology, the ISR suite is only effective when the information it provides is distributed to the right location at the right time. To ensure this result, technologies must be integrated with consideration given to protocol standardization, data fusion algorithms, interoperable sensors and platforms, interoperable battle management systems and security requirements. On the battlefield the effective integration of a modern suite of ISR sensors will provide commanders with critical information on the enemy's positions, movements and vulnerabilities, all key features in establishing battlefield dominance.

"Information is the currency of victory on the battlefield."[50] Eligibility to participate in future coalition operations will be influenced by the "currency," or ISR capability, that is brought to the conflict. Canada must leverage its limited ISR capability and technical expertise to negotiate for access to critical ISR information that will keep our personnel safe and render Canadians welcome partners at the battle-planning table. An understanding of advanced ISR technologies is a key component in identifying Canada's ISR requirement.

Endnotes

1. Alvin and Heidi Toffler, *War and Anti-war Survival at the Dawn of the 21st Century* (Boston, Little, 1993): 118.

2. US Air Force, *Air Force Basic Doctrine* (Washington: Department of the Air Force, September 1997): 79. This document defines 'Battlespace' as the commander's conceptual view of the area and factors, which he must understand to successfully apply combat power, protect the force, and complete the mission.

3. Col Gary D. Payton, USAF, ed., "The Art of Intelligence, by the General," *AirPower Journal* (Winter 1993): 19.

4. *US Air Force, Intelligence, Surveillance, and Reconnaissance Operations Doctrine* (Washington: US Air Force (21 April 1999): i.

5. C^4ISR – Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance.

6. Edward D. Flinn, "Hyperspectral Imaging Reveals Fine Details," *Aerospace America*, (Jun 2000): 26-27

7. Flinn 26. HSI processors can automatically compare preexisting catalogues of a battlespace to determine and identify the arrival of new equipment, personnel or materials.

8. Images of the earth's surface are collected in two spatial dimensions (x and y axis) along the host platform route of travel. The multi or hyperspectral dimension of data collection is comprised of several, perhaps hundreds of spectral slices, which identify materials by their reflectivity or emissivity.

9. Federation of American Scientists, "Hyperspectral Imaging," http://www.fas.org/irp/imint/hyper.htm

10. Nahum Gat and Suresh Subramanian, "Spectral Imaging: Technology & Applications," *Hyperspectrum News Letter*, Vol 3: 5.

11. R. Anderson et al. *Military Utility of Multispectral and Hyperspectral Sensors* (Alexandria: Defense Technical Information Center, 1994): 7-5,7-6.

12. Defence Research Establishment, Valcartier, "The DREV Infrared Imaging Spectrometer (phase II)." www.gsfc.nasa.gov/ISSSR-95/drevinfr.htm. 1

13. Wilson, H.T., "Tests Advance UCAV Role," *Aviation Week and Space Technology*, Vol 149, No 3 (Jul 1998): 60.

14. Nick Speciale, Hyperion Instrument," www.eol.gsfc.nasa.gov/Technology/Hyperion.html. 1-2.

15. A similar strategy of dual-phenomenology is employed in the detection of ballistic missile launches. Confidence in the assessment increases dramatically with each new, confirming sensor / reporter.

16. Robert Trebits, "Synthetic Aperture Radar," in *Principles of Modern Radar* (New York: Van Nostrand Reinhold Company, 1987): 505.

17. George Stimson, Introduction to Airborne Radar (Mendham, New Jersey: Scitech Publishing Inc.): 515.

18. *Ibid*. : 435.

19. Department of the Air force, "E-8C Joint STARS Fact Sheet," [http://www.af.mil/news/factsheets/E_8C_Joint_Stars.html]. June 1999

20. Federation of American Scientists, "Advanced Synthetic Aperture Radar System" (ASARS-2), http://www.fas.org/irp/program/collect/asars-2.htm.

21. Federation of American Scientists, "Enhanced Tactical Radar Corelator" (ETRAC), March 2000. Martin Streetly, "Radar and Electronic Warfare Systems 2000-2001," *Jane's Special Reports* (April 2000).

22. Martin Streetly, "Radar and Electronic Warfare Systems 2000-2001," *Jane's Special Reports* (April 2000).

23. "TESAR Technical Description," http://peoiews.monmouth.army.mil/aps.descr.htm.

24. *Ibid*. Mark Hewish, "Building a Bird's-Eye View of the Battlefield," *Jane's International Defence Review* (1 Feb 1997): 49.

25. Mark Hewish, "Building a Bird's-Eye View of the Battlefield," *Jane's International Defence Review* (1 Feb 1997): 49.

26. David Fulghum, "UAV to Carry U-2 Recce Unit" in Aviation Week & Space Technology Vol. 152, No 20 (15 May 2000): 28. Canadian Space Agency, RADARSAT, (Minister of Supply and Services Canada 1992): 3.

27. Nick Cook, "US Technology Will Lead the Way to Improved Reconnaissance System," *Janes Defence Weekly*, Section 1 C^4ISR (13 May 1998): 29.

28. Canadian Space Agency, RADARSAT, (Minister of Supply and Services Canada 1992): 3.

29. Hewish: 49.

30. XBION Corporation, *Laser Range Gated Imaging Systems* (New Jersey: XYBION Corporation, 2000): 1.

31. V. Larochelle, P. Mathieu, J.P. Simard, "Two Generations of Canadian Active Imaging Systems: ALBEDOS and ELVISS," (Paper presented at 25th SPIE Conference on Infrared Technology and Applications, Orlando, Florida, Apr 99): 2.

32. "MAVs and Fire Ants," *Air International* (Dec 1999): 345.

33. Martyn Cowley and Matthew Keenon, "Micro air Vehicles – A System Developers Point of View, *Unmanned Systems* (Spring 1998): 15.

34. Cathy Handley, "Tiny Planes, Big Tasks," *Compressed Air Magazine Company* (Jul/Aug 1998): 14.

35. "A personal eye in the sky," The Economist (9 Jan 1999): 74. Technologists today can build a miniaturized video camera capable of producing a picture using 72,000 pixels. Pictures created from one million pixels will be available within the next two years.

36. Mark Hewish, "A Bird in the Hand," *Jane's International Defense Review*. (Nov 1999): 22.

37. *Ibid:* : 24. Cathy Handley, "Tiny planes, big tasks," *Compressed Air* (Jul/Aug 1998): 14.

38. Cathy Handley, "Tiny planes, big tasks," *Compressed Air* (Jul/Aug 1998): 14.

39. Davey Hazel, "Flow Cytometry of Microrganisms," http://144.124.112.69/thesis/tchap1.html.

40. Defence Research Establishment Suffield, "Canadian Integrated Bio/ Chemical Detection System (CIBADS)," www.dres.dnd.ca/Products/RD98002/ index.html

41. "What is Chromatograpy?" http://members.kr.inter.net/guesu/gs/a_introduction/chromatography.html

42. DRES CIBADS www.dres.dnd.ca/Products/RD98001/index.html.

43. U.S. Department of Defence, *Airborne Reconnaissance Sub-Domain Annex for the C^4ISR Domain - Draft Version 2.0*, from the Federation of American Scientists Internet Page (29 October 1997): 4-5.

44. Robert Wall, "Sigint Upgrades Nearing Deployment," *Aviation Week & Space Technolog*, (15 November 1999): 1-2.

45. Roy, J. and E. Bossé, Dept. of National Defence, *DREV-R-9719 : A Generic Multi-Source Data Fusion System* (Ottawa : Research and Development Branch, June 1998): 20.

46. Taubenberger: 28-1. "Advanced Tactical Workstation (ATW) for Windows," *Janes's C4I Systems 1999-2000* (24 June 1999).

47. "Advanced Tactical Workstation (ATW) for Windows," *Janes's C4I Systems 1999-2000* (24 June 1999).

48. "Wireless Review," Overland Park (Jun 15, 2000) Vol. 17, No 12.

49. United States Airforce, *Joint Warfighting AY 2000* (Maxwell Airforce Base: Air University 2000): 16.

50. *Ibid:* 16.

COMMAND AND CONTROL FOR ISR

Syndicate 6: Major Douglas Baird, Major Marc LeBlanc (Chair), Major James Macaleese, Major Kevin McCarthy, Major Dave McComb, Major Don Mulders, Major Shirley Neville, Major Jennifer Thompson, Major Herb Wesselman

> "The technological component of war can never fully account for the dynamic interaction of human beings, thus war will remain predominantly an art, infused with human will, creativity, and judgement."[1]

INTRODUCTION

Through much of recorded history, significant technological advances have sometimes been credited with causing Revolutions in Military Affairs (RMAs).[2] Some argue that application of current, rapidly evolving information technologies will also result in an RMA. Whether or not this is accurate is a matter of considerable debate. What is generally agreed, however, is that the future battlespace will look very different from that which Western military forces trained for during the Cold War. Certainly one of its defining characteristics will be the predominance of, and dependence on, intelligence, surveillance, and reconnaissance (ISR) assets.

Military commanders' ability to command and control forces has been long crucial to their success. The architecture that makes up command and control (C^2) can be considered under four main elements: technology, doctrine, organization, and human.[3] Attention to all these elements is necessary for success, but the human element must remain dominant, as this paper will attempt to illustrate. Unfortunately, the recent enthusiasm for technological advances has elevated the importance of the technological component, often at the expense of the human one. This phenomenon has resulted in a situation where the command dimension of C^2 has, in many ways, become subordinate to the control dimension.[4]

To rectify this situation, the operational C^2 architecture must be revisited, with the emphasis placed squarely on the human dimension. Through an examination of the various elements of C^2 architecture in the context of the future battlespace, this paper seeks to provide insight into the C^2 changes necessary to enhance the future operational commander's ability to exercise command and control.

INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE (ISR)

ISR operations have been described as "integrated capabilities to collect, process, exploit, and disseminate accurate and timely information that provide the battlespace awareness necessary to successfully plan and conduct operations."[5] Although it has been the focus of much attention of late, the importance of ISR is not a new concept. The quest for knowledge of the enemy's intentions, capabilities and vulnerabilities has been a priority of commanders throughout history. What has changed, however, is the capability to perform this critical function. Needless to say, ISR techniques have advanced considerably since the days when the military commander would survey the battlefield from atop a nearby hill. However, this early premise of taking advantage of an elevated position has been applied to the extreme in modern warfare, with the advent of airborne ISR platforms and space-based assets.

As technological progress continues, ISR assets will become increasingly pervasive and will influence all aspects of the future battlespace. For the purpose of this paper, the term "ISR" will be used in the context of a key component of the future battlespace that will ultimately result in the collection of a significant amount of data. This data must be analysed, processed and converted into accurate and timely information if it is to provide operational commanders with the requisite situational awareness that will allow them to make the right decisions at the right time. This last step will continue to be critical for success in the future battlespace environment.

FUTURE BATTLESPACE

It is clear that the application of ISR technology will have a significant impact on this environment, creating what is being referred to as a "single integrated battlespace." But the defining characteristics of this environment will also be influenced by political, economic, demographic, and many other considerations. In consequence, the future battlespace is likely to be global in scope and could involve operations ranging from the seabed to space. These operations could also extend across the spectrum of conflict from peace to war and, because of the unpredictability of the threat,[6] military forces will need to be capable of quickly shifting up or down this spectrum at any time during an operation. With the increasing threat of adversarial forces employing asymmetric strategies, which could include the use of weapons of mass destruction, the future battlespace will be more complex and non-linear. Additionally, the expanding use of cyberspace for the passage of information will add a new dimension to the battlespace with a host of additional threats and opportunities.[7] For political and economic reasons, future conflicts will probably continue to be fought as coalition operations, with all their inherent challenges. The current aversion in the West to casualties and collateral damage will probably continue so that future conflict will be increasingly dependent on manoeuvre and long-range precision munitions. Improved situational awareness will allow operations to be conducted at an accelerated pace, further increasing dependence on accurate and timely information. As it becomes more affordable and accessible, advanced military technology and weapon systems will be widely available to all players, considerably increasing the threat posed by both developing states and non-state actors. At the same time, however, the ability to operate against a "low-tech" threat must also be retained.[8]

In short, future commanders will be faced with many difficult challenges. The complexity and unpredictability of the future battlespace, and in particular the availability of ISR assets, will increase the importance of information superiority in seeking to attain a high level of battlespace awareness.

TECHNOLOGY

Technological advancements have led to the development of a multitude of sophisticated sensors with which to view the battlespace. In particular, airborne and space-based ISR systems provide the ability to look across the breadth and depth of the entire battlespace. It is now not only possible to collect more data than ever before, but also to transmit it to users in real or near-real time through digital communication networks. A combination of advanced ISR platforms, improved information-processing technology, and high-speed, secure communications has the potential to provide the commander with significantly improved situational awareness. In addition, because modern communications allow for the simultaneous transmission of this information to all levels of command, it is now technically feasible to achieve the elusive "Common Operating Picture" across the entire strategic, operational, and tactical environments. This level of situational awareness, when combined with other technological advances that allow for rapid response, including "sensor-shooter" technology, allows the commander to increase the pace of activity and thus to stay inside the enemy's decision cycle. Looked at in isolation, these technological advances would seemingly create the conditions necessary for victory in any battlespace.[9]

Unfortunately, as was demonstrated recently during the Kosovo conflict, the notion of information superiority may be nothing more than a myth[10] and there is concern that the efficient collection of data, rather than providing a sure path to victory, may actually be interfering with the commander's ability to exercise command.[11] These concerns are partially the result of information overload. Although some have tried to dismiss this phenomenon as "merely a function of poor presentation,"[12] the reality is much more complicated. Experience is showing that the collection of the data is in many ways the easy part of the information superiority challenge. The more difficult part is efficiently analysing and converting the vast quantities of data into information at the right time and in the right format for the commander to make decisions. If this is not done properly, information overload can lead to a situation where the commander and his staff wait for all the information to come in, only to find that the information flow never stops, or that the flow is delayed or absent.[13] An additional consequence can be a blurring of the line between fiction and reality, and the lack of ability in many users to discern the difference.[14] Therefore, the inherent risk of information overload is that commanders will either fail to make a decision to act when they should, or will make a poor decision resulting in inappropriate action. In either case, the mission may be compromised because the technology, although impressive in its own right, does not meet the basic needs of the commander.

Continued advances in ISR technology are impressive and have led to much speculation on its potential impact on the future battlespace. It appears that, given enough time and money, the potential on the technology side is unlimited. The challenge is to not lose sight of the need to address the rest of the C^2 elements. This is particularly true of the human element, which will always represent the focus and, to some degree, the limiting design factor of C^2 architecture.

UNDERSTANDING COMMAND AND CONTROL

Command and control is a phrase that is so ingrained in the fabric of military consciousness that it is easy to forget that the elements of "command" and "control" are separate entities with very distinct connotations and roles. Of course, NATO and all Western military forces use official definitions to describe command, control, and C^2.[15] Despite these definitions, there remains the potential for confusion over this important terminology.[16] This motivated Ross Pigeau and Carol McCann to write an article, entitled "Putting 'Command' Back in Command and Control: The Human Perspective," where they portray C^2 as suffering from a form of schizophrenia, or split personality. They assert that within this relationship "C^2 as control is emphasized at the expense of C^2 as Command."[17] Symptomatic of the emphasis on control and the confusion surrounding the basic terms of C^2 is the seemingly unending extension of acronyms attempting to represent what should simply be referred to as C^2. Using unwieldy acronyms such as C^4ISRFTW [18] simply exacerbates the problem and further diminishes the most important "C" in the string – "Command". These problems, coupled with the complexity of the future battlespace and the new digital-centric culture of the information age, emphasize the need to revisit the way in which military forces command people, control forces, and develop C^2 systems.

Command is a uniquely human behaviour that is manifested through the structures and processes of control, not the other way around. As a creative act, command is the realization of human potential from which military power and effectiveness is derived. Pigeau and McCann emphasize the human and creative dimensions of command; therefore, they define command as "the creative expression of human will necessary to accomplish the mission."[19] Declaring human creativity as the foundation of command is consistent with the long history of the "art of war." When applied against the backdrop of the complex and unpredictable future battlespace, the human dimension is not only desirable but also essential.

Unlike command, control is not a uniquely human activity. Rather, it is associated with equipment, structures and processes.[20] The control function is a tool of command that may be altered to suit the needs of the mission. Pigeau and McCann define control as "those structures and processes devised by command to manage risk." The key tenet of this definition is that control must ultimately depend on command and, moreover, is incomplete without command. [21] Control mechanisms seek to invoke and control action aimed at reducing uncertainty and increasing the speed of response to events. The reduction of uncertainty implies an increase in order, and this in turn offers a rational basis for selecting and then optimizing appropriate courses of action. In essence, this describes the process where raw data is collected, processed into information, synthesized to a level of understanding and, finally, converted into knowledge. It is important to note that although control mechanisms are used to carry out the first two steps in this process, only a commander, or human, is capable of understanding and possessing knowledge. These final two steps are the most important because they are required before an informed decision can be taken. This reinforces the contention that the human command must retain primacy over control.

When command and control are combined to form C^2, an interesting dynamic between these two elements is revealed. Pigeau and McCann have defined C^2 as "the establishment of common intent to achieve co-ordinated action."[22] But a paradox exists in that control is created both "to facilitate creative command and to control command creativity."[23] The challenge, of course, is to find the right balance between promoting human creativity on the one hand and using control mechanisms to effectively manage risk on the other. This balance will necessarily be situation-dependent, but for reasons already presented command creativity should be given primacy.

Despite the logic of this argument, the recent focus on technology may have compromised this important principle. The enormous enthusiasm for developing more efficient and powerful control systems has reached a point where these systems are being pursued at the expense of the command dimension of C^2. To best meet the challenges of the future battlespace, the command and control balance needs to be restored.

COMMAND AND CONTROL IN THE FUTURE BATTLESPACE

Thomas Czerwinski, in his article "Command and Control at the Crossroads," outlines three methods of command. Command-by-direction is the oldest method and refers to the situation where a commander personally directs all his forces. In the mid-18th century, when armies became too large for one person to direct, command-by-direction was replaced by a command-by-plan methodology that continues today within most modern military forces. The command-by-plan method is highly centralized and is characterized by "trading flexibility for focus."[24] Czerwinski describes this method as a "futile quest to will order upon chaos."[25] The third command methodology is referred to as command-by-influence, a method epitomized by the famous German "*Auftragstaktik*," or "mission type orders." This is characterized by a decentralized approach that begins with a clearly articulated statement of the commander's intent and then relies upon the initiative and competence of subordinates for successful execution.[26]

Of the three command methodologies, the command-by-influence method has been recognized as the most appropriate command philosophy for the complex and unpredictable future battlespace.[27] Such a strategy would align itself well with information age warfare and conflict resolution and would assist in refocusing command and control on the human. With this methodology the emphasis is placed on educating and training a force to exercise initiativeand exploit opportunities to carry out the commander's intent. It allows lower echelons freedom of action and encourages creativity. This basic change in philosophy, coupled with a new human-centric C^2 system, would infuse in subordinate formations both confidence and competence in carrying out their mission. Ideally, a new C^2 system should allow all subordinate levels to operate semi-autonomously with non-intrusive oversight.

It appears that the US Army, with its Force XXI and digitized battlefield initiative, and the US Navy, with its network-centric warfare initiative, are trying to move in the direction of a command-by-influence methodology. They are planning to use information technology to provide a "Common Operating Picture" to all levels of command that will support a decentralized structure. Although their efforts are commendable, there is much more to a change of command methodology than simply obtaining the necessary technology.[28]

Indeed, it is quite possible that instead of laying the foundation towards a more decentralized command structure, advanced information technology will drive the command philosophy back towards the command-by-direction method. When the future commander's unprecedented view of the entire battlespace and advanced communication capability is combined with today's prevalent zero-fault mentality, the temptation for micro-management may be overwhelming. Resisting this will require no less than a fundamental change in culture, without which command-by-influence will not work, regardless of the available technology. As noted in a recent *US Marine Corps Gazette* article, "complex war defies microscopic command and control and instead requires a macroscopic approach that controls the system by influencing the system parameters and boundary conditions."[29]

Another challenge for the command-by-influence method can arise from difficulty in formulating a commander's intent that will alone provide the necessary and sufficient direction to carry out the mission. Ambiguous political direction can hamper this effort, but the real challenge again lies in today's military culture. The current command-by-plan philosophy depends much more on explicit intent, where orders and briefings are passed publicly. In a command-by-influence scenario, the implicit intent, or the unspoken expectations, will play a much larger role.[30] This scenario involves a command climate where "trust, confidence, motivation, creativity, initiative, pride, discipline and esprit de corps are developed."[31] This implicit intent is acquired through years of cultural immersion and experience and cannot be taught over a short period of time.

Although a command-by-influence philosophy is generally best suited to the challenges of the future battlespace, situations might well arise where a more centralized command methodology would be appropriate. However, these apparently distinct command methodologies are not mutually exclusive. With a disciplined military force trained to operate using a command-by-influence philosophy, it is possible to revert relatively quickly to a more centralized command arrangement when the situation dictates. Unfortunately, the reverse does not hold. Forces accustomed to a centralized command structure cannot easily adjust to a command-by-influence methodology. As previously outlined, military forces operating in the future battlespace will quite likely require the capability to adjust quickly in a dynamic environment where the intensity of operations may frequently vary along the spectrum of conflict. Therefore, a level of flexibility and adaptability will be required that only a command-by-influence methodology can provide.

Clearly, re-establishing command as the primary element of C^2 and developing a culture where a command-by-influence philosophy can succeed are long-term endeavours. These important

issues thus need to be addressed as soon as possible if our military forces are to be best prepared for the complex challenges of the future battlespace. More importantly, the commander, or human, leading these forces must be given special attention to ensure that he also is prepared for the future.

HUMAN

Despite "tremendous advancements in technology, organizations, and doctrine, command is still very personal."[32] Human intuition is as much a part of command today as it was in the past. It is true that new technologies might alter the command environment, but it remains that "command potential and effectiveness is limited by the personal attributes of the commander. In this respect at least, the essence of command is unchanged."[33] For this reason, it is essential that the needs of the human be evaluated continually to ensure that he is prepared and supported to meet the challenges ahead.

As a manifestation of command, a commander is a human who works within a defined military position. After some years of study, Pigeau and McCann have articulated their definition of a commander as "a position/person combination lying on the balanced command envelope with special powers to enforce discipline and put military members in harm's way."[34] This balanced command envelope for commanders at any level represents their command capability and is defined by a combination of three independent dimensions: competency, authority and responsibility.[35] If any of these three elements are compromised, the position/person and the designation "commander" are also compromised. Defining command capability in this fashion also further reaffirms the unique role of the human in command, as only a human can accept responsibility and be held accountable.[36]

Commanders require four levels of decision support. They include data gathering, presentation of information in a way that is easily understood, incorporation of "advice" from other sources, and support for the psychological and physiological needs of the human.[37] If any one of these levels is neglected, the effectiveness of the commander will be compromised. Unfortunately, as previously highlighted, the recent enthusiasm for technology has led to the development of systems without due regard for humans and their immediate needs. For a C^2 system to be effective, the needs of the human must be considered first. Human factors engineering considerations, such as those to address the man/machine interface, must be examined and resolved in the early stages of the design of any system and not dealt with as an afterthought. If the vast amounts of data that are being collected cannot be converted into useful information and presented to the human in a way that he can readily digest to form knowledge and understanding, the command process will not be enhanced and may even be hindered.

The level of decision support that is probably the most important, but arguably has been given the least attention, is that for the psychological and physiological needs of the human. Not least this requires an understanding of how a person is likely to react in an extremely high stress environment, when faced with challenges that include such stressors as information saturation, complex technology, foreign cultures, a pervasive media, political interference, and a host of other factors. Also of great importance is an understanding of that most human characteristic, emotion. Effective emotional support is required to maximize the commander's command and leadership performance by encouraging and enhancing his creativity, will, and interpersonal skills. Finally, in a world where computers run twenty-four hours a day, it is sometimes forgotten that people cannot. Without proper attention to the physical needs of the human, this key component of the C^2 system will not be capable of performing at his best.

It is thus clear that proper care of humans during conflict is essential. Equally important, however, is their prior training and development. This begins with recruiting, where people with the right technical and emotional aptitudes for the ISR-dominant battlespace must be recruited. Throughout their careers, military personnel must be provided with education and training, both mental and physical, to prepare them for a command-by-influence philosophy in the setting of the complex and unpredictable battlespace of the future. As mentioned previously, a very important part of this development is the nurturing of a culture that not only accepts but also encourages creativity, initiative, and the use of implicit intent.

If the human is to occupy his proper place in the middle of the C^2 architecture, it is critical that he not become the weak link in the system. Regardless of how much technology a military has at its disposal, if the human in the middle is not capable of making the right decision at the right time, the technology will count for nothing. Even if afforded the proper priority, however, commanders cannot succeed on their own. It is essential that they be surrounded by the right kind of organizational structure.

ORGANIZATION

Organization is an important element of the C^2 architecture because it provides the commander with his decision support framework. Ideally, an organization should be an extension of individual commanders and properly reflect their command methodology.[38] With advances in information technology, this principle can be lost in the rush to obtain the latest technological innovation. It must not be forgotten that the organization exists to serve the commander and it is the commander that should dictate the organizational structure, not the latest technological development or other supporting influences. Respecting this priority will help ensure that the organizational structure reflects an appropriate balance between command and control.

Future organizations will probably require a hierarchical structure similar to those of today. But to respond adequately to the complex and unpredictable environment that is expected in the future, organizational flexibility and adaptability will be key. These characteristics will complement a command-by-influence philosophy, one that may lead to an increased span of control and flattened organizations to improve the speed of information flow.[39]

Organizations must also reflect the characteristics of the most likely future; that is, they should be both joint and capable of operating effectively in a coalition environment. In this instance, joint must mean more than simply two or more services working together. Organizations must be truly and synergistically joint in all regards if they are going to keep up with the demands of the single integrated battlespace. The need for interoperability within a combined or coalition organization will pose unique challenges to employing a decentralized command philosophy unless all contributors have emerged from a similar national culture. Such challenges must be recognized and resolved well in advance.

One of the greatest challenges in preparing for the future battlespace is fostering the necessary organizational culture. Indeed, experts in this field maintain that a leader's most important function in an organization is the creation, management and, sometimes, the destruction, of organizational cultures.40 Preparing organizations for a command-by-influence philosophy will not be a simple affair; it will instead require deep cultural changes. For example, to prepare for a command-by-influence methodology, organizations will need to reward creativity and initiative, move away from today's zero-fault mentality, and recognize the value of allowing people to learn from their mistakes. At the same time, the current tendency to reward "micro-managers" and "workaholics" should be re-evaluated. Although these deeply rooted cultural norms will take a concerted effort over a long period of time to adjust, this is the type of challenge that must be confronted if military forces are serious about preparing for the battlespace of the 21st century.

Regardless of the actions that military organizations take to prepare for the future, flexibility and adaptability should remain the fundamental tenets. For this reason, a key component of any effective C^2 system will be its ability to learn while it executes its missions. To do this, staffs need to practice not so much *what to do* in conflict, but *how to learn quickly* what to do in conflict.[41] Doctrine will play an essential part in maintaining the fundamental organizational principles of flexibility and adaptability.

DOCTRINE

Doctrine, as it applies to C^2 in the ISR-dominated battlespace of the future, should be a series of principles, theories, and policies that guide operational commanders. Like the human element, doctrine often receives scant attention in the rush to acquire and field new technologies. This neglect can be a costly mistake because "absent a strong enabling doctrine, the full potential of any technological improvements will never be reached. In the case of [C^2] systems, increased speed, timeliness, and accuracy may have serious detrimental consequences if integrating doctrine is not in place."[42]

Doctrine designed for the future battlespace should be consistent with the other elements that make up C^2 architecture. This requires that doctrine be truly joint, rather than simply a rehashed version of individual service doctrine. However, a balance will have to be found to ensure that this joint doctrine is "authoritative enough to promote inter-service synergy, while … remaining contingent enough to encourage continual innovation."[43] Doctrine should also be compatible with that of our allies to facilitate interoperability in coalition operations.

Doctrine should also underscore the primacy of the human in the C^2 process. To support a command-by-influence philosophy, doctrine must be true to its definition of being general in nature, while leaving the necessary room for interpretation that is fundamental to success in a decentralized command structure. Well-written doctrine will play a critical role in the cultural nurturing that is so important to prepare people for the unique challenges of the future. Finally, as a result of the rapid advancement of technological innovation, it will be necessary to employ simulation and experimentation to not only facilitate and validate the incorporation of ISR technology into C^2 doctrine, but also to continually optimize its in-service employment.

THE RISK OF THE STATUS QUO

The future battlespace will punish harshly any military force that does not properly prepare in advance. This preparation must start with an acknowledgement that the current C^2 structure needs to be revisited. Furthermore, any review must pursue a multilateral approach that addresses all four elements of C^2 architecture: technology, organization, doctrine, and human. But it is the human element that must be given the priority. If the current trend of technology dictating to the other elements continues, military forces may find themselves in a very inhospitable environment where advanced technology and expensive equipment do not adequately meet the needs of commanders. This will compromise their ability to make timely and accurate decisions, undermining the very essence of successful command.

Indications that military forces are starting to move towards a command-by-influence philosophy are encouraging. But if the necessary cultural adjustments are not made concurrently, the reality may more closely resemble a centralized command-by-direction methodology. Such an approach will stifle the very creativity and initiative that will be fundamental to success in the complex and unpredictable battlespace of the future. Because of the need for long-term cultural redirection to properly effect these changes, a thorough review of C^2 architecture should be conducted as soon as possible. If the objective is to succeed in the future battlespace, retention of the status quo is not an option.

CONCLUSION

The future battlespace will in part be shaped by a significantly increasing dependence on ISR assets, which will create a single integrated environment characterized by speed, complexity, vast amounts of data, and unpredictability. To prepare for the significant and unique challenges that lie ahead, military forces should examine and update the technology, organization, doctrine, and human elements of their current C^2 architectures.

Preoccupation with scientific advancement has resulted in the technology element overshadowing other elements of C^2 architecture. Although all elements are important, of greatest concern is lack of attention being given to the most critical element of C^2, the human dimension. This neglect has reversed the natural order of the C^2 relationship and resulted in a situation where the command side of the C^2 equation has become subordinate to the control side.

Any successful C^2 system must first reverse this trend by placing the human, or command, element at the core and surrounding it with the appropriate control mechanisms designed to satisfy its needs. This balance between command and control should be dictated by a command methodology that is best suited to the conflict environment. In the battlespace of the future, flexibility and adaptability will be critical and a command-by-influence philosophy would thus provide the commander with the best chance for success. However, technology alone cannot bring about such a far-reaching change in command philosophy. Instead, it will require a long-term effort that will fundamentally alter the current military culture.

Regardless of the changing battlespace and continuing technological advancements, command will remain a uniquely human behaviour. For this reason, any evaluation of a C^2 system must begin with the human, or the commander. If commanders' needs are not given the appropriate priority, their ability to exercise command and control will be compromised and no amount of technology will be able to overcome this failure. The commander's vision and command methodology must be supported by an appropriate organizational culture and structure, and be properly reflected in the operational doctrine.

The future success of any military force will be contingent on its understanding of C2 and the unique relationship between command and control. As well, its ability to recognize the requirement to take a multilateral approach in updating their C2 structure against the anticipated threats and challenges of the future ISR-dominated battlespace is equally critical. Only those military forces that are able to look past the deceiving lure of technology, to clearly see the commander, or human, as the rightful nucleus of their C2 system, will be in a position for success in the battlespace of the 21st century.

Endnotes

1. Hoffman, F.G., "An Alternative to the 'System of Systems'," *Marine Corps Gazette* 84-1 (Jan 2000): 22.

2. The Tofflers describe an RMA in *War and Anti-War* as follows: "a true revolution changes the game itself, rather than changing elements within an existing game. The new changes normally occur simultaneously and include the rules, equipment, size, organization, training, doctrine and tactics." By this demanding measure, the Tofflers believe that true military revolutions have occurred only twice in history and, interestingly, both in the last half of the 20th century. They identify first, the first manned mission in space and second, when the parameters of range, lethality and speed reached their outer limits simultaneously.

3. Although different variations and descriptions of the elements of C^2 exist, the four elements listed are commonly used to adequately cover the dimensions of C^2, as presented in DND, *Canadian Defence Beyond 2010: The Way Ahead* (Ottawa: RMA Operational Working Group, 31 May 1999).

4. This theme is developed in Ross Pigeau & Carol McCann, "Putting 'Command' Back Into Command and Control: The Human Perspective," Command and Control Conference, Ottawa, 25 Sep 1995.

5. US, Department of the Air Force, *Air Force Doctrine Document 2-5.2, Intelligence, Surveillance, and Reconnaissance Operations*

(Maxwell AFB, Alabama, HQ Air Force Doctrine Center, 21 April 1999): 1.

6. Although ISR assets are designed to help provide the Intelligence required to make potential threats more predictable, the number and diversity of potential threats, combined with their possible range and movement along the spectrum of conflict, make unpredictability an inevitable characteristic of the future battlespace.

7. Cyberspace is defined in Bob Cotton, *The Cyberspace Lexicon: An Illustrated Dictionary of Terms from Multimedia to Virtual Reality* (London: Phaedon, 1994) as "the virtual space of computer memory and networks, telecommunications and digital media."

8. These characteristics of the future battlespace are reflected in DND, *Shaping the Future of the CF: A Strategy for 2020* (Ottawa, Jun 1999) and are consistent with the vision of the future battlespace shared by most Western nations.

9. The potential benefits of technology, including speed and situational awareness, along with their potential pitfalls are discussed in Barnett, Thomas P.M., "The Seven Deadly Sins of Network-Centric Warfare," *United States Naval Institute Proceedings* (Jan 1999).

10. This theory is explained in Thomas, Timothy L., "Kosovo and the Current Myth of Information Superiority," *Parameters* (Spring 2000).

11. Pigeau & McCann, "Putting…," 3.

12. Branstetter, Terry L., "The Realities of Information Overload", *Marine Corps Gazette* (Sep 1999): 101.

13. Henderson, Steve, "Attack! (send): Computer Overdependence in Combat Units", *Journal of Electronic Defense* (Jan 2000): 46.

14. Ackerman, Robert K., "Intelligence Funding Lags Growth of Global Menace", *Signal* (Dec 2000): 34.

15. *CF Operations, B-GG-005-004/AF-000* (Ottawa, Oct 2000) defines command as "the authority vested in an individual of the armed forces for the direction, coordination and control of military forces." Control is defined as "the authority exercised by a Commander over part of the activities of subordinate organizations, which encompasses the responsibility for implementing orders or directions." C^2 is defined as "the process by which Commanders plan, direct, control and monitor any operation for which they are responsible."

16. Pigeau & McCann, "Putting…," 2-3.

17. Pigeau & McCann, "Putting …," 2.

18. C^4ISRFTW stands for command, control, communication, computers, intelligence, surveillance, reconnaissance, for the warfighter.

19. Ross Pigeau & Carol McCann, "Clarifying the Concepts of Control and of Command," Command and Control Research and Technology Symposium, Newport, RI, 29 Jun-1 Jul 1999: 4.

20. Pigeau & McCann, "Clarifying…," 3-4.

21. Pigeau & McCann, "Clarifying…," 4.

22. Pigeau & McCann, "Clarifying…," 1.

23. Pigeau & McCann, "A Conceptual Framework for Discussing Command and Control," DCDS Retreat, Ottawa, Feb 2001: 4.

24. Thomas J. Czerwinski, "Command and Control at the Crossroads," *Parameters* (Autumn 1996): 124.

25. Czerwinski, 124.

26. Czerwinski, 124.

27. For example, both Czerwinski and Van Creveld recognize the command-by-influence methodology as superior, Czerwinski, 125.

28. Concerns with the network-centric warfare initiative are outlined by Thomas P.M. Barnett in his article "The Seven Deadly Sins of Network-Centric Warfare," *United States Naval Institute* (Jan 1999). The US Army's Force XXI initiative could be subject to similar pitfalls.

29. Schmitt, John, "Command and (Out of) Control: The Military Implications of Complexity Theory," *Marine Corps Gazette* (Sep 1998): 57.

30. Pigeau and McCann address the difference between explicit and implicit intent in "Redefining Command and Control," in C. McCann & R. Pigeau, eds., *Human in Command*, New York: Plenum Press, 2000: 163-184.

31. Forgues, Pierre, Colonel, "Command in a network-centric War," Canadian Forces College, Dec 2000: 18/34.

32. Paul T. Hartig, "The Digital General: Reflections on Leadership in the Post-Information Age," *Parameters* (Autumn 1996): 133.

33. Forgues, 20/34.

34. Pigeau & McCann, "What is a Commander," Human in Command Workshop and Symposium, The Netherlands, 5-8 Jun 2000: 11.

35. Pigeau & McCann, "What…,"4.

36. The future possibilities of Artificial Intelligence are beyond the scope of this paper.

37. These four levels were discussed during a meeting with Pigeau and McCann at DCIEM on 24 Jan 2001. In this context, "advice" infers a higher level of information, beyond "knowledge" into the realm of "understanding."

38. Bell, William F., "The Impact of Policies on Organizational Values and Culture," Joint Services Conferences on Professional Ethics (January 1999): 1 of 20.

39. David F. Bean, "Advanced Technology and the Future of Command and Control," diss., Department of Joint Operations, Naval War College, Newport R.I., 1997.

40. English, Allan, "Contemporary Issues in Command and Control," DCDS Retreat, Ottawa, Feb 2001.

41. Mark Mandeles, et al, Managing "Command and Control" in the Persian Gulf War (Westport, CT: Praeger, 1996): 6.

42. Bean, 1.

43. Czerwinski, 131.

AFFORDABLE ISR ALTERNATIVES FOR APPLICATION IN THE CANADIAN AIR FORCE

Syndicate 7: Major S. Allan, Major W. Barlow, Lieutenant-Colonel B. Boland, Major S. Doyle, Major P. Keddy (Chair), Squadron Leader R. Keir (RAAF), Major G. Loos, Lieutenant-Colonel M. Moore, Major A. Vogler (GAF)

INTRODUCTION

The Canadian Forces' (CF) success in conducting operations will continue to depend on its ability to exploit and benefit from the emerging capabilities being developed and fielded in the area of Intelligence, Surveillance and Reconnaissance (ISR). ISR developments are considered a critical aspect of the ongoing Revolution in Military Affairs (RMA), where current and future military commanders are expected to exercise information dominance in their assigned battlespace and thus shorten decision-action cycles to more effectively apply combat power. Some strategic direction with respect to ISR development has been provided for the CF as a whole; however, there is little evidence of a comprehensive approach to guide the air force in terms of an overarching vision, or capability deficiencies and/or requirements identification. This will increasingly put the air force at risk in terms of interoperability and operational relevance as the CF's other services and closest allies continue to plan, develop, implement and exploit ISR capabilities.

This paper does not propose an air force capability deficiency in a direct or methodical sense; however, it does briefly provide the RMA context and general ISR background prior to exploring and analysing selected "affordable" options that would enhance the CF air force capability to exploit ISR in support of CF operations. Given the breadth of the subject area, the scope for options is limited to mature sensor technologies that will promise "good value" for air force mission performance at the operational level. "Affordable" will be defined as those options requiring an initial capital expenditure of between 3 and 100 million dollars in Canadian funds, fitting into the category of "Non-Strategic Capital."1 To maintain military operational relevance and improve situational awareness in the increasingly complex battlespace of the 21st century, the Canadian air force must exploit affordable ISR alternatives including sensors which can be integrated with the existing air force inventory, on unmanned aerial vehicles (UAVs), and on commercial earth observation satellites.

THE REVOLUTION IN MILITARY AFFAIRS

Reduced to its simplest, an RMA is a "major change in the nature of warfare brought about by the innovative application of new technologies, which when combined with dramatic changes in military doctrine and operational and organisational concepts, fundamentally alters the character and conduct of military operations."[2] The enabling element of the RMA has been the current information revolution along with major advances in sensor technologies and avionics. "The current RMA includes achieving enhanced battlespace awareness with advanced intelligence gathering, surveillance and reconnaissance assets. These may include surveillance aircraft, satellites and unmanned aerial vehicles."[3] These options have the potential to grant the military almost unlimited amounts of information acquisition, processing, storage and transmission capability in packages that are small and inexpensive.

"Air power's priority for the new millennium is the knowledge edge – exploiting information technology so we can use our relatively small forces to maximum effect. That means giving priority to investments in the three areas of intelligence, command and control systems and reconnaissance."[4] Western countries are responding to the RMA in a number of ways; however, the strongest area of technological focus is on battlespace awareness and control. "Successful operations are no longer primarily a function of which nation puts the most personnel, equipment and technology into the battlespace, but rather which has the best knowledge about that battlespace."[5] Countries are therefore investing significantly in measures to increase their ISR capabilities.

Intelligence, Surveillance, and Reconnaissance

"Intelligence, Surveillance, and Reconnaissance (ISR) is an integrated capability to collect, process, exploit and disseminate accurate and timely information that provides battlespace awareness necessary to successfully plan and conduct operations."[6] ISR is aerospace power's oldest mission area, dating back to balloons used to observe the enemy during the French Revolution. Today, as in the past, militaries observe and analyse the impact of a wide variety of events and convey intelligence on the adversaries' capabilities and intentions. The goal of ISR operations is to provide precise, timely intelligence and reduce uncertainties in the decision making process.

"The information derived from surveillance and reconnaissance, converted into intelligence by analysis, is used to formulate strategy, policy, and military plans; to develop and conduct campaigns; and to carry out military operations."[7] In general, ISR supports operations by providing information and intelligence to a variety of command levels ranging from national to unit level decision-makers. Additionally, in order to facilitate decision-making processes, key adversary targets and capabilities must be detected, located and identified by ISR assets.

In general terms, there are three main ISR capabilities: airborne early warning and control (AEW&C), signals intelligence (SIGINT), and imagery intelligence (IMINT). These capabilities may operate within the entire spectrum of the levels of war and conflict and be accommodated in virtually all types of aircraft or space-based vehicles. The sensors on these platforms may include IMINT (electro-optical [EO], infrared [IR], or synthetic aperture radar [SAR]), SIGINT, radar with air and surface search modes, or even visual observation by aircrew or human intelligence collectors. ISR sensors may thus be active (that is, they emit energy which is reflected off the target) such as AEW&C or SAR, or passive (that is, they rely on electromagnetic emissions produced by the target such as electronic signals or light), for example SIGINT or EO imagery.[8]

Today, EO imagery is generally of high resolution and is suitable for a wide range of military purposes such as target intelligence, technical intelligence, and battle damage assessment. EO imagery may only be collected during daylight hours in good weather. IR imagery allows the collection of imagery at night; however, poor weather negates its effectiveness. IR imagery is useful for intelligence analysis of activity such as thermal emissions from engines and power plants, and thermal differentials between tarmacs with and without aircraft. SAR imagery may be collected by day and night in all weather conditions. SAR imagery is useful for wide area surveillance, indicators and warnings and camouflage detection.

SIGINT falls under the broad umbrella of electronic reconnaissance, which is defined as "the detection, identification, evaluation and location of foreign electromagnetic radiation emanating from other than nuclear detonations or radioactive sources."[9] SIGINT is further divided into electronic intelligence (ELINT) and Communications Intelligence (COMINT). ELINT is the "technical and intelligence information derived from foreign, non-communication electromagnetic radiation emanating from other than nuclear detonations or radioactive sources."[10] COMINT is "the technical and intelligence information derived from foreign communications by other than the intended recipient."[11]

As ISR assets each have strengths and weaknesses, the key to their effective use is to ensure that the strengths of one capability overcome the weaknesses of another. As a general rule, active sensors normally *detect* and *locate*, while passive sensors normally *locate* and *identify*.[12] Passive sensors generally do not *detect*, as their fields of view are intentionally limited to increase system resolution. Therefore, to satisfy the *detect, locate* and *identify* functions, both active and passive sensors are required. Finally, the entire array of this information collected must be fused within an all-source intelligence assessment process and be distributed to various levels of command. This process is illustrated in Figure 1.

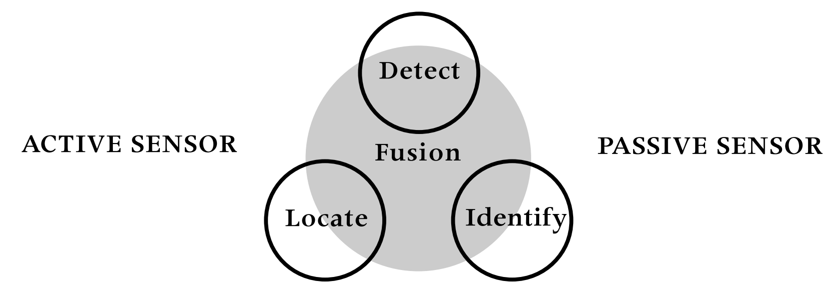


Figure 1. The ISR Model [13]

GUIDANCE AND DIRECTION

Strategic Guidance and Direction

The CF is mandated by the Canadian government in the *1994 Defence White Paper* to be a multi-purpose, deployable, combat-capable force with the ability to respond quickly to domestic and international crisis.[14] The CF's keystone strategic planning document, *Shaping the Future of the Canadian Forces: A Strategy* *for 2020* (*Strategy 2020)* expands on the *1994 White Paper* guidance and provides the strategic vision for the military into the 21st Century. Strategic Objective Three of *Strategy 2020* highlights the need for the exploitation of leading-edge doctrine and technologies to accomplish our roles as an innovative, relevant, knowledge-based institution.[15] Future military operations will be conducted at an accelerated pace, requiring rapid co-ordination of political and military objectives and increasing dependence upon information. Therefore, technological improvements contributing to the RMA should be evaluated and, where appropriate, introduced within the CF.

In light of this, the CF has been directed to develop ways to improve its ability to conduct ISR both nationally and in support of deployed operations. The current *Defence Planning Guidance 2001* (*DPG 2001*) draws from *Strategy 2020*, providing broad yet clear guidance for CF modernisation and ISR development. One major goal of *DPG 2001* is to field a viable and affordable force structure trained and equipped to generate advanced combat capabilities. In concert with this, the Canadian Joint Task List (CJTL) describes and relates the types of capabilities that may be required, to greater or lesser degrees, by the CF. The area of "Information and Intelligence" ranks "medium" in the CJTL, indicating a medium degree of desired capability in these areas at the operational and strategic level. Consequently, the DCDS has been instructed to develop a co-ordinated ISR plan to support operations by March 2002.[16]

Air Force Guidance

In the context of the rapidly changing military environment in general, and the national impetus to chart a coherent course for ISR development in particular, the Canadian Air Force is perilously at risk of "following" in a sphere where it has traditionally "led" from the earliest inception of air power. No overarching air force policy has been formulated to date that might assist air staffs to better identify requirements and thus more prudently focus scarce air force dollars on those technologies which both ascribe to the vision and offer good operational value. The ADGA Group, a think tank company hired for various tasks by the various defence directorates, was commissioned by the Directorate of Space Development (D Space D) to determine CF ISR requirements and comment on current ISR capabilities within the CF. ADGA has stated that "The Canadian Air Force has virtually no organic ISR ability to detect, classify, and identify ground targets," " Canadian aircraft do not have the most current data link equipment used by allies…. that will increasingly marginalise the utility of these aircraft in future mid-intensity conflict situations" and "The Air Force is almost entirely dependent on national level ISR or allies for almost all of its operations outside of Canada."[17]

Although ISR discussions continue at many levels, the potential for the air force to contribute meaningful "pieces" to the larger CF ISR "picture" will continue to be constrained without a coherent and orchestrated service approach. This approach must at once recognise both the unique advantages of air power as well as the complex and complementary nature of the ISR environment.[18] By way of comparison, other services are moving more swiftly in ISR development. The land force (LF) is sponsoring and articulating capability initiatives such as the LF Intelligence, Surveillance, Target Acquisition and Reconnaissance Capability (ISTAR)[19] and the Unmanned Aerial Surveillance and Target Acquisition System (UAS-TAS).[20] Similarly, the Navy has approached their ISR needs from a top-down, holistic perspective by generating a high level blueprint and moving to combine related projects and deficiencies into an omnibus ISR project.[21]

Given the absence of specific air force direction, this paper's exploration of affordable options will necessarily take a "capability-based" planning approach that will both examine some of the emerging ISR technologies and capabilities that are affordable, and that might fit well into an overall air force and CF plan. The focus has been narrowed to information *sensing* and/or *collecting*, fully recognising that other affordable options might exist in the larger contributing ISR processes of direction, analysis, fusion and dissemination. In order to gauge relative merit in terms of operational benefit, the options considered should be cast against the requirements identified in the CJTL. Annex B highlights those *operational* level tasks one might expect to be better accomplished with improved ISR.

Air force ISR initiatives should conform to the national guidance with respect to scenario based planning, and also contribute to the relevant Defence and Change Objectives in *DPG 2001*. Annex C provides a summary of the Force Planning Scenarios, and Annex D outlines the relevant *DPG 2001* objectives. The obvious national goal is to have a complementary, pan-service based approach to CF ISR requirements and capabilities. Notwithstanding the focus here on air force operational level capabilities, it must be understood that they would likely be employed in either a joint or combined scenario, where air power would serve the Joint or Combined Force Commander in the accomplishment of campaign objectives.

REVIEW OF SELECTED ISR CAPABILITIES

Having examined briefly the changing military environment, the resulting impetus for ISR advancement and the current state of strategic guidance available to air force planners, it remains to review some of the affordable ISR sensor alternatives currently available. CF aerospace doctrine, *Out of the Sun*, states that Aerospace Surveillance and Reconnaissance (ASR) involves the compilation of information on the assets and behaviour of an enemy or potential enemy by airborne, ground-based and space-based sensors.[22] This review considers options for manned aircraft, UAVs, and commercial observation satellites. For manned aircraft, capabilities already planned but unfunded are considered with other potential options. Two representative and relatively mature UAV options, the Global Hawk and the Predator systems, are examined for applicability in the CF context. Finally, exploitation of commercial satellite possibilities is presented as a potential complementary capability to military satellite system initiatives such as Polar Star whose cost, classification, and strategic nature are beyond the scope of this analysis. Similarly, AEW&C partnering possibilities with the US or NATO are not considered.

Existing Air Force Aircraft ISR Capability

At present the CF air force operates a number of platforms with limited ISR capabilities. These aircraft include the CF-18 Hornet jet fighter, the CP-140 Aurora maritime patrol aircraft, the CH-146 Griffon battlefield utility helicopter and the CH-124 Sea King maritime helicopter. Each of these aircraft is capable of collecting ISR-related information to some degree. Each, however, suffers from critical weaknesses or deficiencies that affect their overall varying capability to perform the ISR mission.

CF-18 Hornet. After two decades in service, the CF-18 is experiencing significant deficiencies related to avionics and sensors, which have markedly degraded its operational capability. Many of Canada's allies have updated, or are in the process of updating, their fighter aircraft with systems that render the CF-18 non-interoperable. With respect to ISR, the CF-18 lacks a secure jam resistant datalink and the APG-65 radar is readily jammed and is deficient in detection, tracking, and sorting of aircraft. The Nighthawk Forward Looking Infrared (FLIR), although primarily a target acquisition and laser guidance system, has an ISR capability by virtue of its IR imaging and recording capability.

CP-140 Aurora. "As stated in the *DPG 2000*, the Aurora fleet currently constitutes Canada's only strategic airborne surface (sea and land) surveillance capability."[23] The CP-140 was delivered in 1980 with a FLIR system that is "rapidly becoming operationally ineffective and increasingly difficult to maintain."[24] This FLIR system is operationally deficient because the crew is unable to identify targets at acceptable stand-off ranges at night and in inclement weather. Also, at time of purchase the Electronic Signals Measures (ESM) system was accepted with known deficiencies based on the expectation of an upgrade in mid-1980s that did not materialise due to financial constraints. The current system is therefore ineffective against contemporary emitters.[25] A third limiting system for ISR is the radar as it lacks an imaging capability and is therefore capable only of target detection. For close-in identification and evidence gathering, the aircraft is fitted with a fixed 70mm camera, gyro-stabilised binoculars in the cockpit and Night Vision Goggles (NVGs). All of these methods require the aircraft to be flown well within the adversary's weapon engagement zone. In summary, the ISR capabilities of the Aurora are very limited and it has "no long range stand-off target detection and identification capability."[26]

CH-124 Sea King. Similar to the Aurora, the Sea King has a very limited ISR capability. The Sea King's radar was fitted to the aircraft as a weather avoidance system with no means of target identification. A FLIR was installed to some aircraft when they were deployed to the 1990/1991 Persian Gulf War. The FLIR image can only be recorded by an operator hand-held camcorder for evidence gathering and post-flight analysis; there is no downlink capability. Again, the FLIR is very limited in range for vessel identification and similar to the Aurora, this is well within the range of most anti-air weapon systems. The only secure communications means is via a voice radio link. The ISR capability of the CH124 is marginally augmented by the use of stabilised binoculars and hand held digital camera. NVG equipment in the aft cabin is available for ship identification.

CH-146 Griffon. The CH146 is currently fully NVG capable and is equipped with a FLIR system with an onboard recording capability. This FLIR has been operationally evaluated and found to be deficient regarding its vulnerability in a threat environment, functionality in detection, recognition or identification of targets at an acceptable stand-off, and system integration with other aircraft sub-systems. The ISR capability of the CH146 crew is augmented by the use of stabilised binoculars, and hand held camera and video equipment.

Future Planned ISR Acquisitions

The following are current DND proposals to upgrade or replace existing capabilities:

CF-18 Hornet. The CF-18 Incremental Modernisation Project (IMP) will improve avionics supportability and provide interoperability, survivability and operational capability throughout the now extended lifetime of the CF-18. Although not necessarily initiated with ISR capability specifically in mind, the as yet unfunded sub-projects 0583 CF-18 Engineering Change Proposal (ECP) 583, 1816 CF-18 Datalink Project and 0273 Advanced Multi-Role Infrared Sensor (AMIRS) Project will improve the overall ISR posture of the platform. The ECP 583 will integrate the major components and most complicated systems of the IMP into the CF-18, including the replacement of the APG-65 primary radar sensor with the APG-73. The latter will have improved radar modes for ground mapping. The Datalink project will procure, integrate and install Link 16 compatible equipment into the CF-18 to achieve commonality, interoperability and employability with major coalition participants. The ISR benefit will be the ability to share sensor information with other aircraft, AEW&C platforms, and ground-based receiving stations. Although designed principally to improve targeting capability, the AMIRS project aims to acquire a new IR sensor that will be supportable, interoperable and more operationally capable.

CP-140 Aurora. The CP-140 Aurora Incremental Modernisation Project (AIMP) includes a number of ISR sensors and capabilities. These include an upgrade to the EO system which "will be augmented with multi-spectral sensors such as Active-Gated TV and Low Light Level TV to meet the requirement for short and long range all-weather capability."[27] The ESM system will be upgraded to include a modern systems library and accuracy. The radar modernisation programme calls for a Spotlight SAR which must maintain a small target detection (periscope) capability while adding imaging modes to the radar. This system is currently a project with Chief Research and Development (CRAD) and should be incorporated in the AIMP. For communications a "Tactical Common Data Link (TCDL) capability will be implemented to maintain national and international data/imagery transfer interoperability."[28]

CH-146 Griffon. The electro-optical reconnaissance, surveillance and target acquisition system (ERSTA) is currently under development for use on the CH146. The ERSTA system will be designed in a modular fashion to facilitate the ease and rapidity of installation to either current or modified hard points. The ERSTA system will consist of a sensor package, an airborne control station with integrated display, an antenna assembly, and the accoutrement bracket, cables and electronics to optimise functionality. The sensor package will have the following optical and electro-mechanical components: visible camera, mid wave infrared camera, eye-safe laser range finder, and a laser target designator.

The aircraft control station will have a tactical computer system, with a display, keyboard and processor, a hand controller for the system, and an electronics system. The electronics system will be the information integration unit containing the TCDL essential in the secure downloading of information to a ground station. The omni-directional antenna array will be within a radome and will be the link between the TCDL and the ground station.

The present situation is that industry has responded to a solicitation of interest issued by the Department of National Defence (DND). The CH146 operational community has identified a desire to obtain 10 ERSTA type systems. The initial replies from industry suggest the development and subsequent fielding of 10 systems will incur a Rough-Order-Magnitude (ROM) cost of $30 to 40 million. The introduction of the ERSTA system will precipitate an increase in human resources, training and support requirements for the operational community.

<u>Maritime Helicopter Project (MHP) – Sea King Replacement.</u> In accordance with the MH project's statement of operational requirements the MH will have an electro-optical means to search, detect, classify, and identify contacts of interest in ambient light conditions ranging from direct unobscured sunlight to overcast starlight in maritime environmental conditions to include fog, rain, drizzle and high humidity. It must be capable of detecting a vessel (approximately 20 m in length) at approximately 15 nautical miles (nm) and identify and target at greater than 5 nm (unobscured weather).[29] This would prove to be a considerable improvement over the current capability. The MH radar must be optimised for over-water surveillance, detection, classification and tracking of surface vessels, exposed periscope masts, life rafts, and aircraft, throughout the operating range of the aircraft. As well, the radar is to be capable of displaying the target size characteristics when selected by the operator, to include relative aspect profile with a resolution of one metre or less, so as to enable stand-off classification of targets by platform type and target size.[30] To aid in passive detection and identification the MH shall have an ESM sub-system that will permit tracking and analysis of emitters of interest.[31]

Analysis of Future ISR Acquisitions

What has not been addressed is the requirement for the air force to detect, locate and identify targets and collect general military intelligence across the full spectrum of conflict and operating environments. While the Aurora IMP and Sea King replacement will rectify many of the current ocean and littoral ISR deficiencies, the Hornet and Griffon aircraft would benefit from improvements to ISR capabilities. Additionally, there is no evidence of the CF considering the use of non-traditional ISR aircraft as ISR collectors. This paper will therefore provide a CC-130 option.

Airborne Electro-Optical and IR Sensors

A number of pod or retrofitted reconnaissance systems are presently available that may be fitted to fast jet, maritime or special mission aircraft. Three systems will be discussed.

<u>Tactical Airborne Reconnaissance Pod System</u>. Perhaps the oldest pod system still in service is the Tactical Airborne Reconnaissance Pod System (TARPS) used by the United States Navy (USN) on its F-14 fighter aircraft. TARPS contains wet film, optical and infra red camera systems which do not have a data link capability. An update of the TARPS system is called TARPS – DI (DI for Digital Imagery). TARPS-DI will have an electro-optical capability with higher resolution over present TARPS pod sensors. The USN intends to field 24 of the TARPS-DI pods by 2003 for between US$6-8 million instead of purchasing the Advanced Tactical Airborne Reconnaissance System .[32]

<u>Advanced Tactical Airborne Reconnaissance System</u>. The US F/A-18 Tactical Reconnaissance System is primarily comprised of the Advanced Tactical Airborne Reconnaissance System (ATARS) which includes a dual band EO/IR sensor system, an interface with the APG-73 radar and a digital data link pod. ATARS is designed to fit into the nose of any post-Lot 14 F/A-18D in place of the gun. Imagery is transmitted to a ground station via the data link pod where it is analysed and disseminated.[33] The United States Marine Corps (USMC) is at present the only ATARS operator and they successfully employed the system during Operation ALLIED FORCE in 1999. Although costs are difficult to ascertain, in February 1997 a contract was let to McDonnell Douglas for three ATARS systems, two radar upgrade/conversion kits, 12 upgrade modification kits, test flight support, logistics, training and technical publications.[34]

<u>DB-110 Reconnaissance System</u>. The DB-110 reconnaissance system is a dual band EO and IR system that is designed for carriage on both fast jet and maritime patrol aircraft, but may be fitted to other aircraft types as required.[35] It is a derivative of the imaging sensor employed by the U-2. The Royal Air Force (RAF) has selected the system for its Tornado aircraft and the Royal Australian Air Force (RAAF) has conducted a trial of the system with its RF-111 aircraft. The RAF has adopted the pod name "RAPTOR" or Reconnaissance Airborne Pod for Tornado. The DB-110 is a Long-Range Oblique Photographic System (LOROP) capable of imaging targets in a variety of mission profiles outside the range of many threat systems. The EO and IR capabilities provide a 24-hour good weather capability in both tactical and strategic intelligence collection scenarios. EO imagery can be collected of targets at some 30 nm range and IR imagery at 15 nm.[36] The collected EO and IR imagery is digital and thus allows near real time exploitation and dissemination.

<u>C-130 Hercules</u>. Lockheed Martin has developed, in support of the Open Skies activities, a wing mounted fuel pod converted to accommodate a variety of palletised control, display, data processing and sensors for reconnaissance and surveillance missions. The Special Avionics Mission Strap-On Now (SAMSON) pod was designed to facilitate ISR activities without seriously degrading the primary transportation role of the aircraft.[37]

The system, which a trained crew of four can install in about eight hours, was designed to flexibly meet a variety of sensor system installations for mission specific employment. The system can currently be fitted with combinations of sensors including terrain following radar, moving target indicators, photographic equipment ranging from cameras to low light television, sea-search radar and infrared systems. The system was designed to accommodate future synthetic aperture radars. The real-time secure data transmission capability of the system requires verification; however, Lockheed Martin has a myriad of equipment to effect the specific data capture and transmission needs of the user. Canada has been exposed, though Open Skies operations, to the system and some CF personnel may have operational knowledge of this system, which may affordably meet some CF ISR needs.

Airborne SAR Sensors

For a 24-hour, poor weather capability, a SAR would be required as optical and IR systems may be constrained by obscuring weather. At least one such system is now available as commercial-off-the-shelf (COTS) for adapting to any airborne platform. General Atomics of San Diego and the US Department of Energy jointly developed the Lynx SAR to provide a "lightweight, user friendly system with extended range and much higher resolution" than older SAR technology.[38] General Atomics indicate that the "real time, interactive nature of the radar and the innovative operator interface, make it a breakthrough for meeting the ease of use needs of front-line military users."[39] The Lynx SAR provides strip map, spotlight, and Ground Moving Target Indicator (GMTI) modes, real-time video and digital displays, and image resolution from 0.1 to 3 metres at ranges up to 42 nm. The system weighs 52 kg, has flown onboard UAVs for extensive testing, and has performed as specified. If it could be integrated into CF aircraft as easily as advertised, it would provide an effective option for improving CF ISR capability.

Airborne SIGINT Sensors

SIGINT systems consist of integrated subsystems of high performance antennas, receivers, recorders and analysis equipment. This equipment, normally platform mounted, can be installed in aerial, maritime assets or in permanent or deployable ground stations. In aerial applications, uniquely configured aircraft or satellite systems specifically designed for a reconnaissance and surveillance role usually support this equipment in operations. Many of the advanced militaries of the world have air assets specifically dedicated to this role and the missions it entails. Large, long-range aircraft with considerable endurance normally accommodate the requisite SIGINT equipment for such a mission. These platforms must be supplemented by independent and precise navigational, positional and attitudinal sensing equipment. Additionally, the onboard equipment must accommodate a wide band of frequency detection and be capable of recording emitter transmissions with a high degree of fidelity.

The SIGINT role has been conducted by all military elements since the activity has been technologically viable. The land and naval forces have developed a number of systems that are modular and tactically deployable. Air force SIGINT assets remain, for the most part, integral to the specialised airborne platform that conducts the mission. Modularisation and the development of a SIGINT pod are limited for aviation-related SIGINT activities and will not be analysed further.

Concept of Operations

A range of ISR capabilities could be acquired for the five aircraft fleets (CF-18, CP-140, CH-146, CH-124 and CC-130) to ensure that ISR capabilities are available to commanders across the conflict spectrum and levels of war. However, a comprehensive analysis of ISR capability deficiencies in the context of CF force planning scenarios would have to be completed before proposing a meaningful concept of operations, and therefore, this is beyond the scope of this paper.

Advantages/Disadvantages. The main advantages of modifying existing aircraft in the air force inventory include: speed of procurement and initial operating capability; lower cost and risk than new platform and ISR technology, and reduced impact on existing force structure and command and control arrangements. Additionally, depending on where the CF is operating within the conflict spectrum, it is possible, if not likely, that a Canadian commander will have operational control of manned air force assets in his theatre and therefore can task them according to his operational priorities. Further, the additions of some selected ISR capabilities to specific platforms ensure a greater likelihood that some ISR capability will be relevant to the operation and available to the commander. For example, in high intensity operations such as Operation ALLIED FORCE, the CF-18 or CP-140 might be available. For maritime interdiction operations, the CH-124 and CP-140 might be available. For traditional land-oriented peacekeeping operations, the CH-146 and CC-130 might be available.

ISR UNMANNED AERIAL VEHICLES

Whether in lieu of, or complementing, the options for integrating ISR sensors onto existing CF aircraft, UAVs offer purpose-built solutions to CF ISR deficiencies. UAVs have many classifications and perform a variety of tasks, depending on mission requirements and the design of the UAV. Until 1993, with only some exceptions, most UAVs had "limited range, were generally unarmed, had poor self-protection, and were employed mainly in direct support of surface forces."[40] Advances in both UAV and sensor technology make it possible for UAVs to perform many of the ISR, electronic combat support and battle damage assessment missions that have been historically done by manned aircraft.

UAVs come in many shapes and sizes and provide a wide range of mission capability, and they may have extensive range and endurance capabilities. Medium-altitude endurance (MAE) and high-altitude endurance (HAE) UAVs are suitable for the purposes of operational level capability requirements outlined in the CJTL. [41] HAE/MAE UAV platforms are relatively large land-based aircraft with a wide wingspan and sleek airframe.[42] UAVs may be divided into two main components: the platform (or vehicle) and the sensors (or payload).

The fundamental differences between a MAE and HAE UAV are reflected in their speed and range capability.[43] The range of a HAE UAV supports a transcontinental or global flight capability, whereas MAE UAVs normally operate within a limited radius from a supporting base. An HAE UAV could effectively respond to cues that would take it thousands of miles from its current location within a matter of several hours, whereas the slow cruising speed of a MAE UAV prevents any effective response capability outside of its current operating area.

The Predator and Global Hawk have been selected for study due to their maturity of design, relative affordability, interoperability with close allies, and likely best capability match to CF air force operational level tasks.

RQ-1A Predator

The RQ-1A Predator is a medium-altitude, long-endurance unmanned aerial vehicle system. A fully operational system as employed by the US costs approximately US$32 million and consists of four air vehicles (with sensors), a ground control station (GCS), a TROJAN SPIRIT (Special Purpose Integrated Remote Intelligence Terminal) II satellite communications suite, and 55 personnel.

The aircraft is equipped with a colour nose camera (generally used by the Air Vehicle Operator [AVO] for flight control), a day variable-aperture TV camera, a variable-aperture IR camera (for low light/night), and SAR for looking through smoke, clouds, or haze. The cameras produce full motion video and still frame SAR images. The three sensors may be carried simultaneously on the same airframe but cannot be operated at the same time.

Each Predator air vehicle can be disassembled into six main components and loaded into one container to enable rapid world wide deployment. The largest component, the GCS, is designed for C-130 roll-on/roll-off. Two C-130s would be needed for a complete system deployment. Some of the key characteristics of the Predator are listed with those of the Global Hawk in Annex E.

Concept of Operations. The Predator is currently being employed for ISR in support of NATO operations in the Former Yugoslavia. The Predator is ideal for missions in areas where enemy air defences have not been fully suppressed, open ocean environments, and biologically or chemically contaminated environments. NATO deployed a broad range of surveillance assets to Bosnia Herzegovina, where the developing situation demanded continuous ground surveillance to monitor agreements and enhance force protection of NATO troops. There the Predator conducted 128 ISR missions in support of Operations DENY FLIGHT and DELIBERATE FORCE, and they were effectively used again for Operation ALLIED FORCE.

The Predator air vehicle and sensors are controlled by its GCS via a C-band line-of-sight data link or a Ku-band satellite data link for beyond-line-of-sight operations. During flight operations the crew complement in the GCS is one AVO and three Sensor Operators. All components must be co-located on the same airfield, and the system needs 5000 ft x 125 ft of hard surface runway with clear line-of-sight to each end from the GCS to the air vehicles.

Global Hawk

Under development since 1995, the Global Hawk programme goal was to create a vehicle that can loiter for 24 hours, 3500 nm from its base, at an altitude of 65,000 feet out of range of most surface-to-air and air-to-air missile threats, and providing an outstanding slant range for its sensors. Capable of operating in all weather conditions day or night, it carries SAR, EO and IR sensors simultaneously. Moreover, it utilises high-rate satellite and line-of-sight datalink systems, and employs self-protection electronic countermeasures. It has a wing span of more than 35 metres, a length of 13.5 metres, weighs 10,500 kg and flies at speeds in excess of 300kts. The Global Hawk can provide imagery coverage of 137,196 square kilometres or 1,900 spot targets per 24-hour period.[44]

Recent technological developments in propulsion systems and miniaturisation of sensors now allow UAVs to operate relatively cheaply when compared to manned platforms. For example the Global Hawk costs approximately US$15 million. It carries an 820 kg package of EO/IR and SAR sensors with image resolutions of 0.3 metres in the spot mode and one metre in the search mode. Sensors cued with a GPS reference will be able to locate targets to within 20 metres. Future developments will facilitate the employment of a GMTI radar mode also. However, with an estimated cost of $US 14.8M per platform, the Global Hawk cannot be considered expendable. Notwithstanding this, it would still be the preferred platform in a high-risk environment where aircrew of manned aircraft would be at risk.[45]

Concept of Ops. Unlike the Predator and most other UAVs, Global Hawk is not controlled from the ground. Flight control, navigation and vehicle management are autonomous. Launch and recovery are controlled by the Launch and Recovery Element (LRE) by using differential GPS, which is deployable to theatre if necessary. The Mission Control Element (MCE), which may be located anywhere in the world, directs the vehicle. The goal is to make the Global Hawk and its imagery available to commanders whose need is immediate. Both ground units can be transported by two C-17s and the vehicle itself can fly anywhere it is needed with a straight-line range of 13,500 nautical miles.[46]

Global Hawk has flown several test flights and has successfully transmitted good quality imagery from an altitude of 56,000 feet. It has been called "the theatre commander's low-hanging satellite" by the Commander in Chief of United States Joint Forces Command. [47] The USAF intends to deploy a fleet of Global Hawk UAVs beginning in Financial Year 2001. This continuous eye over the battlefield will provide commanders with near real time ISR, feeding sensor information directly to commanders on the ground.

Advantages/Disadvantages of UAVs

With a robust suite of sensors, either of the Predator and the Global Hawk would greatly enhance the ISR capability of the air force and the CF. Both reduce risk to aircrew in high threat environments, offer low operating costs, and are more flexible than space-based systems with respect to desired timing of image capture.

Although cheaper than the Global Hawk, the Predator would be at greater risk of loss due to lower flight altitudes over the battlefield. The Global Hawk would be comparatively more protected against enemy attack due to higher flight altitudes above most missile systems. As well the Global Hawk offers greater coverage than the Predator and will have a MTI mode covering 15,000 square kilometres per minute, with a minimum detectable velocity of 4 kts for moving targets on the ground. The Predator must be transported to the area of operations, whereas the Global Hawk could be flown from Canada to potentially anywhere in the world.

For the Canadian surveillance mission, the Global Hawk offers greater capability due to its greater range/coverage, high altitude flight profile, and all weather/day/night capability. The Predator, would be at risk of mission cancellation due to flight restrictions if poor weather was encountered at its flight altitude of between 15,000 and 25,000 feet. On the other hand, the Predator is a more mature technological option, having been deployed and employed in several operational theatres, whereas the Global Hawk will not be in operation until at least the beginning of FY 2001 with the USAF.

UAVs are relevant to joint and combined operations, and would therefore offer a key niche capability for the air force and the CF. One major lesson learned from the Gulf War, Bosnia and more recently in Kosovo is that there are never enough reconnaissance assets for ISR, especially high-altitude platforms that can be flown in high threat environments.[48]

EXPLOITING COMMERCIAL ISR SATELLITES

The CF makes little use of commercial imaging satellites products, even as the number of fielded and planned systems continues to grow, and the quality of their imaging capabilities is greatly improving. For international deployments, CF commanders and planners would normally make use of *military* satellite imagery products, relying on allies to provide it. After being requested and received at the strategic level, these products are then distributed via secure means to the operational or tactical level. As noted in many CF operations in the past decade, this incurs the limitations of not having independent sources, of greater operational security demands and restricted distribution for handling classified information, of limited communications bandwidth for distribution, and of competition for priority among many operational level Requests for Information (RFIs). If imagery from commercial sources *is* used to augment military satellite imagery, it is also normally ordered at the national level via phone or Internet, with the products provided in a few weeks. Dissemination then follows, with many of the same limitations of military system products mentioned above, excepting classified handling. Advances in both commercial imaging satellites, and in deployable ground stations to access them, make it possible to circumvent these limitations and provide decision-makers with relevant imagery directly for a modest investment on the order of US$10 million per ground station.

In the next 5 years, nearly 20 US and other foreign organisations plan to launch civilian and commercial high-resolution observation satellites attempting to benefit from the growing market for imagery.[49] Organisations in India, Europe, China, Brazil, Israel and Canada all have plans to build and launch new remote sensing satellites with resolutions of 30 metres or less,[50] and many new ventures from US companies will deliver resolution down to one metre. One metre defines the high-resolution range where it is possible to make distinctions between cars and trucks, to recognize types of fighter aircraft, to count vehicles in convoy, to distinguish different types of tanks, or to identify buildings for target selection. Annex F provides a snapshot of many of the existing and planned commercial/civil earth observation satellites.

To meet the *DPG 2001* Change Objective Seven for the CF to establish external strategic partnerships, RADARSAT-2 offers considerable potential. When launched in 2003, RADARSAT-2 will be the most technologically advanced commercially available Space-Based SAR (SBSAR) in the world. Its main advantage over RADARSAT-1 will be improved resolution: as low as three metres. This level of SAR resolution is not normally found in commercial satellites. To put this in perspective, RADARSAT-1's highest resolution of eight metres permits detection of small aircraft and ships, or large mobile land targets while buildings, airports, runways and large aircraft are recognizable.[51] RADARSAT-2's three-metre resolution will improve detection and recognition significantly.

Military uses of commercially supplied imagery have increased dramatically over the past decade, but one of the biggest advances has been to provide this information directly to deployed forces. For example, the National Reconnaissance Office (NRO) and US Army programme, EAGLE VISION II, is a self-contained imagery downlink and processing station designed to provide military commanders direct access to multiple imaging satellites. The genesis of the EAGLE VISION programme was a result of lessons learned during the Gulf War. Tactical ground commanders lacked sufficient imagery, and national imagery was classified too high for it to be easily processed by tactical air commanders' air planning software.[52] The aim of EAGLE VISION, therefore, is to directly provide the warfighter with unclassified imagery products that will help to both visualize the battlespace and develop precise terrain and geographic data.

At a cost of approximately US$10 million,[53] this system is based on commercial-off-the-shelf (COTS) components, housed in an expandable 34-foot trailer carrying mission electronics equipment, and provided with a 5.4 metre tracking dish antenna to receive the satellite signals. It may be loaded for transport onboard two C-130s or one C-17 for deployment, and requires approximately four hours to set up.

To ensure effectiveness, EAGLE VISION II must be located in direct line-of-sight of the satellite such as RADARSAT-1 and SPOT to accept the imagery downlink. Further, there are funded plans within this programme to provide reception of imagery from LANDSAT 7, OrbView 3, Quickbird and Ikonos satellites. After reception of raw imagery, the station's imagery hardware and software processes it and supplies results in minutes as unclassified panchromatic (black and white), multi-spectral (colour) and radar images for use by existing mission planning, topographic and intelligence systems. A separate, modular data processing van contains the tools to match satellite imagery with digital terrain and chart information yielding value-added products for three-dimensional visualization, mission planning and rehearsal.

EAGLE VISION II is not the only proven capability in this area, as commercial industry has tested similar ground station configurations with a target market of emergency response and other similar government organizations. Examples include, MacDonald Dettwiler's *Fast TRACS,*[54] IOSAT's *Sentry,*[55] and US EOSAT/Italian Telespazio's ground stations.[56]

Concept of Ops. To augment ISR capability in the area of theatre reconnaissance, targeting and Battle Damage Assessment (BDA), the CF could acquire two systems based on the EAGLE VISION II configuration. If acquired, this capability would be located at one of the air force vanguard deployable units such as No. 8 Air Communication and Control Squadron. It could be similarly configured for rapid deployment, to support many observation satellites operating in different spectra, and to include post-processing tools for purposes such as intelligence, mission planning, and mapping and charting. Alternatively, as the capability would be primarily focused at operational level tasks and is inherently joint in potential application, it may be best suited to be employed by the CF's Joint Operations Group (JOG). In either case, the ground station would be operated from its garrison location when not employed on operations, for training purposes, to update image archives on areas of interest, and to monitor regions of tension or crisis where the CF might be called upon to support.

Special attention would be paid to establishing favourable service provision in terms of cost and access for RADARSAT-2 imagery in particular, given the potential synergy and cost savings of such a strategic partnership. The concept is a proven one, as both IOSAT's SENTRY system, and the EAGLE VISION II system have demonstrated the ability to receive and process RADARSAT data.

Advantages/Disadvantages. Overall, this capability is well suited for the execution of CJTL tasks highlighted earlier. Given the greatly improved resolution of new systems, many types of information are available from commercial earth observation satellites giving significant operational utility. For mission planning, space-based sensors bring in a critical vertical component to battlespace visualisation – extending the commander's view beyond the horizon and deep into the enemy rear to support the deep battle. When realistic views of the battlespace are needed in order to plan and rehearse, high-resolution imagery could be draped over digital terrain models to create three-dimensional databases that would be useful for air and ground attack planning.

For intelligence support, the capability to receive data from space at a useful reception rate is a critical force multiplier. Imagery would add to ground and air systems and other sources to provide a more comprehensive Intelligence Preparation of the Battlespace (IPB), and thus improve the decision-making process. Although high-resolution imagery does not have the wide coverage of systems designed specifically for surveillance, it can still provide early warning of attack by opposing ground forces, target intelligence, technical intelligence on an adversary's capabilities, and battle damage assessment.

Since the Gulf War, commercial satellite imagery has been used to support targeting planning and battle damage assessment.[57] As one to two metre resolution imagery can now be combined with digital terrain data to provide effective targeting information,[58] this application continues to become more effective. The trend for future war fighting and application of joint fires will move toward "dominant" manoeuvre, which translates to a massing of "effect" vice "forces". For this concept, space-based imagery products are key to targeting and the subsequent massing or "manoeuvre" of effects, and are thus an obvious combat multiplier.[59]

RADARSAT-2 imagery would improve Canada's ability to exercise surveillance and sovereignty over extensive coastal waters and northern regions. Presently, Canada relies on foreign sources for almost all its coastal and arctic space-based radar surveillance. This situation is contrary to the *1994 White Paper* which states: "Canada should never find itself in a position where, as a consequence of past decisions, the defence (by extension, surveillance) of our national territory has become the responsibility of others." [60] This is especially worrisome given that the US does not recognize Canadian sovereignty over the Northwest Passage. RADARSAT-2 would ensure Canada's influence in the area of space-based radar surveillance.

Advantages. Some of the advantages of direct access to commercial imagery satellites include ease of distribution and handling of unclassified material, avoidance of strategic to operational level bottlenecks in C^2 links, and improved timeliness/response (with longer revisit times offset by accessing multiple satellites). Fusing information from multiple sources also creates value-added data. As well, this might represent a potential niche capability for the CF, since the imagery products of this system would be highly desirable for any combined force.

Disadvantages. Disadvantages for this approach are those typical for space-based systems. For EO sensors, images cannot be taken at night or through clouds or smoke. Radar imaging can overcome weather, but is more costly and not always suitable due to lower resolutions and active sensing, therefore potentially disclosing intent. [61] Revisit times are shortening with newer systems, but they may still be too long to prevent acquisition of desired images as quickly as needed. By supporting and exploiting many imaging satellites using different spectra, the proposed configuration could mitigate this limitation to a certain extent by increasing the probability of successful image capture.

Observation satellites are vulnerable to many kinds of countermeasure or "negation", including avoidance strategies such as camouflage and masking (smoke), disinformation and deception. Avoidance strategies are becoming less effective due to the increasing number of platforms, and exploiting images from many different spectra may overcome camouflage and smoke.

CONCLUSION

Advances in ISR technologies are key enablers of the RMA and the ongoing efforts towards greater battlespace awareness and information dominance for military commanders. CF strategic guidance has provided the impetus and direction to pursue improvement in its ISR capabilities in order to reap the operational benefits that will accrue for assigned missions, roles or tasks; and to ensure that it can generate viable and relevant forces for combined operations with allies. In this context, the air force must recognize the critical importance of ISR to operations, and therefore focus efforts on producing an overall plan for air force ISR development that incorporates jointness, interoperability and the traditional strengths of air power.

Given an overarching air force ISR planning framework, air staffs will be better positioned for assessing the alternatives available to enable force development and procurement decisions that are coherent, complementary and affordable. This cursory review of affordable ISR options indicates that significant operational benefit is achievable with the sensor technology currently available. Sensors which are added to existing aircraft, are borne by UAVs, or already exist on commercial imaging satellites, can all aid the commander visualize the battlespace and therefore enhance campaign planning and decision making. The various sensor systems come with a range of ISR capabilities, advantages and disadvantages, and although individually affordable, it is unlikely that the CF can afford them all. Ultimately, the air force must prepare its plan, decide among contending alternatives based on the vision and priorities in that plan, and carry on with modernizing the force with a sufficient range of ISR capabilities.

RECOMMENDATIONS

The following four recommendations are made based on this study:

- CAS Staff generate a comprehensive ISR guidance document, which factors in strategic guidance, state-of-the-art technological possibilities, joint and combined mission and interoperability requirements, budgetary constraints and ongoing initiatives. This capstone document should establish the need for a balanced, mutually-supporting ISR sensor mix for maximum effectiveness in compensating for inherent weaknesses in individual systems;
- CAS Staff initiate additional ISR-related force development and equipment acquisition consistent with capability priorities established in the aforementioned ISR guidance document;
- CAS Staff carry on with those capability initiatives which ascribe to the vision and priorities established in the ISR guidance document and cease activity for those that do not; and
- if ISR technologies such as UAVs or ground stations for commercial imaging satellites are embraced as national strategic or joint initiatives, then the air force must act to be fully engaged in system definition and conceptual development to ensure that air ISR requirements are sufficiently addressed.

Annex A

List of Abbreviations

ADGA	ADGA Group of Companies
AEW&C	Airborne Early Warning and Control
AIMP	Aurora Incremental Modernization Project
AMIRS	Advanced Multi-Role Infrared Sensor
ASR	Aerospace Surveillance and Reconnaissance
ATARS	Advanced Tactical Airborne Reconnaissance System
AVO	Air Vehicle Operator
CF	Canadian Forces
CH/CP/CF	Canadian Helicopter, Canadian Patrol, Canadian Fighter aircraft types
CJTL	Canadian Joint Task List
COMINT	Communications Intelligence
COTS	Commercial-Off-The-Shelf
CRAD	Chief Research and Development
DPG 2001	Defence Planning Guidance 2001
D Space D	Directorate of Space Development
ECP	Establishment Change Proposal
ECP 583	Engineering Change Proposal 583
ELINT	Electronic Intelligence
EO	Electro-Optical
ERSTA	Electro-Optical Reconnaissance, Surveillance and Target Acquisition
ESM	Electronic Signals Measures
FLIR	Forward Looking Infrared
GCS	Ground Control Station
GMTI	Ground Moving Target Indicator
GPS	Global Positioning System
HAE UAV	High-altitude Endurance UAV
IMINT	Imagery Intelligence
IMP	Incremental Modernization Project
IPB	Preparation of the Battlefield
IR	Infrared
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
ISR	Intelligence, Surveillance and Reconnaissance

JOG	Joint Operations Group
LOROP	Long-Range Oblique Photographic System
LOS	Line-Of-Sight
LRE	Launch and Recovery
MAE UAV	Medium-Altitude Endurance UAV
MCE	Mission Control Element
MHP	Maritime Helicopter Project
MTI	Moving Target Indicator
NRO	National Reconnaissance Office
NVG	Night Vision Goggles
OTH	Over-The-Horizon
RAPTOR	Reconnaissance Airborne Pod for Tornado
RFIs	Requests for Information
RMA	Revolution in Military Affairs
ROM	Rough-Order-Magnitude
SAMSON	Special Avionics Mission Strap-On Now
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SBSAR	Space-Based SAR
SIGINT	Signals Intelligence
SPIRIT	Special Purpose Integrated Remote Intelligence Terminal
Strategy 2020	Shaping the Future of the Canadian Forces: A Strategy for 2020
TARPS	Tactical Airborne Reconnaissance Pod System
TCDL	Tactical Common Data Link
TROJAN SPIRIT	Special Purpose Integrated Remote Intelligence Terminal
UASTAS	Unmanned Aerial Surveillance and Target Acquisition System
UAVs	Unmanned Aerial Vehicles
USN	United States Navy
USMC	United States Marine Corps
1994 White Paper	1994 Defence White Paper

Annex B

Operational Tasks with ISR Impact from Canadian Joint Task List

Task #	Task		Sub-task
OP 1	**Operational Command**		
OP 1.1	Assess situation	1.1.1.	Staff branches review current situation
OP 1.2	Prepare plans and orders, direct ops & training	1.2.2	Conduct operational mission analysis & staff the commander's estimate
OP 1.5	Plan and direct operational manoeuvre & force positioning	1.5.2	Posture joint forces
		1.5.3	Coordinate operations in depth
		1.5.4	Coordinate Offensive Operations in the JOA
		1.5.5	Coordinate Defensive Operations in the JOA
OP 2	**Operational Information and Intelligence**		
OP 2.1	Plan and direct intelligence activities and reports	2.1.2	Conduct JIPB & produce intelligence estimate & prepare collection plan
		2.1.8	Provide follow-on intelligence support to the OA planners and decision makers
OP 2.2	Collect & share information	2.2.2	Collect and share information on adversary's forces and hazards
		2.2.3	Collect environmental information
		2.2.4	Coordinate theatre surveillance and recce
		2.2.5	Directly support theatre strategic surveillance and recce requirements
		2.2.6	Collect target information
OP 2.3	Process and exploit collected information	2.3.2	Collate and correlate information
		2.3.3	Evaluate, integrate, analyse & interpret OP information
		2.3.4	Identify operational issues and threats
		2.3.5	Determine adversary's operational capabilities, COA & intentions

Task #	Task	Sub-task	
OP 3	**Conduct Operational Campaign**		
OP 3.1	Control or dominate operationally significant areas	3.1.1	Identify and control operationally significant land area in the JOA
		3.1.4	Assist host nation in populace and resource control
		3.1.6	Plan and coordinate blockades
OP 3.2	Peacetime security	3.2.2	Deploy and coordinate geographic meteorological, hydrographical and oceanographical support
		3.2.3	Orchestrate non-combat evacuation operations
		3.2.4	Orchestrate operations to provide service assistance for disaster relief & humanitarian aid outside Canada
OP 3.3	Plan & assist in national and multinational peacekeeping operations	3.3.1	Establish and coordinate a peacekeeping infrastructure and observe and monitor
OP 3.4	Plan & assist in national and multinational peace enforcement operations	3.4.5	Establish and supervise protected or safe areas
OP 3.6	Plan joint force targeting	3.6.5	Assess battle damage on operational targets & conduct BDA
OP 3.7	Coordinate attack on operational targets	3.7.2	Plan the interdiction of operational forces/targets
OP 5	**Protect Operational Forces**		
OP 5.1	Provide defence against an attack by all weapons systems	5.1.8	Conduct tactical warning & attack assessment in the JOA
OP 5.2	Coordinate hazard removal, survival & control measures	5.2.5	Coordinate personnel recovery, search and rescue, & escape & evasion
OP 5.4	Provide security	5.4.3	Provide counter deception operations

Annex C

Summary of Force Planning Scenarios

No.	Scenario	Summary
1	Search and Rescue in Canada	Sub-scenarios include rescue from a ship at sea, search and rescue of an Overdue hunting party in the North, and the rescue of survivors from a major airliner downed in a remote area in the North.
2	Disaster Relief in Canada	Assist in the relief of human suffering and assist authorities to re-establish the local infrastructure after a major earthquake on the west coast of Canada.
3	International Humanitarian Assistance	As part of a UN operation, assist with the delivery of relief supplies to refugees amassed in a central African nation.
4	Surveillance \ Control of Canadian Territory and Approaches	Assist Other Government Departments and law enforcement agencies in identifying, tracking and, if required, intercepting platforms suspected of carrying contraband goods or illegal immigrants before or after entering Canadian territory.
5	Protection and Evacuation of Canadians Overseas	Assist DFAIT, as part of a combined force, in the protection and evacuation of Canadian nationals in a foreign nation threatened by imminent conflict.
6	Peace Support Operations (Chapter 6)	Participate as part of a UN peacekeeping force maintaining a cease-fire and assisting in the creation of a stable and secure environment where peace building can take place.
7	Aid of the Civil Power	Assist civil authorities in the establishment of law and order in an area where lawlessness has occurred as the result of disputes over the control of water rights in a time of severe drought.
8	National Sovereignty/ Interests Enforcement	Claiming extended jurisdiction under UNCLOS III, Canada has requested the cessation of

Summary of Force Planning Scenarios		
		seabed exploitation operations by a foreign nation. The CF will assist OGDs in the enforcement of Canadian claims.
9	Peace Support Operations (Chapter 7)	At the request of a foreign nation, as part of a UN coalition, the CF will participate in operations to restore pre-conflict boundaries and return control of an occupied area to the control of the rightful country.
10	Defence of Canada/US Territory	In cooperation with US forces, the CF will defend Canada/US territory against potential threats initiated by an emerging world power as a result of Canadian and American support for a foreign military operation.

Annex D

DPG 2001 Defence and Change Objectives Impacting ISR Planning

Defence Objectives	
D01	To provide strategic defence and security advice and information to the Government.
D02	To conduct surveillance and control of Canada's territory, airspace and maritime areas of jurisdiction.
D03	To respond to requests for Aid of the Civil Power.
D04	To participate in bilateral and multilateral operations.
D05	To assist other government departments and other levels of Government in achieving national goals.
D07	To provide emergency and humanitarian relief.
D08	To maximize defence capabilities through the efficient and effective use of resources.
Change Objectives	
C01	Innovative Path. Create an adaptive, innovative and relevant path into the future.
C03	Modernize. Field a viable and affordable force structure trained and equipped to generate combat capabilities that target leading-edge doctrine and technologies relevant to the battlespace of the 21st century.
C05	Interoperable. Strengthen our military relationships with our principal allies ensuring interoperable forces, doctrine and C^4I.
C07	Strategic partnerships. Establish clear strategic, external partnerships to better position Defence to achieve national objectives.

Annex E

Key Characteristics for Predator and Global Hawk

Characteristic	Predator	Global Hawk
Primary function	Airborne surveillance Reconnaissance and Target Acquisition	Airborne surveillance Reconnaissance and Target Acquisition
Contractor	General Atomics Aeronautical Systems Incorporated	Northrup Grumman
Power Plant	Rotax 912 four cylinder engine, 81 horsepower	AE3007 jet engine (COTS)
Gross takeoff weight	> 1,873 lbs (EO/IR)	25,600 lbs
Wingspan	48.7 feet	116.2
Length	27 feet	44 feet
Height	6.9 feet	15 feet
Weight	950 lbs empty, gross 2,250 lbs	10,500 kg
Fuel Capacity	665 pounds (100 gallons)	
Mission Duration	24+ hours on station	24 hours on station
Operating Radius	@500 NM	@3000 NM
Maximum Endurance	40+ hours	42+ hours
Ferry Range	N/A	15,000 NM
Payload	>450lbs	2,000 lbs
True Air Speed	60-110 knots	350 knots
Loiter altitude	25,000 feet max. 15,000 Feet Nominal	>66,000 feet
Survivability Measures	None	Threat warning, ECM and deception.
Command and Control	UHF MILSAT/ Ku BandSATCOM/ C-band LOS	UHF MILSAT/LOS
Sensors	SAR: I ft IPR, Swath Width Approx. 800 m EO: NIIRS 7 IR: NIIRS 5 Simultaneous Dual Carriage	SAR: I ft IPR, 0.3 m spot EO: NIIRS 6 IR: NIIRS 5 Simultaneous Dual Carriage
Coverage per mission	13,000 sq NM search imagery	40,000 sq. NM. search imagery, or 1900 spot image frames
Sensor Data Transmission Band	Ku Band: 1.5 Mb/sec UHF SATCOM: 16Kb/sec LOS: C-band 4.5Mb/sec	Wide band COMSAT: 20-50 Mbits/sec LOS: X-Band Wide (CDL): 137-275 Mbits/sec
Deployment	6 C141s or 10 C-130s 2 C-5s or C-17s	Self deployable, SE requires airlift
Ground Control Station	LOS and OTH	Maximum use of GOTS/COTS (LOS and OTH)
System Cost	$US 3M per air vehicle $US 32M per system (USAF)	$US 14.8M per air vehicle

Annex F

Selected Existing and Planned Commercial Imagery Satellites[62]

Country	Company	Year	Spectrum	Resolution
United States	Space Imaging Inc. (Ikonos satellite)	2000	panchromatic multispectral	< 1 m < 4 m
	Space Imaging Inc. (Ikonos 3)	2003-4	panchromatic multispectral	< 0.5 m < 2 m
	Orbital Imaging Corp (Orbview 3,4)	2000, 2005	panchromatic multispectral hyperspectral	1-2 m 4 m
	Earthwatch Inc. (Quickbird)	2001	panchromatic multispectral	1 m 4 m
	Space Imaging EOSAT (LANDSAT 5)	1984	multispectral	30 m
	Space Imaging EOSAT (LANDSAT 7)	1999	panchromatic	15 m
Europe	Eurimage (ERS-1, ERS-2)	1991, 1995	synthetic aperture radar	30 m
France	Spot Image (SPOT 1,2)	1986, 1990	panchromatic multispectral stereographic pan	10 m 20 m 5 m
	Spot Image (SPOT 4,5)	1998, 2002	stereographic pan multispectral short wave infrared	5 m 10 m 20 m
	Helios 1[63]	1995	panchromatic	2 m
	Helios 2	2001-2	panchromatic infrared	1 m
Canada	RADARSAT I	1995	synthetic aperture radar	8-100 m
	RADARSAT II[64]	2002	synthetic aperture radar	3-100 m
India	Space Imaging EOSAT (IRS-1C/1D)	1995, 1997	multispectral	5 m
	Space Imaging EOSAT (IRS-P6)	2001-2	panchromatic	1-2.5 m
Cayman Islands (Israel)	West Indian Space[65] (EROS A1 to A2, B1 to B6)	2000 2001 to 2005		2 m 1m
Japan	NASDA (ALOS 1)	2003	panchromatic multispectral synthetic aperture radar	2.5 m 10 m 7-44 m

Endnotes

1. "Non-Strategic Capital" is defined in the Defence Services Program as capital projects greater than $3M but not exceeding $100M.

2. Canada, Minister of National Defence and the Chief of the Defence Staff, *Shaping the Future of Canadian Defence: A Strategy for 2020*, (Ottawa: Department of National Defence, 1999) p. 1.

3. Elinor Sloan, "Canada and the Revolution in Military Affairs: Current Responses and Future Opportunities," *Canadian Military Journal*, (Autumn 2000) p. 7.

4. Stuart Peach and David Gates, *Air Power for the New Millenium* (Lancaster University, Great Britain: Centre for Defence and International Security Studies, 1999) p. 49.

5. *Ibid*, p. 55.

6. US, Secretary of the Air Force, *Air Force Doctrine Document 2-5.2. Intelligence, Surveillance, and Reconnaissance Operations* (Washington, DC: Government Printing Office, 1999) p. 1.

7. *Ibid*, p. 2.

8. W.B. Danskine, "*The Time Critical Targeting Model*" (Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, April 2000) p. 15.

9. J.P.R. Browne and M.T. Thurbon, *Electronic Warfare* (London, UK: Brassey's,1998) p. 188.

10. *Ibid*, p. 188.

11. *Ibid*, p. 188.

12. W.B. Danskine, "*The Time Critical Targeting Model*" (Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, April 2000) p. 15.

13. *Ibid*, p. 17.

14. Canada, Minister of National Defence, *1994 Defence White Paper*, (Ottawa: PWGSC, 1994).

15. Canada, Minister of National Defence and the Chief of the Defence Staff, *Shaping the Future of Canadian Defence: A Strategy for 2020* (Ottawa: DND, 1999) pp. 7-9.

16. Canada, Deputy Minister of National Defence, *Defence Planning Guidance 2001*, (Ottawa: DND, 1999) p. 206.

17. Paige Cutland, *CAS ISR Capability Brief*, (Produced Jan 2000)

18. Unique advantages of air power are speed, range, elevation, surprise, precision, flexibility, mobility, responsiveness and concentration, from: Canada, Chief of the Air Staff, *Out of the Sun*, (Winnipeg: Craig Kelman & Associates LTD, 1997).

19. Capability Initiatives Database, Project 00000276, (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp.), 27 Feb 01.

20. Capability Initiatives Database, Project 00001225, (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp.), 27 Feb 01

21. Briefing (http:/www.mcan.marlant.halifax.dnd.ca/Josic/moiscc/blueprin/.)

22. Canada, Chief of the Air Staff, *Out of the Sun,* (Winnipeg: Craig Kelman & Associates LTD, 1997).

23. Capabilities Initiative Database, Project 00000140 Aurora Incremental Modernisation Project (AIMP), (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 01.

24. Capabilities Initiative Database, Project 00000317 AIMP – Electro-Optics (EO) System Replacement, (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 01.

25. Capabilities Initiative Database, Project CAS 6 AIMP – Electronic Support Measures (ESM) Replacement, (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 01.

26. Capabilities Initiative Database, Project 00000140 Aurora Incremental Modernisation Project (AIMP), (http://diso.dwan.dnd.ca/IM-MDP/cdi/Details-e.asp), 27 Feb 01.

27. Capabilities Initiative Database, Project CAS 15 AIMP – EO System Upgrade, (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 01.

28. Capabilities Initiative Database, Project 00000140 Aurora Incremental Modernisation Project (AIMP), (http://diso.dwan.dnd.ca/IM-MDP/cdi/Details-e.asp), 27 Feb 01.

29. Canada. Minister of Public Works and Government Services Canada, *Maritime Helicopter Statement of Operational Requirement DSP No 00002680,* (Ottawa: DND, 14 Jul. 1999) p. 33.

30. *Ibid,* p. 33.

31. *Ibid,* p. 37.

32. Federation of American Scientists, "Advanced Tactical Reconnaissance Airborne System," (www.fas.org/irp/ program/collect/tarps.htm), 26 Feb 01.

33. Federation of American Scientists, "Advanced Tactical Reconnaissance Airborne System," (www.fas.org/irp/ program/collect/atars.htm), 4 Feb 01.

34. *Ibid.*

35. DB-110 Raptor Reconnaissance System, www.raytheon.co.uk/raytheon-noflashstems/isr/db_110_raptor/db_110_raptor/db_110_raptor.htm. 26 Feb 01.

36. Raython, "DB-110 Reconnaisance System," (www.raytheon.com/es/esproducts/ ses110/ses110.htm) 26 Feb 01.

37. Keith Atkin, ed, *Lockheed Martin Special Avionics Mission Strap-On-Now (SAMSON) pod* (Coulsdon, Surrey: Jane's Electro-Optical Systems, sixth edition 2000-2001), p 571.

38. "Lynx Synthetic Aperture Radar," www.ga.com/atg/SAR/lynxSAR.html, September 1999.

39. "Sandia and General Atomics Develop New Synthetic Aperture Radar," www.spacedaily.com/news/radar-99c.html, August 1999.

40. "New Roles Emerging For UAV's," *Asian Defence Journal,* (Nov, 2000), p. 28

41. Extensive range and/or endurance are platform characteristics that allow for long mission times of greater than 40 hours. This, in turn, allows for long over-water surveillance missions – an ideal trait for a Canadian sensor platform.

42. HAE/MAE UAVs basically resemble the old U2 spy plane.

43. Currently, high-altitude UAVs are capable of flying 18,000 nm (i.e. from Canada to Australia then back to Canada). Medium-altitude UAVs are effectively limited to an operating radius of 2,000 nm.

44. Craig McPherson, NG Review, "Global Hawk," www.northgrum.com/ news/revmag/review09-18.html, November 1999.

45. Craig McPherson, NG Review, "Global Hawk," www.northgrum.com/ news/revmag/review09-18.html, November 1999.

46. Craig McPherson, NG Review, "Global Hawk," www.northgrum.com/ news/revmag/review09-18.html, November 1999.

47. Craig McPherson, NG Review, "Global Hawk," www.northgrum.com/ news/revmag/review09-18.html, November 1999.

48. Stuart Peach, ed., *Perspective on Air Power in its Wider Context* (Joint Services Command Staff College Bracknell, London: The Stationery Office, 1998).

49. Ann M Florini, Yahya Dehqanzada, "Commerical satellite imagery comes of age," *Issues in Science and Technology*, Fall 1999, pp. 45-52.

50. Dee Ann Divis, "Imaging regulations stalled," *Geo Info Systems*, July, 1999, pp. 18-22.

51. M. McKean et al, "RADARSAT: A Dual Use Earth Observation Platform," *AGARD Conference Proceedings 582* (NATO, October 1996), p. 38-7.

52. Robert K. Ackerman, "Air Force Planners Exploit Commercial Space Imagery," *Signal*, June, 1995, p. 15.

53. Pennington Way IV, "NRO Gives Army Operational Control of EAGLE VISION II," *Defense Daily*, October 15, 1999, p. 1.

54. MDA product publication BA-BR-MDA-50-8019 8/97 XP-8471-IR3/EM, "Fast TRACS" August 1997.

55. Mark Hewish, "Military Takes a Giant Leap with Commercial Space Technology," *Jane's International Defense Review*, April 1, 1999, p. 63.

56. Robert K. Ackerman, "Air Force Planners Exploit Commercial Space Imagery," *Signal*, June, 1995, p. 19.

57. Robert K. Ackerman, "Air Force Planners Exploit Commercial Space Imagery," *Signal*, June, 1995, p. 15.

58. Dee Ann Divis, "Imaging regulations stalled," *Geo Info Systems*, July, 1999, pp. 18-22.

59. Edward G. Anderson III, "The Army and Space," *Field Artillery*, May, 1998, pp. 7-10.

60. Canada, Department of National Defence, 1994 Defence White Paper, Ottawa: 1994, chap 4, p. 1.

61. Bill Sweetnam, "Spy Satellites: The Next Leap Forward," *Jane's International Defense Review*, January, 1997, p. 27.

62. Except as noted, information derived from David Baker, ed, *Jane's Space Directory,* 15th Edition, 1999-2000.

63. Bill Sweetnam, "Spy Satellites: The Next Leap Forward," *Jane's International Defense Review*, January, 1997, p. 27.

64. RADARSAT International web site, [www.rsi.ca].

65. "Satellite Pictures: Private Eyes in the Sky," *The Economist*, May 6, 2000, pp. 71-73.

BIBLIOGRAPHY

Canada, Minister of National Defence, *1994 Defence White Paper*, Ottawa: DND Canada, 1994.

Canada, Minister of National Defence and the Chief of the Defence Staff, *Shaping the Future of Canadian Defence: A Strategy for 2020*, Ottawa: DND Canada, 1999.

Canada, Department of National Defence Deputy Minister of National Defence, *Defence Planning Guidance 2001*, Ottawa: DND Canada, 2001.

Canada, Chief of the Air Staff, *Out of the Sun*, Winnipeg: Graig Kelman & Associates LTD, 1997.

Canada, Minister of Public Works and Government Services Canada, *Maritime Helicopter Statement of Operational Requirement DSP No 00002680*, Ottawa: DND Canada, 14 Jul. 1999.

US, Secretary of the *Air Force, Air Force Doctrine Document 2-5 2, Intelligence, Surveillance and Reconnaissance Operations, 21 April 1999*. Washington, DC: Government Printing Office, 1999.

US, Department of Defence, *United States Joint Publication 1-02, Department of Defence Dictionary of Military and Associated Terms*, Washington, DC: Government Printing Office, 23 March 1994.

Capabilities Initiatives Database "Project 00000140 Aurora Incremental Modernization Project (AIMP)" (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 2001.
"Project 00000317 AIMP – Electro-Optics (EO) System Replacement" (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 2001.
"Project CAS 6 AIMP – Electronic Support Measures (ESM) Replacement" (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 2001.
"Project CAS 15 AIMP – EO System Upgrade" Capabilities Initiatives Database (http://diso.dwan.dnd.ca/IM_MDP/cdi/Details_e.asp), 27 Feb 2001.
"Project 00000276" (http://diso.dwan. dnd.ca/IM_MDP/cdi/Details_e.asp.), 27 Feb 01
"Project 00001225" (http://diso.dwan. dnd.ca/IM_MDP/cdi/Details_e.asp.), 27 Feb 01

Ackerman, Robert K. "Air Force Planners Exploit Commercial Space Imagery." *Signal*, June, 1995, p. 15-19.

Atkin, Keith, ed. *Lockheed Martine Special Avionics Mission Strap-On-Now (SAMSON) pod*. Coulsdon, Surrey: Jane's Electro-Optical Systems, sixth edition 2000-2001, pp. 570-571.

Anderson, Edward G. III, "The Army and Space." *Field Artillery*, May, 1998, pp. 7-10.

Baker, David ed, *Jane's Space Directory*, 15th Edition, 1999-2000.

Blyenburgh, Peter, "UAVs: Where Do We Stand?" *Military Technology*, 23(3) 1999: pp. 29-45.

Browne, J.P.R., and Thurbon, M.T. *Electronic Warfare*. London, UK: Brassey's, 1998.

Correll, J.T., "Signs of a Revolution," *Air Force Magazine*, August 1995, p. 2.

Cutland, Paige, "CAS ISR Capability Brief," Produced Jan 2000.

Danskine, W.B., "The Time Critical Targeting Model," Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama. April 2000.

Divis, Dee Ann "Imaging regulations stalled." *Geo Info Systems*, July, 1999, pp. 18-22.

Dyer, R.D. "SMARTPOD – The United Kingdom ISR Systems Test-Bed," *Proceedings of the SPIE Conference on Airborne Reconnaissance XXIII*. Denver, Colorado, July 1999.

English, A., "Technology and the Future of War," Presentation to No 27 Command and Staff Course. Canadian Forces College, Toronto, Canada, 30 November 2000.

Federation of American Scientists "Advanced Tactical Reconnaissance Airborne System," (www.fas.org/irp/program/collect/tarps.htm), 26 Feb 01.

Federation of American Scientists "Advanced Tactical Reconnaissance Airborne System," (www.fas.org/irp/program/collect/atars.htm), 4 Feb 01

Florini, Ann M., Yahya Dehqanzada, "Commerical satellite imagery comes of age," *Issues in Science and Technology*, Fall, 1999, pp. 45-52.

Fulghum, D.A. "New Radar Would Meld AWACS, J-STARS Roles," *Aviation Week & Space Technology*, 152 June 12 2000: pp. 29-30.

Fulghum, D.A. "Future UAV Sensors to Scan Vast Areas" *Aviation Week & Space Technology*, February 7, 2000, pp. 58-61.

Gerkin, Louis C. UAV-Unmanned Aerial Vehicles. *USA: Library of Congress in Publication Data*, 1991.

Hewish, Mark "Military Takes a Giant Leap with Commercial Space Technology." *Jane's International Defense Review*, April 1, 1999, pp. 41-47.

Holler, J.P. "Royal Danish Air Force Tactical Reconnaissance System," *Proceedings of the SPIE Conference on Airborne Reconnaissance XXIII*. Denver, Colorado, July 1999.

Lamb, Greg S. and Stone, Tony G., "Air Combat Command Concept of Operations for Endurance Unmanned Aerial Vehicles," (Langley AFB): Air Combat Command, 1996.

Lax, M.R. "Per Ardua Ad Astra: Australian Air Power Post 2010," Air War College, Air University, Maxwell Air Force Base, Alabama. April 1997.

Marsh, Bill, Chief of the Air Staff, Air Strategic Planning. Teleconversation. 29 Jan. 2001.

McKean, M. et al, "RADARSAT: A Dual Use Earth Observation Platform", *AGARD Conference*

Proceedings 582 (NATO, October 1996), pp. 38-47.

McPherson, Craig, NG Review, "Global Hawk," www.northgrum.com/news/rev-mag/review09-18.html, November 1999.

MDA product publication BA-BR-MDA-50-8019 8/97 XP-8471-IR3/EM, "Fast TRACS" August 1997.

Nordwall, B.D. "Small-Aircraft Mapping System Uses PCs to Process Data." *Aviation Week & Space Technology*, 150 June 14 1999: pp. 192-193.

Oberg, James "Spying for dummies." *IEEE Spectrum*, November, 1999, pp. 62-69.

Oxlee, G.J. Group Captain. *Aerospace Reconnaissance*, London: Brassey's (UK) Ltd., 1997.

Peach, Stuart and David Gates, *Air Power for the New Millennium*, Lancaster University, Great Britain: Centre for Defence and International Security Studies, 1999.

Peach, Stuart ed., *Perspectives on Air Power, Air Power in its Wider Context*, Defence Studies (Royal Air Force), Joint Services Command Staff College Bracknell, London: The Stationery Office, 1998.

Pennington Way IV, "NRO Gives Army Operational Control of EAGLE VISION II." *Defense Daily*, October 15, 1999, p. 1.

Robinson, Clarence, "Unmanned Surveillance Vehicle Grabs Over-the-Horizon Imagery," *Signal*, 50 Sep 1995: pp. 15-23.

Sengupta, Prasun K., "New Roles Emerging For UAV's," *Asian Defence Journal*, 11/2000: pp. 28-31.

Sloan, Elinor, "Canada and the Revolution in Military Affairs: Current Responses and Future Opportunities." *Canadian Military Journal*, (Autumn, 2000), pp. 7-14.

Sweetnam, Bill "Spy Satellites: The Next Leap Forward." *Jane's International Defense Review*, January, 1997, pp. 26-32.

"Wargames raise questions about commercial satellites." *Aerospace Daily*, October 15, 1997, p. 73.

INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE – THE OPERATION ALLIED FORCE EXPERIENCE

Syndicate 8: Wing Commander A.K. Groves, Lieutenant-Colonel W.M. Roberts, Major B.J. Ellaschuk, Major J.B.M. LaGrange, Major O.N. McDermid, Major C.G. Ness, Major W.M. Snedden (Chair), Major M.A.P. Stouffer, Major W.S. Williams

> *[Gen Wesley] Clark's team improvised a computerized, real-time target development and review process which pulled together American and NATO intelligence assets, the force commanders in Italy, Macedonia and Albania and the battle planners and targeters at Clark's headquarters in Belgium. No such system existed at the beginning of the war, and it wasn't fully operational until late April. But when it had been cobbled together, it gave Clark control of his air war.*
>
> Michael Ignatieff – Virtual War[1]

INTRODUCTION

The Gulf War taught senior military planners that massive application of airpower from all components would be instrumental in shaping the battlefield prior to committing ground troops to an inevitable land battle. Critical to this process was the judicious application of available intelligence, surveillance, and reconnaissance (ISR) assets to ensure that an accurate picture of the current battlespace could be presented and exploited in a joint and combined fashion by coalition forces.

Operation ALLIED FORCE, like the Gulf War, was an air-intensive, joint and combined operation, which used a myriad of assets to strike targets deep in the former Yugoslavia.[2] The concept of employing joint assets to target mobile and time-sensitive targets on the battlefield was initially exercised during Desert Storm and became standard practice during ALLIED FORCE as NATO increasingly focussed air operations on finding, identifying and targeting mobile land and air defence forces in Serbia and Kosovo. The inability of the JFACC to effectively use ISR assets to develop a coherent picture of the battlespace that would permit rapid targeting of Serbian forces has focussed attention on the management, collation and dissemination of ISR data.

While ALLIED FORCE was predominantly an air operation, managing a coherent air picture and ISR data will be an even more acute problem in a fully joint operation comprising of large ground and naval forces. Because air power is inherently flexible and is resident among all components in varying degrees, a detailed, accurate, coherent and timely portrayal of the battlespace is critical to exploiting joint capabilities. Capitalizing upon air power's flexibility means being able to adjust target allocations while aircraft are airborne. It means having the ability to shorten the air tasking cycle in order to take advantage of rapid changes in the battle situation. It means being able to efficiently employ valuable air resources without the excessive risk that results from long loiter times required to confirm targets, or having to attack targets repeatedly because of poor battle damage assessment. Finally, it means being able to immediately task the most appropriate weapon system, regardless of component, to attack targets within the area of operations.

> *The need to minimize time over target and maximize kill will require accurate and continuous knowledge and location of targets, especially mobile targets, rapid battlefield damage assessment, and in-flight retargeting of missiles and weapons.*[3]

To accomplish this aim, the Joint Force Commander needs to have complete access to an integrated ISR system that provides a responsive, unified picture upon which reliable and critical decision-making can be applied. According to the United States Air Force Doctrine Document 2-52, "[i]ntelligence, surveillance, and reconnaissance (ISR) are integrated capabilities to collect, process, exploit, and disseminate accurate and timely information that provides the battlespace awareness to successfully plan and conduct operations."[4]

The Joint Force Commander (JFC) of Operation ALLIED FORCE – Rear-Admiral Ellis - had access to a wide variety of ISR platforms from which to draw information, including E-8 JSTARS and E-3 AWACS aircraft, RC-135 Rivet Joint and U-2 reconnaissance platforms, Keyhole / Improved Crystal and Lacrosse / Vega satellites, and a variety of unmanned aerial vehicles such as the SR-UAV Hunter and MAE-UAV Predator. Simply having access to ISR assets, however, is not enough to permit acquisition of a soluble picture of the battlespace. Such a picture can only be achieved through centralized control of force ISR assets and information processing that permits the production of an integrated battlespace picture for real-time joint targeting.

ISR DOCTRINE

ISR assets are required to supply data for development of intelligence that covers the whole range of intelligence tasks including, Intelligence Preparation of the Battlespace (IPB), targeting, and Battle Damage Assessment (BDA). Increasingly, threats, including ballistic missiles and Weapons of Mass Destruction (WMD), and improved targeting capability, demands improvement in intelligence support. Specifically, there is a requirement for a near real-time target acquisition capability. All Component Commanders have a vested interest in the management of ISR resources to provide the capability of meeting these targeting requirements. This includes the development of a real-time battlespace picture that will permit targeting in real or near-real time.

The United States is the largest holder of ISR assets and the largest consumer of intelligence in the world. Its joint doctrine reflects the interests of all components and the importance of ISR in support of operations. All components are tasked for time sensitive missions including Theatre Missile Defence (TMD) and Joint Targeting. The doctrine in these areas crosses all component boundaries highlighting the need for a joint approach to these tasks and missions. While joint doctrine on Reconnaissance, Surveillance, and Target Acquisition (RSTA) outlines the process for management and control of these assets on a joint basis, there is no doctrine that takes the next step of defining the requirement and process for development of the joint battlespace picture required for timely joint targeting.

Similarly, NATO and CF doctrines are very explicit with respect to traditional intelligence requirements. These bodies of doctrine are written to support IPB and traditional targeting requirements in a more timely and accurate fashion using all available ISR resources. However, as with US joint doctrine, there is no detailed requirement for real-time, or near real-time, targeting intelligence as mandated by today's threats and emerging war-fighting doctrine. Specifically, there is no NATO or CF doctrine that deals with the requirements of a joint integrated battlespace picture required for near real-time targeting and the centralized control of the ISR assets needed to produce this operationally critical picture.

This doctrine deficiency was somewhat masked during ALLIED FORCE because of the lack of a true joint operation and structure; however, it remains an important flaw in overall joint doctrine. Rather than being strictly an intelligence issue, ISR support to real-time operations is now an operational issue. How specifically will CF doctrine, NATO doctrine, and US Joint doctrine address this issue?

Current Doctrine

Any study of ISR doctrine in general, including any doctrine outlining the requirement for the production of an integrated battlespace picture, must include US doctrine since the US possesses the bulk of ISR assets and will likely provide the leadership for any large-scale western operation. Thus, US Joint doctrine will usually provide the framework for an ISR organizational structure and utilization in future joint and combined operations. There is a body of US joint doctrine outlining requirements for joint missions in terms of countering air and missile threats, theatre missile defense, and joint fire support that implicitly requires joint access to ISR products and a system that will allow joint targeting in a time sensitive manner.

> *The purpose of the joint counter-air mission is to attain a desired degree of air superiority to allow freedom of action and protect the joint force. To execute this mission, joint force commanders (JFCs) integrate the capabilities of each component to conduct offensive and defensive operations. Offensive counter-air (OCA) operations seek to dominate the enemy's airspace and prevent the launch of threats, while defensive counter-air (DCA) operations defeat enemy air threats after launch. Joint counter-air missions may employ aircraft, surface-to-air missiles, surface-to-surface missiles, artillery, special operations forces, or information operations against a variety of threats. These threats include enemy aircraft (manned or unmanned), ballistic missiles, and cruise missiles (air, land, or sea launched).*[5]

This quote highlights the fact that this is a truly joint mission requiring the support of all available forces in theatre. Implicit to the nature of the threat (cruise and ballistic missiles), and the joint nature and importance of the air and missile threat defensive operation, is the requirement for real-time intelligence and targeting data that will permit formatting and distribution of ISR information that permits timely joint targeting.

> *Immediate [OCA] missions are conducted against unexpected mobile and time sensitive targets and require rapid action. Minutes often define the timeline when these targets are vulnerable to attack.*[6]

The counter-air and missile threat mission is a joint mission requiring the support of all deployed forces to employ, within minutes of detection, appropriate weapons to neutralize time critical targets such as ballistic missiles and/or their launchers. Detecting these threats is a high priority mission. The consequences of failure could be catastrophic for a coalition or host nation support.[7] Implicit in this mission is the need to continuously survey the battlespace and target adversarial weapons systems using a common target numbering system that allows targeting information transfer to the most appropriate weapon system in a timely fashion (single-digit minutes).

Joint doctrine for the theatre missile defence mission is the *JP 3-01.5 Doctrine for Joint Theater Missile Defense*, which characterizes this mission as inherently a joint responsibility.

> *TMD is inherently a joint mission. During the planning stage, TMD forces, requirements, and capabilities must be integrated into all phases of the operation and mission areas early on.*[8]

To integrate all TMD forces requires the ability to target all theatre missile threats with any available weapon system. As well, targeting must be done with precision and in real-time. There is no time for manual resolution of target tracks. Theatre missile weapon systems must be attacked before they are employed or before their missiles impact if detected after launch. Providing effective missile defense assets is a critical mission for all Component Commanders.

US *Doctrine for Joint Fire Support* implies the need for an integrated battlespace picture that permits joint targeting in a seamless and timely manner. This doctrine states that the Land and the Maritime Force Component Commander will be supported commanders in their areas of operation. They will support each other and be supported by the Air Component Commander for the attack on targets detected within the theatre of operations. As the doctrine states:

> *Within the joint force Theatre and/or JOA, all missions must contribute to the accomplishment of the overall objective. Synchronization of efforts within land or naval AOs with Theatre- and/or JOA-wide operations is of particular importance.*[9]

The supported commander will not execute his mission without the support of the other components. The supporting commanders must be capable of complementing the operations plan, including contributing fires, and fire support.[10] The principles that underlie joint fire support highlight the need for an integrated approach to the mission.

An integrated battlespace picture will enhance the application of all principles needed for the fire support planning and coordination function in joint fire support. Essential to the application of these principles is an integrated real-time picture. Examples of these principles include:

a. ensuring a continuous flow of targeting information;
b. accessing all available lethal and non-lethal means (including assets from supporting components);
c. using the most effective fire support means available (including assets from supporting components); and
d. avoiding unnecessary duplication.

It is impossible to effectively apply these principles without an effective means to target using all appropriate forces quickly and seamlessly. All components require a means to pass targeting information with sufficient fidelity to permit precision tasking. The current concept of operations for all components includes a level of automation that requires quality-targeting information to be passed in a coherent fashion among information networks throughout the battlefield. Different systems produce different battlespace pictures. The result is different track numbers assigned to the same target, which in turn confuses the targeting process by not matching the principles of joint fire support.

The efficient production of this targeting picture will be a very high priority for the JFC because of missions that this capability will support. Failure due to component emphasis on independence and control of resources will place the success of the mission at risk. To produce this picture, a single task element must have access and indeed control of the required resources. Other tasking requirements for these critical resources must flow through this single task element. Tasking priorities will be established by the JFC following consultation with the component commanders.

There is well-established and coherent US Joint Doctrine for ISR asset management (*JP 3-55 Doctrine for Reconnaissance, Surveillance and Target Acquisition (RSTA) Support for Joint Operations)*. Recognizing that there will never be enough RSTA assets, this doctrine establishes procedures and authorities for the establishment of intelligence priorities and the tasking of Theatre RSTA assets. Unity of command and centralized control are guiding principles within this doctrine.

Essentially the J2 establishes the intelligence collection plan in accordance with priorities set by the Joint Force Commander (JFC). The Joint Reconnaissance Center (JRC) under the J3 coordinates the RSTA assets to meet the RSTA requirements of the JFC. The J3 tasks assigned Theatre-RSTA assets to meet the collection plan needs of the J2 and the Joint Force Air Component Commander (JFACC) controls the airborne RSTA assets on behalf of the J3.[11]

> *The JFACC's responsibilities normally include planning, coordinating, allocating, and tasking of appropriate airborne RSTA assets made available, based on the JFC's apportionment decision. Following the JFC's guidance, and in coordination with other Service component commanders and other assigned or supported commanders, the*

JFACC will recommend to the JFC apportionment of air sorties to various missions and geographical areas.

JP 3-55 (III-4)

This doctrine is very logical with respect to intelligence collection and targeting done in traditional timelines with fixed targets and a three-day ATO cycle or normal operational planning cycle. However, it only obliquely refers to time sensitive operations when it states: "[t]o be effective, targeting must identify the best weapon for the intended target with appropriate timing to meet the objectives established by the commander."[12]

There is no outline process for developing real-time targeting intelligence to support time sensitive joint operations such as TMD or joint targeting. Nor is there a process identified for the production of a joint integrated battlespace picture that can support these targeting requirements including the logical requirement for centralized control of ISR assets to permit the effective production of this coherent battlespace picture. This may explain the fact that the targeting requirements are only found in doctrine published since the RSTA doctrine was promulgated. However, it remains that current RSTA doctrine does not support current targeting requirements. The centralized control of ISR assets in support of traditional intelligence requirements, therefore, provides a framework for the establishment of doctrine that will detail how ISR assets will be utilized for the production of an integrated battlespace picture in support of real-time operations.

Implicit in US Joint doctrine is the requirement for an integrated battlespace picture. Nevertheless, this requirement is not addressed directly by the doctrine, nor does it include the critical supporting issue of command and control of ISR assets to support real-time targeting. It does, however, provide good guidance for the management of ISR assets in support of traditional intelligence functions. This doctrine establishes the principle of centralized control of critical ISR assets and should be adopted for the support of real-time operations through the production of an integrated battlespace picture. While there is no explicit doctrine for real-time targeting support, the US is not alone in this deficiency. Canada and NATO have similar doctrinal shortcomings.

Although Canada does not possess an ISR doctrine, intelligence doctrine can be found in several manuals including *B-GG-005-004/AF-000 Canadian Forces Operations* and *B-GG-005-004/AF-008 Intelligence Doctrine and Procedures for Canadian Forces Operations*. The principles of using all available resources to produce the most accurate intelligence possible, and the requirement to use all available collection resources to produce intelligence products in the most expeditious manner possible, permeate CF doctrine in the same manner as the US Joint doctrine. Similarly, the principle of centralized management of intelligence resources to support this effort is found in CF doctrine to the same extent as it is in US doctrine.

However, as with US Joint doctrine, CF doctrine does not to address the requirement for intelligence support to real-time or near real-time operations. While target acquisition is identified as a primary role for ISR resources in *Out of the Sun*, specifics on how this acquisition should be accomplished, including command and control of ISR resources, are not detailed in *Out of the Sun*.[13] While *Canadian Forces Operations*, Canada's keystone manual for CF doctrine, acknowledges that timely and accurate intelligence is a prerequisite for the conduct of effective operations, it does not mention the importance of an integrated battlespace picture nor the best means to produce this picture.

The essential problem is that real-time collection and dissemination, and the use of ISR assets to produce the integrated battlespace picture, is an operational issue as well as an intelligence issue. Intelligence is just one part of the process. And while the intelligence principles of employing all necessary ISR assets and the requirement for a centralized process for intelligence support are valuable, the nature of these operations requires direct operational control of the process. In particular, *B-GG-005-004/AF-008 Intelligence Doctrine and Procedures for Canadian Forces Operations* emphasizes an all source intelligence approach to the support of operations. According to this document, "the intelligence system should strive to provide for holistic views, not intelligence discipline views."[14] The same principles are required to support real-time operations through the production of an integrated battlespace picture using all required ISR assets under control of a single officer.

NATO doctrine in this area can first be found in *AJP -01, Allied Joint Doctrine*, which is the capstone document for the planning, execution, and support of allied joint operations. Similar to the Canadian Forces' *Out of the Sun*, *AJP-01* provides a summary of ISR operations. More importantly, *AJP-01* identifies the requirement to "establish an intelligence architecture linking NATO and national intelligence centres with All Source Analysis Cells (ASAC) at the various headquarters. This is to provide the Commander Allied Joint Force (COMAJF) with a common, timely and accurate picture of the situation during all phases of the campaign."[15] Chapter 12 of *AJP-01*, which is dedicated to Intelligence, goes further with respect to ASAC by stating that "the role of an ASAC is to fuse the information and intelligence collected by various sources and agencies, including intelligence input from strategic sources through national intelligence cells."[16] Therefore, while it appears that NATO has recognized in its high level doctrinal manual the requirement for an integrated intelligence picture, it must be emphasized that NATO doctrine does not address the importance of an integrated battlefield picture with a link to real-time or near real-time targeting.

AJP-3.3 Joint Air and Space Operations Doctrine is the key document for joint aerospace operations within NATO. Although it provides fundamental principals for the conduct of joint and combined aerospace operations, *AJP-3.3* provides very little in terms of ISR doctrine. However, *AJP-3.3* does provide a summary of the targeting process, which identifies the requirement for timely intelligence input. Furthermore, *AJP-3.3* recognizes the Command and Control (C2) difficulties inherent with the employment of national ISR assets in a coalition operation. Specifically, it recognizes that the Joint Force Commander will not have operational control of the entire pool of coalition ISR assets.[17] This omission presents significant challenges for the support of real-time targeting operations requiring centralized control of ISR resources. In addition to the challenges of providing centralized control of ISR assets in a joint operation, there will be challenges to mission accomplishment in a combined operation. The combination of these challenges will be more acute in the future as the threat levels and the consequences of failure increase with the proliferation of WMD technology and weapons.

Threats such as theatre ballistic missiles and WMD combined with new precision targeting capabilities require a change to traditional intelligence support doctrine. The requirements for real-time target acquisition and targeting capability is implicit in US Joint doctrine. TMD and other critical missions are not achievable without a real-time targeting capability that integrates all joint targeting assets. To enable joint targeting, there must be a single integrated battlespace picture. The production of this picture must be centralized using all contributing ISR resources available to the joint force commander. Implicit to this requirement is the necessity for centralized control of the required ISR assets.

There is a wide body of ISR or RSTA doctrine that identifies the need for timely intelligence produced through diffusion and analysis of a wide range of data from the full complement of ISR assets available to commander. While this doctrine addresses the critical nature of timely collection, analysis, and dissemination of ISR data, real-time target acquisition requirements are not specifically addressed. This doctrine is written with the traditional intelligence preparation of the battlefield mission in mind and seeks to speed up the intelligence process to provide more timely and accurate intelligence for traditional targeting. A new approach is required that not only recognizes a continuing need to improve traditional intelligence capabilities, but also addresses the emerging operational requirement to conduct targeting in support of new missions such as TMD. This new approach must allow for the full exploitation of improved targeting technology under the principle of unity of command and centralized control of ISR assets.

Given the importance of the requirement for an integrated battlespace picture that will allow joint targeting during real-time, or near real-time operations, it is recommended that the CF develop Joint Doctrine that addresses the doctrine deficiency for the integration process. This doctrine should:

a. define the operational requirement for an integrated battlespace picture;
b. identify the process as largely an operational issue rather than an intelligence issue;
c. identify the requirement for access to all required ISR assets by the officer responsible for the production of the battlespace picture; and
d. be based on the principles of unity of command and centralized control of the process found in intelligence doctrine for the management of the intelligence production process.

Finally the CF should ensure that these doctrinal issues are dealt with in a truly joint and combined fashion when co-operating with our allies in international ISR projects.

ISR AND ALLIED FORCE

Operation ALLIED FORCE introduced an explosion of new technology onto the battlefield, particularly in the area of ISR. The analysis of the operation continues and additional conclusions will be reached as a result; however, lessons are not learned until improvements are made to correct analyzed weaknesses. Therefore, it will not be until the next operation that lessons learned from Operation ALLIED FORCE will be truly verified. For example, many of the ISR shortfalls that were identified during the Gulf War were successfully overcome in Operation ALLIED FORCE.[18] Although it is still too early to assess whether all Operation ALLIED FORCE ISR deficiencies have been determined, many deficiencies are in the process of being addressed.

Operation ALLIED FORCE presents an excellent study for examining current ISR doctrine by assessing how well doctrine was implemented during this conflict. ISR assets used during Operation ALLIED FORCE were unprecedented in terms of capability and variety. Space ISR assets provided the capability for wide area electro-optical and infrared surveillance that was relatively impervious to the effects of terrain masking as compared to other ISR assets.[19] E-8 Joint Surveillance Target Attack Radar System (JSTARS) aircraft provided near-real time radar imagery through synthetic aperture radar and ground movement target indicator systems (GMTI), that enabled detection of stationary and mobile vehicles plus the production of detailed maps. E-3 Airborne Warning and Control System (AWACS) aircraft provided surveillance, control, electronic support measures (ESM) and radio relay capabilities. Photographic and radar imagery was provided by the U-2. Additionally, the U-2 and the RC-135 Rivet Joint electronically monitored enemy communications and located their transmission source while the SR-UAV Hunter supplied near-real time video imagery intelligence. Though employed primarily in a surveillance role, four MAE-UAV Predators were fitted with an AN/AAS-44(V) space infrared laser detecting ranging tracking set. This multi-purpose thermal-imaging sensor provided long-range surveillance, target acquisition, tracking, range-finding and laser designation for tri-service and NATO laser-guided munitions including attacks by AH-64 Apache helicopters carrying Hellfire air to surface missiles.[20]

Though successful in some areas, Command, Control, Communications and Computers (C^4) infrastructure proved to be a key limitation for the effective use of ISR assets. The ability to gather intelligence was compromised by the coalition's inability to effectively disseminate appropriate data in a timely manner. In part, this was caused by the sharing of bandwidth amongst C^4 assets; the lack of C^4 network integration standards at the combined and joint task force level; spectrum management challenges; network security difficulties; and the lack of timely compliance with NATO standardization agreements, as identified in the US Kosovo After Action Report.[21]

Another major problem was the lack of interoperability between various receivers and transmitters of data. Some agencies that required specific information could not accept the data even when it was available. This inability to exchange high-fidelity digital data was identified as a shortfall at every stage of Operation ALLIED FORCE. Enabling a successful strike against a time-sensitive target requires the continuous timely transfer of precise target information. Lack of interoperability during Operation ALLIED FORCE strikes meant reaction times were slow thereby compromising the force's ability to engage time-sensitive targets.

Although a joint data network was established, the various tactical digital systems, multiple transmission systems, and message formats resulted in the ISR components being unable to properly interact with one another. To circumvent the inherent barriers of these stovepipe systems, liaison personnel were required to manually pass information – a function that automated interfaces should perform more efficiently and effectively. This manual interface increased the operations workload and the potential for error.[22] A singular integrated data network was never achieved and as a result, a common operational picture was never generated.[23]

As the capabilities of ISR assets have increased, so too have commanders' demands for information generated by these assets. As identified in the UK and US "After Action Reports," ISR availability, in terms of limited resources for critical missions, was classified as low-density high demand (LD/HD). The US had to re-allocate non-theatre assets, such as additional JSTARS, AWACS, U2, and UAVs, from other CinCs in order to meet the requirements of the ALLIED FORCE campaign.[24]

ISR capabilities were an integral part of the success of ALLIED FORCE. However, the extensive and unprecedented utilization of ISR assets brought to light serious shortfalls in the ability to use this intelligence effectively. Commanders at all levels were inundated with information.[25] Data shortfalls and incompatibilities meant much of the ISR information had to be integrated manually and relayed in less than ideal modes, decreasing both the timeliness and accuracy of the data. Commanders' decision-making cycle and the potential for error were thus increased commensurately.

At the tactical level, integration of information is essential, particularly when the attacking system is unmanned as in the case of Tomahawk Land Attack Missiles. Campaign constraints required visual identification of the target and correlation with other targeting intelligence.

> *During Operation ALLIED FORCE, our precision intelligence capability played a significant role in the employment of precision munitions to systematically degrade important Serbian military targets.* [26]

Sufficient background information is required to allow accurate assessment of operations impact and to ascertain the adversaries' remaining capability. Limited collation of valuable BDA information degraded this assessment diminishing the value of the assessment to the commander and potentially compromising some missions while increasing the potential for the redundancy of others.[27]

Overall, ISR capabilities provided the JFC with a greatly improved ability to pursue his operational plan while at the same time meeting the restrictive requirements of ROE in operations other than war.[28] Unfortunately, the lack of a single common integrated air picture limited the optimum exploitation of ISR resources and data.

> *There are not lessons learned from Kosovo. There are lessons. …[W]hether we are able to act on those lessons will be an issue of resources and political will. I believe the jury is still out on that.*
>
> Lt Gen Michael C Short

It was recognized that technologies, which can provide real-time imagery and target location directly to fighter and bomber crews, must be developed and introduced. Targeting data must be completely integrated between all available air and space sensors and be readily available to operational commanders with the final goal of reducing target identification to target destruction time from hours and days to minutes.[29]

The Joint Worldwide Intelligence Communication System (JWICS) was a valuable force multiplier during Operation ALLIED FORCE and was integral to the success of the federated intelligence process.[30] In particular, the use of a secure video-teleconferencing system – Secure Internet Protocol Routing Network (SIPRNET) – proved invaluable and demonstrated a considerable breakthrough in technology. ALLIED FORCE was for the most part planned and directed using secure video-teleconference, secure telephone and e-mail. This new technology gave operational commanders a common operational perspective and allowed information to be drawn from around the world across national, service and organizational boundaries. Although joint doctrine prior to ALLIED FORCE stressed the need for component commanders to be collocated with the Joint Force Commander, in reality none were. For the first time, modern technology allowed component commanders to be stationed wherever it made the best tactical sense.[31]

It became clear during Operation ALLIED FORCE that there was a growing technology gap between the United States and her NATO allies. The "After Action Report" to Congress on the Kosovo campaign has suggested that a top priority should be to coordinate with NATO member nations to seek improved secure telephone and PC/network based information systems. Programmes, such as the Defence Capabilities Initiative, will help to address NATO interoperability challenges. The Defence Capabilities Initiative seeks to enhance allied military capabilities in five key areas including command control and information systems.[32]

The United States recognizes the key role of ISR and has committed substantial funding to ISR related development as a result of lessons learned from Kosovo. The United States Congress provided $37 million in the FY2000 supplemental budget to replace and enhance UAVs, $111 million for additional EP-3 aircraft and enhancements and $30 million for other related ISR research. some of these projects are a result of the positive contribution seen as a result of the unprecedented use of unmanned aerial vehicles. Funding is also being used to replace Predator UAV losses, to repair or replace damaged and lost Hunter UAVs, for repairs to maintenance facilities and to add a laser designator capability to Predator. The FY 01-05 budget also calls for an additional $918 million for a new JSTARS aircraft, $260 million additional funding for the Global Hawk program, and $390 million for other ISR enhancements. In addition the FY01-05 budget also includes $1.5 billion increased investment in the tasking, production, exploitation and dissemination (TPED) of intelligence assets. These investments will be used to address many of the shortcomings identified in ISR integration in the ALLIED FORCE operation.[33] This large influx of cash to replace and expand ISR capabilities highlights the necessity to ensure that all of these assets can operate in a unified manner.

THE IDEAL ISR SITUATION

Comprehensive employment of ISR assets is essential to the effective exploitation of the modern battlefield. While Operation ALLIED FORCE provided a glimpse into the future potential of ISR operations, there were numerous problems with respect to a lack of centralized command and control of ISR assets. In order to fully exploit the modern capabilities of various ISR assets it is essential that a centralized command and control organization employing common processes, and equipped with the attendant resources be developed around an organization that is responsible for these tasks.

Within the context of current technology, intelligence products must still be processed by the base component of the applicable asset (for example the ground station for the Pioneer UAV) due to the numerous unique data formats that are utilized by various ISR assets. Data fusion technologies must be developed that can manage a variety of unique data streams for collation at a central location. Additionally, serious efforts must be made to standardize data products that could then be fed directly into a common intelligence picture (CIP) from the source – in a manner similar to the AWACS and Link-16.

As identified in the US after action report, a "…joint, secure, tactical data link capability such as Link-16 is needed across all strike platforms to allow real-time data exchange and precision target processing between sensor and shooter, and to establish a robust common tactical picture."[34] This capability is fundamental to the establishment of a single integrated battlespace picture. All data streams must be automatically fused into the common picture while maintaining data integrity at all times. Data must be timed stamped and processed to ensure the most current data is used and a data reliability assessment is assigned. These two features are vital for practical engagement of targets by tactical forces. Unique assignation and identification of all friendly and enemy assets is key to the battle commander's situational awareness and ultimate success.

To achieve data synergy from integrated ISR assets, it is essential that ISR products be fed to an ISR coordinator. This coordinator – termed the J2 Common Intelligence Picture (CIP) – would be an element of the J2 organization responsible for initial information conflict resolution and immediate reply to RFIs (Figure 1). This organization must have adequate personnel resources in order to effectively compile the CIP to include intelligence experts, information systems experts, and knowledge management experts.

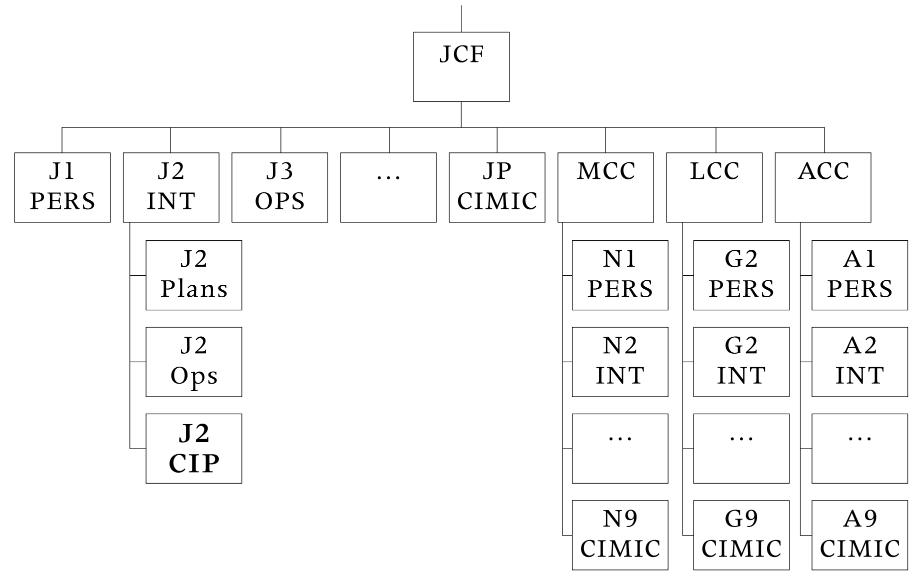


Figure 1 - J2 CIP Organization

The J2 CIP would be responsible for the coordination of the data streams populating the CIP. The CIP is similar to the Common Operating Picture (COP) but also includes associated intelligence data such as sensor data, imagery, RFIs, RFI history, and intelligence databases. This provides the centralization of ISR data that is critical to the effective coordination of ISR assets. More importantly, much of the airborne sensor data would be collated in near real-time – a capability critical to the success of rapid targeting. The J3 would be able to use this technology to maintain an accurate picture of the battlespace thereby better facilitating dynamic tasking of available assets.

The following is a representative list of assets that would provide input to the CIP:

- Strategic assets such as satellites
- Special Operations Forces
- Tactical Air Recce
- AWACS
- JSTARS
- UAVs
- EP3
- U2
- Tactical Unit Situation Reports
- Human Intelligence (HUMINT)
- National Intelligence Centres
- Recognized Air Picture (RAP)
- Recognized Maritime Picture (RMP)
- Recognized Land Picture Common Operating Picture

The output is the CIP, a digital compendium of all available information applicable to the theatre of operations, which would be immediately accessible by all supporting and supported units.

Figure 2 shows the conceptual flow of the CIP process. It displays both how requests for information and replies are processed. The J2 CIP would produce and maintain the CIP based on inputs from the assets listed in Figure 3. Any and all units/users will then draw on the CIP to extract ISR data as required.

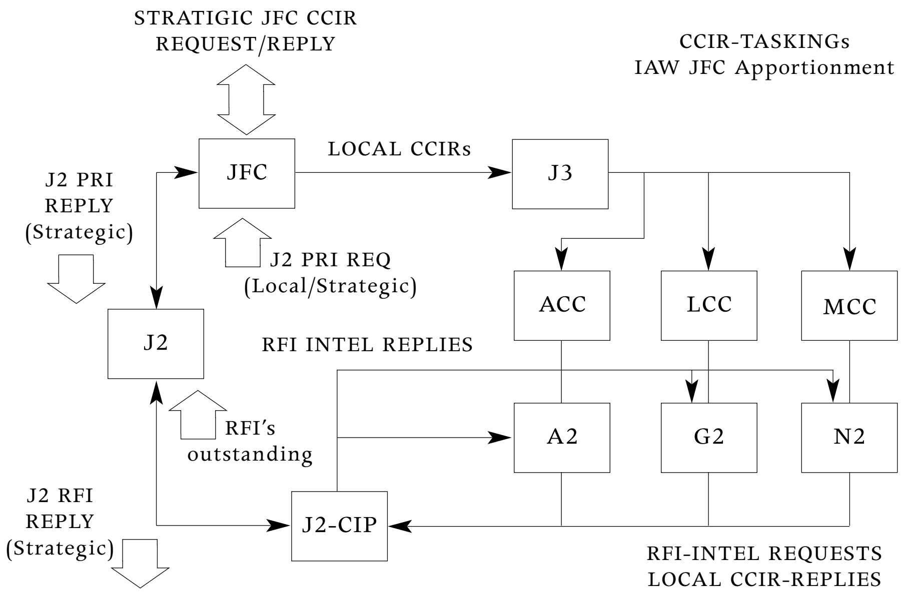


Figure 2 - Joint ISR RFI / Tasking Flow

There are three options available when accessing the CIP. The first option is where the information has been "pushed" in order to be readily available on the CIP without the need for further interaction.[35] For the J3 in a joint force, this method of data presentation is vital for rapid assimilation of information. In the second instance, the information having been previously requested via RFI is now available on the CIP. In this case the user has the option of accessing the information directly from the CIP or via the RFI Reply database containing hyperlinks to the appropriate data. In the third approach, the information has been requested, but has not yet been satisfied. The request for information has been registered and the requester has been informed of when the data will be available.

Within the daily operations planning cycle the J2 CIP will forward all unsatisfied RFIs to the J2 who will recommend priority and asset allocation. The J2 will create a list of locally tasked CCIRs in addition to strategic-level CCIRs that will be forwarded to the JFC. The JFC will then authorize/amend the two prioritized lists thereby providing direction to the J3 for subsequent tasking of the various ISR assets.

Strategic CCIRs will be sent to the superior HQ (NATO or multi-national HQ) for resolution. Once the strategic-level reply is received by the JFC, the information will be passed to the J2 who in turn will pass the reply to the J2 CIP for inclusion in the CIP. The J2 CIP then informs the RFI originator that the reply is available. Any operational missions generated by the J3 to satisfy a local CCIR will automatically forward the acquired information to the J2 CIP, who will compile the information and inform the request originator that the information is now available.

In addition to near real-time functionality, the CIP will highlight the latest information inputs for all users. Alternatively, users may view new information via a search tool that allows the user to design the search based on time, type of information, or source of information. This search tool allows customized searches based on the users' needs thus providing the user with the necessary ISR information in the most expeditious manner.

To fulfill the mandate of centralized ISR data management and control, the J2 CIP would require a robust information management capability that is fully connected via a secure network with all ISR sources, analysts and product users. A comprehensive software tool is necessary to compile, index, and present all available ISR information. Additionally, this same tool must provide access to RFI information consisting of RFIs satisfied, RFIs pending, and RFIs submitted and awaiting prioritization. Embedded within the CIP will be additional ISR databases as generated by the various strategic and national ISR assets.

The proposed J2 CIP process would offer the following advantages:

a. the overall theatre strategy would be supported by the harmonized apportionment of ISR assets in direct correspondence to the JFC's priorities;
b. ISR and targeting assets are controlled at the same level, which would result in an effective coordinated strategy and allocation; i.e., the ISR can support the targeting in terms of providing pre-strike intelligence and post-strike assessment;
c. the J3 would have immediate access to a near real-time portrayal of the battlespace to provide timely decision-making ability – particularly when conducting operations against mobile or "pop-up" targets;
d. centralized control would eliminate duplication of effort with scarce ISR assets potentially freeing up assets to hold standby/alert. This may help reduce the operational tempo while at the same time providing a quick reaction capability;
e. centralized control allows for the assignment of the most appropriate available asset to each target;
f. the process would allow users to customize their portal (customized view) to selectively display the information they require;
g. simultaneous access by users with diverse security clearances to a common pool of ISR data could be programmed;
h. the information and decision cycle would be much shorter for commanders and staff in those instances when information has been previously compiled and available;
i. decision-makers could potentially satisfy an ISR requirement immediately (assuming the information is readily available on the CIP); and
j. it would avoid duplication of similar RFIs and CCIRs from the various component commanders. If the data has been requested the result is either in the system or the requirement is in the process of being satisfied.

The J2 CIP Process may suffer from the following disadvantages:

a. ISR asset owners may be reluctant to release assets to a centralized authority;

b. there may be concerns over the sensitivity of releasing specific information to coalition partners. The requirement for multi-level secure access creates the requirement to efficiently sanitize the product to the appropriate level while ensuring maximum usefulness of the CIP;
c. dynamic targeting, while improved, may remain problematic with current technology until such time as all ISR assets are capable of feeding compatible real-time data formats into the CIP;
d. this system may not be as responsive to subordinate commander ISR demands due to a lack of asset ownership. To alleviate this, select ISR assets may be assigned to units utilizing TACOM/TACON C2 relationships to support specific short-term requirements; and
e. national expectations and/or security concerns may preclude optimum information sharing and access to national ISR assets for JFC tasking.

The J2 CIP system facilitates the centralized control of ISR assets and information – a problem noted during Operation ALLIED FORCE. Uniquely formatted data streams translated into a standardized protocol for the CIP is the predominate hurdle to be surmounted in realizing the ideal solution. The J3 must have immediate access to near real-time data to effectively prosecute targets on the modern battlefield; therefore, efforts to completely integrate ISR assets and their subsequent data products must progress quickly.

CONCLUSION

The Gulf War built the foundation upon which current ISR doctrine has been constructed. General Schwarzkopf required timely and accurate information in order to maintain confidence in the critical decision-making process. Rapid target information was essential in minimizing the threat from Iraqi mobile missile launchers and other mobile targets. These Gulf War lessons were known prior to Operation ALLIED FORCE, but the solutions were not well implemented in the early stages of the conflict.

ALLIED FORCE ISR assets were not immediately integrated into a single product - perhaps as a result of the confidence in the anticipated short duration of the conflict – which resulted in a slow target identification and selection process. By March 1998, General Clark had only 100 approved targets available and desperately needed several hundred more. Identifying these targets was a daunting task. Lacking sufficient troops on the ground to visually confirm targets, General Clark was forced to rely on airborne Forward Air Controllers (FAC) providing modest reaction times.[36] The execution of a fully integrated ISR system under centralized control with centralized information processing would have produced a clear and comprehensive battlespace picture.

The US doctrinal framework for the employment of ISR assets is well documented. Control of ISR assets rests with the J3 within the joint force structure. The J2 is responsible for producing the intelligence picture; however, a lack of guidance on the management and production of that integrated picture detracts from a near-future solution to the problem. Additionally, a lack of combined operations doctrine will make future coalition operations a challenge in the initial confusing stages of a conflict similar to Operation ALLIED FORCE.

Once ISR assets have been placed under the centralized control of the appropriate commander then the intelligence requirements can be collated by a centralized agency such as the J2 CIP. The data collection process will prevent overlapping of parallel processes allowing information to be easily transmitted using existing technology to all users in near real time so that all commanders and associated staffs have the same understanding of the battle situation.

Initiating the centralized control and processing of ISR assets and products will not be easy as many commanders will want to protect their interests and maintain influence over collection of what they feel is critical information. In fact, for some commanders there may be a loss of responsiveness to data collection. This, however, should be a minor concern when considering the "big" picture. Despite the rapidity, quality, and accuracy of any ISR product, political demands may still require a human visual confirmation of politically sensitive targets, which no integrated picture can provide quickly. This too is of minor concern and should be considered an isolated problem.

The role of ISR in the targeting process cannot be understated. Modern, mobile weapon systems, diverse operational theatres, and intense scrutiny by politicians and public alike, demand that targeting be conducted rapidly with accurate and detailed information which will provide for the necessary level of destruction without unacceptable collateral damage. A lack of centralized control over ISR assets will produce a fragmented, confusing, and a potentially destabilizing battlespace picture while sacrificing critical timeliness.

It is clear that future application of ISR in both joint and combined operations must be centralized and that prioritization and processing of intelligence information must be handled by a dedicated organization that can quickly produce a single accurate portrayal of the battlespace. As ISR platforms become more capable, and data transmission faster and more reliable, this comprehensive approach to ISR will become all the more important.

Endnotes

1. Michael Ignatiaff, *Virtual War – Kosovo and Beyond* (Toronto, ON: Penguin Books, 2000), 99.

2. Operation ALLIED FORCE was a limited joint operation due to the lack of a large presence of land and naval assets other than the integral air and aviation assets they provided to the campaign.

3. United States, Department of Defense, *Military Critical Technologies: Part III, Developing Critical Technologies, Section 16 – Positioning, Navigation, and Time Technology* (Dulles, Virginia: Defense Threat Reduction Agency, 2000) III-16-1.

4. United States, Department of Defense, *Air Force Doctrine Document 2-52 Intelligence, Surveillance, and Reconnaissance Operations* (Maxwell Air Force Base, Alabama: Headquarters Air Force Doctrine Center, 21 April 1999)

5. United States, Department of Defense, *JP 3-01 Joint Doctrine for Countering Air and*

Missile Threats (Washington D.C.: United States Department of Defense, 1999) v.

6. "JP 3-01" ix.

7. Richard Hallion, *Storm Over Iraq* (Washington D.C.: Smithsonian Institution, 1992) 180. As an example of the political consequences of these weapons the Persian Gulf War coalition was threaten by the possible Israeli response to the impact of chemical warhead equipped Scuds launched by Iraq. Schwarzkopf believed it would have meant the end of the coalition.

8. United States, Department of Defense, *JP 3-01.5 Doctrine for Joint Theater Missile Defense* (Washington D.C.: United States Department of Defense, 1996) vii.

9. United States, Department of Defense, *JP 3-09, Doctrine for Joint Fire Support* (Washington D.C.: United States Department of Defense, 1998) vi.

10. *JP 3-09* v.

11. United States, Department of Defense, *JP 3-55 Doctrine for Reconnaissance, Surveillance and Target Acquisition (RSTA) for Joint Operations* (Washington D.C.: United States Department of Defense, 1993) III-6.

12. *JP 3-55* IV-1.

13. Canada, Department of National Defence, *B-GG-005-004/AF-008 Intelligence Doctrine and Procedures for Canadian Forces Operations* (Ottawa, Ontario: Queen's Printer) Preface.

14. *B-GG-005-004/AF-008* article 407, paragraph 2.

15. North Atlantic Treaty Organization, *AJh ADoctrons*

27. United Kingdom Secretary of State for Defence, *Kosovo: Lessons from the Crisis* (London, England: Queen's Printer, June 2000) para 7.21.

28. *Operations in Kosovo, US Armed Services Committee* 18.

29. *Operations in Kosovo, US Armed Services Committee* 53.

30. *Report to Congress KOSOVO* 53.

31. *Operations in Kosovo, US Armed Services Committee* 73-74. According to some analysts, however, this was a principal failing, not an enhancement, of Allied Force.

32. Oper*ations in Kosovo, US Armed Services Committee* 139.

33. *Report to Congress KOSOVO* 3.

34. *Report to Congress KOSOVO*.

35. The term "pushed" is used to imply that the information has not necessarily been requested but it is deemed to be useful information and is then included in the CIP by the J2 CIP.

36. Ignatiaff, 99.

The Decline of Meaning and the Rise of Leadership?©

Joseph A. Engelbrecht Jr., Ph.D.
Toffler Associates®

This report represents the views of the author and does not represent the views of Toffler Associates® or individuals or organizations who participated or supported its development.

Introduction

This essay imagines a future in which strategy, initiative, and leadership compensate for an emerging world characterized by the decline of meaning and the rise of mystery. Elsewhere, others and I have posited that the world around will be increasingly transparent. Yet, despite such transparency, we may be inundated with data that lacks focus and which appears meaningless. In addition, as we unveil and unwrap the world around us, we will discover new mysteries that seem to defy explanation. This essay briefly repaints this future, examines recent efforts to offer us an information advantage, and suggests that leadership and initiative must inevitably emerge to lead us from this "chaos."

The Decline of Meaning and the Rise of Mystery©

Imagine a world in which technology promises us vast amounts of data. Already, there are nearly half a billion PCs on the planet – one for every 13 human beings. By 2005, forecasters expect 1 billion Internet users. Sixty-two percent are expected to access the Internet with wireless devices. Commercial satellite revenues are expected to climb from $30 billion in 2000 to $115 billion in 2007. High capacity Ka band broadband satellite services are expected to dominate a market, composed of mid and small business, small office – home office (SOHO) and consumers, which will drive down prices for everyone.

Some scientists expect that technology may drive changes too complex for us to process. They note the human mind has evolved over 10,000 years to a processing capability of about 10^6 million instructions per second or MIPS. The mind is thought to have memory accessing capabilities in the range of three to five terabits. These technologists anticipate that in three decades non-human processing speeds will be beyond 10^{24} MIPS and note that transport speeds already exist with information inputs at speeds from forty terabits to one or more petabits per second. The scientists see raw processing power that is simply beyond human comprehension.[1] Given exploding telecommunications interconnectivity and processing power, we should expect tremendous amounts of data and information to be available.

Yet, increased data does not mean more meaning. Consider the movies. Our Hollywood friends tell us that making movies is about telling stories. Telling stories is all about advancing the plot. Vivid characters enrich the story, but the critical dynamic is moving the plot. So when the camera captures the action, the objective is not to reproduce the exact details of the scene, but to reproduce those details that convey the development of the story. In fact, the camera obscures details that would interfere with the audience's attention to the meaning of the story's twists and turns. So, when we see a close up of a couple kissing, we may be seeing it through a filter, cheesecloth of sorts, which softens the pores, hairs and blemishes on the actors' face to keep the mood romantic. If the story element is clear, in this case romance, then it becomes a metric for the appropriate level of detail. More detail would distract from the meaning. Our movie experience reminds us that eliciting meaning is not simply a function of the data available, but more importantly a matter of achieving the right focus.

The meaning of "meaning," the philosophers tell us, is rather ambiguous. Meaning can have at least four meanings.[2] Meaning can mean intention or purpose. It can mean designation or reference. A third meaning is that of definition or translation. And a final meaning for meaning relates to the causal antecedents or consequences of a thing or of things in motion. The word "mystery" has a rich etymology, deriving from the Greek *múein*, meaning "to close one's eyes and mouth" or to "keep secret."[3] Hence "mystery" means something that is beyond understanding. As we enter the Third Wave more deeply, we must consider the possibility that competition and warfare in the Third Wave are characterized by an environment wherein meaning is less easily acquired, and a number of mysteries could arise to supplant it. Said another way, we wonder aloud whether we should prepare ourselves for a future when the much-prized transparent battlespace could become the domain of mystery and realm of apparent meaninglessness. When compared to yesterday, transparent it may be, but understandable it may *not* be.[4]

Modern ISR and Information Superiority

Does the future we suggest contrast with that envisioned by senior government and military officials? The U.S. envisions modern intelligence, surveillance, and reconnaissance (ISR) systems that will deliver information superiority. The U.S. *Joint Vision 2010,* for example, called for information superiority, which it defined as "the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."[5]

The U.S. military and intelligence community are planning on modernizations of space-based systems to produce more intelligence and important data. In fact, the Future Imagery Architecture being developed for the U.S. National Reconnaissance Office (NRO) is such an improvement that some believe that it and other proposed systems will generate more data and images than can be analyzed.[6] To ensure a balance between collection capability and analytic capability, the U.S. Congress allocated multiple billions of dollars to the U.S. National Imaging and Mapping Agency (NIMA) to handle the new analytic volumes in the tasking, processing, exploitation, and dissemination or TPED process.[7] In addition to the Future Imagery Architecture, the NRO has set its vision to create a revolution in global reconnaissance and has reportedly increased R&D funding to achieve it. Further, in an example of growing partnerships among high technology organizations, DARPA, the U.S. Defense Advanced Research Projects Agency, USAF, and NRO allied to create Discoverer II, a low earth orbiting system that promised the ability to detect moving targets. While the U.S. Congress reduced funding for Discover II, it seems likely that future space-based systems will bridge the gap between strategic intelligence for national users and intelligence products and services tailored for military activities. In addition, the U.S. military is replacing communications satellites with a "wideband gapfiller" until their advanced communications systems and commercial services fill an exploding need for broadband voice and data telecommunications.

Learning to assimilate and act on richer data will not await new space systems. Airborne systems are increasingly being augmented by UAVs – uninhabited aerial vehicles. During Kosovo's Operation Allied Force, unmanned aerial vehicles were used at unprecedented levels. The U.S. Air Force Predator, the U.S. Army Hunter, and the U.S. Navy Pioneer provided general surveillance and reconnaissance, real-time targeting, and cueing of other ISR systems.[8] These C^{4}ISR initiatives are increasing. For example the U.S. Army is developing the Organic Air Vehicle (OAV), which is designed to provide real-time "over-the-hill" reconnaissance and surveillance to small units equipped with the Future Combat System. It builds on existing technologies developed as part of DARPA's Micro Air Vehicle program.[9] While military forces are learning to operate with richer data, some are calling for even more leverage from information.

The U.S. JCS Chairman's *Joint Vision 2020* now tops the quest for information superiority with decision superiority. Military commanders are stating that an information advantage is not enough; we must have decision advantage. Said another way, knowing more than the adversary knows about the situation, the condition of friendly forces, and the capabilities of enemy forces is important. But, commanders should have information about patterns of behavior, alternative options, and potential consequences of choices in a form and time that permits better decisions to be made than the adversary's. These decisions could also be faster than the adversary can assess the circumstance and decide on a new course.

Different Futures for Information Leverage

Information superiority may not evolve as some expect. The circumstances may deviate. The players may vary. The full range of capabilities may not be brought to bear. Support may wane. And, the information may be faulty.

Americans, who believe they are the leaders in information technology and advantage, are the natural case to examine, but many others are on a similar heading. American military energy is focused on attaining some form of information superiority, "full spectrum dominance," and "net centric warfare" advantage in a theater conventional war. The U.S. *Defense Report* summarizes information superiority.

> **INFORMATION SUPERIORITY**
>
> Information superiority is all about getting the right information to the right people at the right time in the right format while denying adversaries the same advantages. The

United States enjoys a competitive advantage in many of the technical components of information superiority, but the U.S. also has vulnerabilities stemming from its increasing dependence on high technology. Experiences from Somalia to the Balkans have shown that low technology adversaries also can wage effective information campaigns, especially in urban environments. Given that DoD information can be adequately assured, and the opponents' capabilities are appreciated, U.S. strengths in the information domain can be translated directly into competitive advantages by emerging network-centric concepts that are designed to leverage high-quality shared awareness….

IMPORTANCE OF INFORMATION SUPERIORITY

In the Information Age the opportunities and obstacles to achieving national security objectives will often be informational in nature. Information superiority is a principal component of the transformation of the Department. The results of research, analyses, and experiments, reinforced by experiences in Kosovo, demonstrate that the availability of information and the ability to share it significantly enhances mission effectiveness and improves efficiencies. Benefits include: increased speed of command, a higher tempo of operations, greater lethality, less fratricide and collateral damage, increased survivability, streamlined combat support, and more effective force synchronization. Kosovo also highlighted the shortage of assets for intelligence, surveillance, and reconnaissance and the need for more secure interoperability and information protection, especially within coalitions. [10]

To obtain an information edge in circumstances that they consider the most stressful, American military leaders expect a multi-dimensional array of assets to be available. Space-based reconnaissance will be supplemented with manned and UAV sensors and communications links. Airborne battle management platforms like AWACS and JSTARS, or potentially wide-bodied replacements,[11] will direct forces and augment ground-based operations centers. Surface units will be netted together as well as be informed by local sensors and transponders. The natural question is, absent a theater conventional war, will this rich array of assets still be available? In lesser circumstances, will coalition and American leaders' information be less superior?

Accurate, timely information should give allied forces a distinct advantage over an adversary handicapped by key information gaps and lags. Such an advantage could be realized across a whole coalition if allies invest in command and control and information assets at a rate similar to the United States. The collaboration would be dependent on Americans' opening their networks and intelligence flows to allies. While each ingredient of decision superiority is plausible in the next twenty years, all are not apparent.

Indeed, American aspirations for dominance, which in fairness are aimed at adversaries, are frequently articulated and received as claims to be able to act with minimal regard to the information behaviors of friends and allies. Achieving allied information collaboration, at a speed and fidelity that enables a collective action consistent with the future operations Americans describe, remains a future feat.

In the wide range of future imbroglios that Americans and friends may face, the full complement of C^4ISR assets may not even make an appearance at the garden party. Space based sensors and communications promise to be ever-present, but can be limited by higher priority tasking, insufficient or incompatible equipment on the ground or temporarily masked by topographical features, which reduce effectiveness. Information collection and connectability are becoming integrated with ground, sea, and air equipment and units in ways that make one believe that most units who deploy for future operations will bring some inherent capability for information-rich operations. For every deployment, however, non-inherent forces will be scrutinized and often minimized. For example, will airborne ISR assets be deployed for the next Somalia operation, for the next Mozambique relief, or for the next Balkans' monitoring? When information assets are omitted, the way information superiority is achieved will have to vary from the normal model. Said another way, allied operations without AWACs, JSTARS, and the UAVs that follow the Predator and Global Hawk are highly plausible and present an alternate to the JV2020 future. The diverse information assets of non-governmental organizations (NGOs) or global businesses may play critical roles in such alternate futures.

Choosing what air, land, and sea information assets to commit to future engagements can produce unanticipated consequences. In one circumstance, allies may decide to deploy a full complement of C^4ISR capabilities to enhance our effectiveness. Allies might contend that bringing all information assets reflects the way our forces train and is most likely to quickly achieve results. Some at home may loyally support military thoroughness. Others might challenge a "one size fits all" approach, and question the military's stewardship of scarce tax resources. To respond to this critique, in another circumstance, allies may deploy selective information assets. But customizing information assets to the particular situation could have other consequences. Commentators at home are frequently quick to critique high cost units that are being left out. Thus, future decisions to deploy or not to deploy enabling information assets could shape the future and affect the transparency that current visions advocate. Further, on the one hand, we expect information capabilities to become embedded in normal operations and to become more ubiquitous so that physical deployment of special platforms becomes less likely. On the other hand, as in these two examples, support for expensive C^4ISR assets can wane if they are not employed optimally. Consistent support will be needed to grow the robust information superiority capabilities that advocates envision.

The e-risk of unreliable or disrupted information may also be climbing faster than efforts to assure our information. Although computer security breeches are often underreported, the number of acknowledged incidents is rising.[12] A recent analysis of over one hundred executives concluded that concern among business leaders and security specialists is increasing. Several senior business executives labeled information security as a "hot button" issue.[13] An information security industry is springing up to address these concerns and governments are calling for special efforts to protect critical electronic infrastructures.[14] Some technologists believe that security fixes such as firewalls that attempt to construct a moat and fortress around networks will be insufficient and that many existing security technologies cannot be scaled to dispersed, mobile computing and communications. Such concerns raise important issues for military electronic and communications systems that are increasingly dependent on commercially based technologies and often ride on commercial electronic infrastructures.

Even if C4ISR evolves more closely to the images that some officials project, the settings for using these assets will likely be different.

Conflicts won't be like they used to be

Two extensive explorations of future security issues have recently concluded that traditional interstate wars fought with conventional forces will be much less likely in the coming decades. The U.S. National Intelligence Council assessed global trends through 2015 with the assistance of an array of non-governmental experts. The NIC concluded:

> Through 2015, internal conflicts will pose the most frequent threat to stability around the world. Interstate wars, though less frequent, will grow in lethality due to the availability of more destructive technologies. The international community will have to deal with the military, political, and economic dimensions of the rise of China and India and the continued decline of Russia.[15]

The U.S. Commission on National Security in the 21st Century's *New World Coming* elevated concerns for internal conflict and for threats from non-state actors.

> As with most periods of rapid change, both the actors and the means by which violence is used in pursuit of political goals may shift abruptly. Non-state actors, individuals as well as groups, will gain power and influence, and many will have at their disposal alarming means of destruction. Even in a world in which major wars are less frequent… Interstate wars will not disappear over the next 25 years…. Violence within states, on the other hand, could reach unprecedented levels…. There will also be a greater probability of a far more insidious kind of violence in the next millennium: catastrophic terrorism….
>
> Non-state actors will also use these weapons [weapons of mass destruction] in direct attacks…. Missile threats will also continue to proliferate…. Outer space, as well as cyberspace, will become a warfare environment.[16]

Few would postulate we will see no conventional fighting in interstate wars or that modern style C4ISR assets will not be employed in interstate war in the future. But most agree that the situation will be infrequent. Some say extremely rare.[17] If the circumstances when C4ISR can be employed are quite different from the international wars that form the setting for most of the concepts in *Joint Vision 2020*, how differently should we expect information assets and concepts to evolve?

Initially, modern ISR may seem more like chaos

If the futures posited by *Global Trends 2015* and *New World Coming* arrive, they will pose "chaotic" situations near the bifurcation point where chance matters and where proactive ISR may be key to adaptation and success. But, successful ISR will likely be quite different from the traditional hierarchical, stove piped model and different from the one-sided dominance model.

Traditionally, ISR systems were based on the assumption that information was scarce, difficult to acquire, valuable, doled out to select few. Listening to or imaging an adversary was technically difficult. Sensing the signatures and actions of his weapons systems was hard. Intelligence officers became experts in one discipline; seldom in more than one. Intelligence was collected, processed, and then distributed by these specialized experts to only those with a "need to know." Need was most frequently predetermined by position – often by position in the government or military hierarchy.

Slowly ISR systems are opening to each other and to end-users. The Gulf War demonstrated the value of knowledge enabled military forces and began a move to make intelligence more responsive to military users. Many users were given access to information that had previously been restricted. And users' expectations increased. They demanded more. In addition to wanting more information from space-based systems, military users increased their use of airborne assets. U.S. AWACS aircraft and crews, for example, are deployed for more days per year than nearly any other USAF unit.

During the same period, the World Wide Web appeared. The 1993 graphical user interface (GUI) enabled individuals to access networks of information without prior computer training. The Web made creating information that was accessible to others easy. The amount and availability of this increased information changed the perception of end users about information itself. Rather than information being scarce, it could be abundant. Sources of information increased and were less dependent on specialized intelligence systems and personnel.

As end users, such as military commanders, value abundant information and knowledge more, they propose to use it to dominate their adversaries. Yet, the same pull for more and better information invites the flood of extra data. Much of the data will be without meaning and appear chaotic.

The new science of chaos and complexity suggests that what appears to be chaotic and without order, can be quite orderly.[18] The new science suggests that the ISR of the future might need to operate under different principles than the traditional models of C4ISR and information superiority. Chaos and complexity give us new insights into how difficult "knowing" might be. Future security challenges with other players, other concerns, other methods, megacities, migrations, and democracies with internal conflicts appear chaotic in one sense of the word – random and unpredictable. The new science counters a reductionist view that tried to isolate a few key variables to help explain or predict. During the Cold War, for example, nuclear theorists isolated the throwweight of ballistic missiles as a key indicator of nuclear delivery capabilities. In the Gulf War, allies focused on Scud launchers as a key threat. In many security situations of the future, key threats may not be neatly organized into military units. Instead, ISR will need to monitor many variables, potentially too many for serial processing and dissemination through intelligence channels down to operational players.

Chaos theory advises that our ability to operate depends on increasing the information flowing through boundary layers of the organism or organization.[19] Becoming highly adaptive to the unpredictable situations we will face entails creating organizations and systems that operate at a high-energy state. Classic ISR systems with a slow state of energy and established information flows will miss changes in the environment.

Chaos and complexity science explain that there is an underlying attractor that provides order to apparent chaos. The central figure in making order out of the potential ISR chaos of data inundation could be the leader or military commander at the operational or perhaps even the tactical level.

Learning from chaos, leaders and military commanders could operate at the edge between stasis and disorder. The edge is the source of innovation. Leaders who operate on the edge will likely be the most highly adaptive to changing situations.[20] This alternate future suggests leaders must adapt ISR and knowledge assets to their particular situation. Leaders must figure out "the plot" and apply meaning to the swells of data. Such thinking and acting cannot be a function of staffs, or systems, or equipment for a long time to come, whatever the advances in processing power. Operating in knowledge-enabled ways will not be a function of the toys of ISR, but could be a function of the behaviors leaders create.

How do we prepare future leaders for this alternate future of ISR? Leaders must capitalize on the non linearity to create new order out of apparent chaos. We will almost certainly keep making ISR systems more info rich, and will provide decision support software to ease the burden somewhat. We need to help leaders learn to operate with greater information, communication, and complexity, becoming more adaptive and not suited for just one kind of information or environment.

In the Third Wave, ISR may be open and demassified—creating new challenges and opportunities for leadership

A potential logic for understanding the ISR chaos of the future is the Third Wave framework. Years ago, Alvin and Heidi Toffler described a new knowledge era emerging that is swelling with revolutionary change sufficient to displace the industrial civilizations around the planet. The Tofflers used the metaphor of a giant wave to illustrate that the new phenomena will overtake

the previous agricultural and industrial economies and societies, but that features of past civilizations will persist.

In the Third Wave future we are beginning, knowledge becomes a new, more powerful economic resource along with land, labor, and capital. Unlike other resources, however, knowledge is reusable and can be shared. As a result of this new appreciation of knowledge, especially when enabled by information technology, activities can be efficiently accomplished on small scales and in small units. In the Third Wave, massed production and activities are increasingly replaced by demassified units and dispersed behaviors. In a Third Wave world, we also expect ISR to be demassified rather than centralized or hierarchical. ISR will include NGOs, the Internet, and personal wireless devices. This means that the decision on specific military actions can be pushed down ever further to the "user" level, while generally remaining within the processes and rules of engagement – the plot — set by senior leaders.

Some, inspired in part by the Tofflers,[21] have begun to consider the knowledge strategies that future leaders and commanders will need to bring order and script the "plot" for the specific situation.[22] In a series of wargames, dubbed *Forward Focus*, the National Reconnaissance Office and the Office of the U.S. Secretary of Defense for Net Assessment elicited the value of "knowing" in different situations. Hand picked warriors and operators used a future value analysis model to attribute the importance of knowing specific bits of information in a particular scenario. *Forward Focus* revealed how warriors value knowing at the "detect" level of cognition for agile attack forces with high lethal range, high mobility, and low signature. Operators seek wide area coverage with very short timelines to detect agile attack forces which can threaten quickly. For other types of objects or forces with high mobility but high signatures, warrior leaders advise that knowledge gathering should "recognize" such objects and distinguish them from non-targets and that longer periods of collection are acceptable.

Leaders can devise knowledge strategies. Will they?

In sum, this essay has tried to describe a plausible future and make four simple points.

First, increased information in the future may be meaningless.

Second, different situations we will face in the future may make it more difficult to apply our information assets than we expect.

Third, chaos suggests that order is possible at a higher state of complexity if communication is increased.

And fourth, leaders can create a framework for increased complexity and communications and must attribute meaning to enable successful action.

The United States is not the only group thinking about the role of knowledge and knowledge assets in the future. Americans call for leveraging knowledge against adversaries to gain information and decision superiority. They and their allies are quickly adding ISR assets to enable this goal, and importantly beginning to develop concepts to bring the goal closer to reality. This essay suggests that the vector is very important, but that the course to achieving it will be challenging in part because so many other variables are changing in these revolutionary times. In the meantime before information leverage becomes integral to operations, we wonder if creating actionable knowledge and discerning the plot will be dependent on leadership.

Endnotes

1. Michael Loescher and John W. Peterson, "A Technology based Alternative to 'Warfare Beyond Boundaries,'' Lucent Technologies draft paper, January 17, 2001.

2. Lester E. Denonn and Alonzo Church in Dagobert D. Runes, ed., *Dictionary of Philosophy* (Totowa NJ: Littlefield, Adams and Company, 1967), pp. 193-194.

3. John Ayato, *Dictionary of Word Origins* (New York: Little, Brown and Company, 1990), p. 359.

4. This passage is derived from Richard Szafranski, Frank Strickland, and, Joseph A. Engelbrecht Jr, "The Decline in Meaning and the Rise of Mystery," presented to the InfoOps Workshop, Bonn, Germany, 29-30 September 1998.

5. General John Shalikashvili, *Joint Vision 2010*, (Washington, D.C.: Office of the Chairman, Joint Chiefs of Staff), p. 16.

6. "In September, the NRO awarded Boeing a contract worth potentially $4.5 billion over the coming decades for the Future Imagery Architecture (FIA) satellites.... The FIA satellites are to enter service between 2005 and 2010." Armed Forces Newswire Service, February 4, 2000.

7. Vernon Loeb. "Mapping Agency Gets Boost From Critique," *Washington Post*, January 15, 20001, p. A19. "US NIMA juggles modernisation needs and goals," *Jane's Defense Weekly*, January 17, 2001.

8. U.S. Department of Defense, *Report to Congress: Kosovo/Operation Allied Force After-Action Report*, 31 January 2000, p. 56.

9. *Inside the Army*, July 25, 2000 12:00am.

10. William S. Cohen, Secretary of Defense, *Annual Report to the President and Congress*, 2001, p. 107.

11. General Jumper, remarks to the United Aerospace Power Conference, 8 February 2001.

12. For example, in 1990, the U.S. CERT Coordination Center reported 252 incidents. In 2000, they reported 21,756. Carnegie Mellon University Software Engineering Institute, "CERT Coordination Center Statistics 1988-2000," at http://www.cert.org/stats/ cert_stats.html. CERT counts broadly infectious viruses like "I LOVE YOU" as one incident. Other countries are also reporting intrusions or damage at varying rates.

13. Toffler Associates, *E-Risk: Exposed in the Information Age*, A Toffler Associates Report on Risks in an Intangible World, September 2000.

14. See, for example, the U.S. National Infrastructure Protection Center, at http://www.nipc.gov/

15. Nation Intelligence Council. *Global Trends 2015: A Dialogue About the Future with Nongovernment Experts*. NIC 2000-02, December 2000, p. 49.

16. The U.S. Commission on National Security in the 21st Century's *New World Coming: American Security in the 21st Century – Supporting Research and Analysis*. The Phase I Report on the Emerging Global Security Environment for the First Quarter of the 21st Century, September 15, 1999, pp. 46-48.

17. See, for example, Martin Van Creveld, *The Transformation of War*, New York: The Free Press, 1991.

18. James Gleick, *Chaos: Making a New Science*. New York: Penguin Group, 1987.

19. Frank Masterpasqua and Phyllis A. Perna, eds. *The Phychological Meaning of Chaos: Translating Theory into Practice*. Washington, D.C. American Psychological Association, 1997.

20. Ralph D. Stacey, *Managing the Unknowable: Strategic Boundaries between Order and Chaos in Organizations*. San Francisco: Jossey-Bass Publishers, 1992.

21. Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the Twenty-first Century*. Boston: Little, Brown and Company, 1993.

22. Frank B. Strickland, Jr., "It's Not About MousetrapsMeasuring the Value of Knowledge for Operators," *Joint Force Quarterly,* No. 13 (Autumn 96), pp. 90-96.

CONTEMPORARY ISSUES IN COMMAND AND CONTROL[1]

Allan English

Intelligence, surveillance, and reconnaissance (ISR), the focus of this Air Symposium, is a topic that has generated a great deal of interest recently in Canadian defence circles. However, in the bigger picture, ISR is just one input into the command and control (C^2) system that helps to provide the commander with situational awareness. Before ISR systems are acquired, those involved in the acquisition process need to understand what the C^2 system, and especially the commander, needs from ISR to achieve situational awareness. This essay will summarize the fundamental C^2 issues that must be grasped before committing resources to any particular ISR technology.

Command and control has been conceptualized by Western armed forces for most of the 20th century in terms of technical systems to transmit and receive information or an exercise in designing organization charts that attempt to explain command relationships. The importance of the human element of command has been recognized and studied systematically only in the past decade. Nevertheless, considerable knowledge in this field is now available to assist modern commanders and their staffs in creating effective C^2 models.

Certain elements of the CF have demonstrated increasing interest in the effects of human factors on command because many recent problems in CF operations have been attributed to a neglect of these factors. Comments from the Debrief the Leader project reflect several of these problems from the perspective of those deployed on operations. Their perceptions, summarized as follows, were described as pervasive: "Many of the problems faced relate to perceived problems with senior leadership and senior national headquarters. These problems were identified as lack of capability, lack of competency, careerism, over sensitivity to media influence, passing the buck and lack of willingness to support commanders in the field and trust them to do their job." Some more specific comments from leaders in the field indicated that higher headquarters were not organized in such a way as to be able to understand "actual mission requirements in theatre," and that there was a "general lack of confidence and trust between junior and senior officers, including a major disconnect between commanders and troops in theatre and senior headquarters in Canada, especially NDHQ." In addition to these personal comments, as part of the project data was collected and analyzed that showed that superiors at NDHQ were rated significantly lower than other groups on such factors as moral courage, accountability, and loyalty to subordinates.[2] It should be noted that similar perceptions are shared by members of other armed forces today[3] and are consistent with the findings of the recently published "Ethics and Operations Project Report" and the "First Baseline Survey on Ethical Values in the Department of National Defence."[4]

It is clear from the preceding perceptions that the critical issues in command and control today are "people problems." The human factors of command have been the subject of research conducted by Ross Pigeau and Carol McCann of the Defence and Civil Institute for Environmental Medicine over the past six years. Their findings have been acknowledged as ground breaking by the international military research community and are summarized in a recent essay.[5]

The emphasis now being placed on the human elements in command does not ignore technology, but stresses that technology must be responsive to human needs. In the past, many Western armed forces have purchased C^2 technology without considering how it would serve the commander. This often resulted in ineffective C^2 systems that focussed on what the technology could do rather than what outputs the commander needed from the technology to be effective. Another weakness in the creation of C^2 systems in the past can be found in complex organization charts intended to represent relationships in "the chain of command" which actually existed only on paper. The example of the Gulf War is instructive. Once thought by some to be the epitome of a successful C^2 system, the actual Coalition C^2 system is now known to have had numerous shortcomings. For example, the formal air component C^2 system in that war was circumvented when it was perceived by some to be unresponsive to the air component commander's needs. Most of its organization charts became largely meaningless as informal networks were formed, aided by new technology, outside the formal chain of command. These informal networks eventually usurped many of the functions of the formal chain of command in the conduct of the air war.[6]

Some commentators have suggested that the C^2 shortcomings of the Gulf War can be overcome in the future by information superiority or dominance. But lessons from Operation Allied Force, the air war over Kosovo and Serbia in 1999, challenge the belief that information superiority will make the commander's job easier. While the attacking forces had tremendous amounts of data, the data was often not exploited because it could not be interpreted in a timely fashion and transformed into knowledge that the commander could use in his campaign planning and execution. As Admiral James Ellis, C-in-C NATO Allied Forces Southern Europe noted, "too much information has the potential to reduce a military leader's awareness of an unfolding situation." If information is not handled properly it can become "a voracious consumer of leadership and key staff working hours." This, according to analyst Timothy Thomas, is the most interesting and underrated lesson learned from the Kosovo campaign, namely that "information superiority overload can actually hurt mission performance."[7]

New C^2 systems and concepts, such as network-centric warfare, based on the Revolution in Military Affairs (RMA) may exacerbate the information overload problem. These new systems are creating a "data revolution" and despite their capacity to collect and distribute vast amounts of data, this will amount to nothing unless commanders and their staffs are able to transform the data into knowledge which can then be used productively.[8] Admiral W.J. Holland's argument that network-centric systems may lead to a change in command relationships based on a flatter and shorter chain of command implies that this change may also amplify the information overload problem.[9] Critics of the RMA-driven rush to acquire technology without considering its effect on the human beings in the C^2 system point to human factors that constrain organizations from embracing technological change. These factors include a zero-defects mentality that leads to an aversion to prudent risk-taking; poorly designed war fighting experiments featuring an overemphasis on technological prototypes and an underemphasis on organizational prototypes; a leadership that does not appear to welcome decentralized innovation and initiative; and widespread satisfaction with current systems despite their failings.[10]

The current debate on command and control has examined the subject from many different perspectives. Thomas Czerwinski proposes a framework based on three types of command style that summarizes many of the concepts in the current debate. He describes the first command style, currently used in the US Army's Force XXI/digitized battlefield concept, as "command-by-direction." This form of command has been used since the beginning of organized warfare, and it is based on commanders attempting to direct all of their forces all of the time. This form of command fell into disfavour in the middle of the 18th century as the increase in the size of armed forces made it increasingly difficult to exercise. Czerwinski argues that "command-by-direction" has been resurrected by the US Army because it believes that technology can provide the commander with the ability to exercise this type of command again; however, he asserts that, because of the size and complexity of the technical support required to support this command style, it will be inadequate and self-defeating if applied to 21st century conflict.

Czerwinski's second style, "command-by-plan," was created by Frederick the Great 250 years ago to overcome the limitations of "command-by-direction." "Command-by-plan" emphasizes adherence to a pre-determined design and it has evolved as the norm for modern military forces in the West. The US Air Force's air campaign doctrine is cited as an example of this type of command system which is characterized by trading flexibility for focus in order to concentrate on identifying and neutralizing an opponent's centres of gravity. Czerwinski claims that "command-by-plan" is useful only at the strategic and operational levels of war, but if too much emphasis is put on adhering to the plan, this method will be ineffective because of its inability to cope with unforeseen or rapid change.

Czerwinski advocates the adoption of a third type of style, "command-by-influence," to deal with the chaos of war and the complexity of modern operations. This command style attempts to deal with uncertainty by moving decision thresholds to lower command levels, thereby allowing smaller units to carry out missions bounded by the concept of operations derived from the commander's intent. The emphasis in this method of command is on training and educating troops to have the ability to exercise initiative and to exploit opportunities guided by the commander's intent. Czerwinski's contention that only "command-by-influence" systems are likely to be consistently successful in the 21st century is supported by a number of military communities, especially the US Marine Corps.[11]

No matter what style of command is chosen, a critical characteristic of any effective C^2 system is its ability to learn while it executes its missions. To acquire this ability in peacetime or in times of relative calm, staffs need to practice not so much *what to do* in war or other operations, but *how to learn quickly* what to do in war or other operations.[12] The key to creating an adaptable and effective C^2 system is the establishment and nurturing of an organizational culture to support it, because innovation in large organizations is usually constrained more by the organization's culture than technology.[13] Whatever technical and structural solutions are chosen in planning a C^2 system, programs and policies must also be devised to create an organizational culture that both enables the other elements of the system and enhances the staff's ability to learn. However, recent research has shown that Western armed forces have not been particularly successful in this regard, as dysfunctional military cultures appear to be frustrating the best intentions of some commanders.[14] Therefore, a critical component of designing and implementing new C^2 systems is the capacity to gauge current organizational culture, decide on and articulate any necessary changes, and then have the capability to implement them. In fact, experts in organizational culture maintain that leaders' most important functions in an organization are the creation, management, and sometimes the destruction, of organizational cultures. Details of how the process of cultural change may apply to DND can be found in "*Mutabilis in Mobili*: Leading and Managing Strategic Change in DND and the CF."[15] But changing organizational culture is a lengthy process usually measured in years. Therefore, according to experts in the field, effective leaders of complex organizations must be prepared to map out a long range strategy that includes constant monitoring and adjustment of the organization's culture. Coupled with this process is an ongoing program of professional development so that members of the organization will have the knowledge required to implement necessary changes.

After discussing many of these issues in the context of ISR, the syndicate group of Air Symposium participants examining C^2 reached the conclusions that follow. Information gathered through ISR will always exceed the capacity to process it; therefore, effective filter systems will be required to covert as much raw data as possible into information. To avoid getting information that is "neat to know" instead of information that is "need to know," commanders must clearly understand then articulate the information they require to achieve situational awareness. They must then avoid micromanaging the information gathering process, and trust their subordinates to provide that information. Even then, to avoid being overwhelmed by information, commanders must set aside time to develop their plans and to interact with subordinates. Of all the culture changes required in the air force command environment, syndicate members believed that a change that without deciding which tasks are essential to do immediately and which tasks can be postponed or even ignored. The ensuing "can do" attitude often leads to fragmented effort, poor results, and staff burnout. A new culture reflecting the fact that human effort is most effective when focussed on a reasonable number of tasks done well was seen to essential.

The plenary discussion supported many of these views and confirmed that most Symposium participants appreciated that the human dimension of command had to shape and define technical aspects such as ISR.

Dr Allan English joined the Royal Canadian Air Force in 1966 under the Regular Officer Training Plan. He attended Collège militaire royale de St-Jean and graduated from the Royal Military College of Canada (RMC) in 1971. He then served in the Canadian Forces (CF) for the next 20 years in various operational and instructional positions as an air navigator. He completed his MA in War Studies at RMC in 1987 and taught in the Military Psychology and Leadership Department there until he retired from the CF in 1991. He completed his PhD in history at Queen's University, Kingston, Ontario in 1993. His most recent book, The Changing Face of War: Learning from History, *which is an edited collection of essays by serving officers who have applied lessons of the past to current and future defence problems, is now being translated into Chinese. Dr English has taught in the War Studies and Continuing Education programs at RMC and is an adjunct professor in the History Department at Queen's University. He has taught courses in the Theories of War, Air Warfare, and Human Behaviour in War at the post-graduate level. He has been an instructor for the first three Advanced Military Studies Courses (AMSC) held at the Canadian Forces College, Toronto and he has co-ordinated the Command and Control portion of the curriculum for AMSC 2 and 3. He was an advisor to the Board of Inquiry - Croatia on issues related to Operational Stress, Leadership, and Command and Control and he was a member of the Special Review Group (appointed by the Chief of the Defence Staff) Operation Harmony (Rotation Two).*

Endnotes

1. This essay is based on a paper prepared by the author for the Deputy Chief of Defence Staff retreat held in Kingston, ON in Feb 2001.

2. Excerpts from draft copy of "Decade of Turmoil: Debrief the Leaders" prepared by the Special Advisor to the Chief of the Defence Staff (Professional Development), in press.

3. For an overview of these issues see Allan D. English, "The Americanization of the Canadian Officer Corps: Myth and Reality?" in Bernd Horn, ed. *Contemporary Issues in Officership: A Canadian Perspective* (Toronto: Canadian Institute of Strategic Studies, 2000), 181-204.

4. "Ethics and Operations Project Report" (9 March 2000), http:// www.dnd.ca/ ETHICS/documents/ethops_e.doc ; and "First Baseline Survey on Ethical Values in the Department of National Defence" Phase I (1999) and Phase II (July 2000) Reports available on the DND ethics intranet site at http://ethics.mil.ca.

5. Ross Pigeau and Carol McCann, "What is a Commander?" in *Generalship and the Art of the Admiral*, Bernd Horn and Stephen J. Harris, eds. (Vanwell Press, 2001), 79-104.

6. A detailed account of this example can be found in Mark D. Mandeles et al., *Managing "Command and Control" in the Persian Gulf War* (Westport, CT: Praeger, 1996).

7. Timothy L. Thomas, "Kosovo and the Current Myth of Information Superiority," *Parameters* 30, no. 1 (Spring 2000), 13-29.

8. Mackubin Thomas Owens, "Technology, the RMA, and Future War," *Strategic Review* 26, no. 2 (Spring 1998), 69.

9. Rear Admiral W.J. Holland Jr., "Where Will All the Admirals Go?" *US Naval Institute Proceedings* 125, no. 5 (May 1999), 36-40.

10. William K. Lescher, "Network-Centric: Is It Worth the Risk?" *US Naval Institute Proceedings* 125, no. 7 (July 1999), 58-63.

11. Thomas J. Czerwinski, "Command and Control at the Crossroads," *Parameters* 26, no. 3 (Autumn 1996), 121-32.

12. Mandeles, 6.

13. Lescher, 60.

14. See for example William F. Bell, "The Impact of Policies on Organizational Values and Culture," paper presented at the Joint Services Conference on Professional Ethics (January 1999) http://www.usafa. af.mil/jscope/JSCOPE99/Bell99.html; Paul Johnston, "Doctrine is not Enough: The Effect of Doctrine on the Behavior of Armies," *Parameters* 30, no. 3 (Autumn 2000), 30-9; and Walter F. Ulmer, Jr. et al., *American Military Culture in the Twenty-First Century* (Washington, DC: CSIS Press, 2000).

15. "*Mutabilis in Mobili*: Leading and Managing Strategic Change in DND and the CF." (In reading package).

The United States Air Force's Transformation Vision and the Aerospace Operations Center

Colonel Peter Faber, Ph.D., USAF[1]

Note: In the wake of the "9-11" precision air attacks against the World Trade Center and Pentagon, there were immediate calls to redirect the focus of the US military. American forces now need to concentrate on "twilight wars," pundits argued, where "end states" and "exit strategies," "signaling resolve," and "proportionate responses" meant little. In making this argument, however, the critics offered up a false either-or dilemma. They suggested that a burgeoning counter-terrorism campaign conducted by the US Department of Defense (DoD) would lead to a zero-sum game. DoD would have to turn its back on existing (i.e., irrelevant) roles and missions to prosecute an unprecedented "shadow war."

In reality, nothing could be further from the truth. The US military will not pursue a single future against a single hostile "ism." Its fight against terrorism will merely add new responsibilities to those that already exist. The United States, in short, will continue much of the military activism that helped define its international behavior in the 1990s. Its military will fulfill its global responsibilities — including "constabulary" ones — across a broad spectrum of potential conflicts. Given this expansive, proactive approach, the following article has not been overcome by events. Recent United States Air Force (USAF) leaders have designed their transformation efforts to deal with myriad threats, including asymmetric ones. One of their most ambitious efforts has been to integrate their command and control structure into a "weapon system" — the Aerospace Operations Center (AOC) — that will direct air campaigns and/or operations across the spectrum of conflict.]

INTRODUCTION

In the wake of an influential 1997 report issued by the reform-minded National Defense Panel (NDP), military transformation became an increasingly prevalent theme in Washington, DC. There remains, however, some ambiguity over just what transformation means. Is it a destination or a process? Is it a near-, mid-, or long-term activity? Is it open-ended, or does it have a beginning, middle, and end?[2] Should it merely expand upon existing organizations, technologies, and doctrines, or should it "leap ahead" and fundamentally break with the past, as the NDP and Defense Science Board argued?[3] Regardless of how others may answer these questions, the USAF — as an institution — believes there are three "truths" that define military transformations.

First, it believes that authentic transformations require sustained and determined conceptual, organizational, and technological innovations over time. These innovations, when combined together, then lead to fundamental, order-of-magnitude improvements in aerospace power that may or may not appear as sudden and dramatic "90-degree turns" in USAF capabilities.

Given the above definition, the USAF also believes that it has always been a transformation force. Perpetual innovation and adaptation have always been part of its creed, but over the last 10-15 years in particular the USAF has accelerated the pace of its self-transformation. It significantly improved and expanded its fundamental capabilities, and then put them on full display in the Persian Gulf, Bosnia, and Kosovo.

To illustrate the point, here is a small sampling of just how far US aerospace power has come from the 286-computer world of Desert Storm to the gigabyte realities of today.

- In Desert Storm the USAF had approximately 150 aircraft capable of delivering laser-guided munitions.[4] Today it has approximately 1,000 aircraft with this capability.
- In Desert Storm the Air Force had a very limited number of aircraft that could precisely attack multiple targets per sortie. B-2s can now simultaneously assault 16 targets per sortie with all-weather Joint Direct Attack Munitions (JDAMs). This number will increase further as the USAF fields smaller, more precise weapons across its entire bomber fleet. (The B-2, for example, will be able to carry over 300 Small Diameter Bombs.)
- In Desert Storm American airmen used a limited number of handheld Global Positioning Satellite (GPS) receivers. Some pilots literally taped them to their cockpits. Today, GPS is an integral component of almost all USAF aircraft, and GPS receivers guide American bombs. (The latter adaptation is possible because the GPS system – which has doubled in size since 1991 – provides redundant, worldwide navigation and timing standards that improve both US weapon systems and everyday lives.)
- In Desert Storm the US Air Force had no conventional B-1 capabilities, no B-2s, and no operational JSTARS aircraft. Today, all three are operational, and all three have been extensively improved from their original configurations. B-1s, for example, can now carry 84 general-purpose bombs (Mk82) or 1,200 Sensor Fused Weapon submunitions designed to kill columns of vehicles.
- In Desert Storm a limited number of American F-15Es were LANTIRN-capable with laser guided bomb precision[5]. Today, all F-15Es and over 450 F-16s are LANTIRN-capable; soon a total of 720 F-16s will have this capability.[6] As a result, a serious limitation the US once experienced in night operations is rapidly disappearing. The USAF's large fighter-bomber force can now routinely bomb with precision around the clock. When configured to drop JDAMs, these fighter-bombers will be all-weather capable as well.
- In Desert Storm the US Air Force had "stovepiped" intelligence from the theater to Washington, DC, and then back to the "shooter." Now the Air Force is aggressively introducing near real-time targeting to the cockpit through direct, shooter-in-the-loop data distribution networks.
- In Desert Storm the USAF fought without the systematic use of Unmanned Arial Vehicles (UAVs). Now, for example, it deploys the medium altitude Predator UAV in a variety of missions. Airmen can use satellite data links to operate the Predator "over the horizon," and they can receive back combat-related imagery through the same links. Additionally, its ground stations can use precision satellite imagery to identify the locations of potential ground targets in near real-time.
- In Desert Storm the USAF's primary air superiority fighter was the F-15C. While superb in air-to-air combat, the F-15C had no air-to-ground capability. It depended on afterburners for supersonic cruise and had a high radar signature. Today, we are developing its replacement, the F-22. The F-22 combines stealth design with supersonic cruise. It will have the highly maneuverable, dual-engine, long-range requirements of an air-to-air fighter, plus an inherent air-to-ground capability. This will give us a more flexible, lethal and survivable weapon system.
- Finally, in Desert Storm we had a very limited ability to strike hardened underground targets. Now we have conventional warheads that can penetrate granite and use smart fuses to explode at pre-programmed depths.

Thirdly, the USAF believes that when it comes to resolving political and military conflicts, aerospace power has become a critical American asymmetric advantage. The USAF will continue to improve this advantage – as it has in the past – by exploring new operational, organizational, and technological concepts, including developing the Aerospace Operations Center as a "weapon system." The Air Force will then identify which of these concepts offer the greatest potential for revolutionary improvements in its capabilities, especially by testing the concepts through planned experimentation and by formalized innovation in Service-level battle labs. The result will be an institution that innovates and adapts rather than merely modernizes.

Now in order to "flesh out" the above transformation theme (and its three "truths"), this deliberately aerospace-centric article will attempt the following: First, it will highlight six working propositions or assumptions about the post-Cold War world that have bounded and directed US military transformation since 1989. Second, it will highlight what is old and what is new in modern warfare, while also singling out some of the salient capabilities that define aerospace power. (Again, counter-terrorism is just one of a host of capabilities the USAF must have in order to deal with a wide assortment of challenges in an uncertain future.) Finally, the article will explore a specific transformation area — e.g., given the basic theme of this particular volume, it will explore how the USAF developed new operational concepts in the late-1980s and 1990s, how these strategy-related changes significantly improved our intelligence, surveillance, and reconnaissance (ISR) capabilities, and how the latter improvements make the Aerospace Operations Center a necessary "weapon system" for the future.

The Post-Cold War World — Six Working Propositions and Assumptions

Proposition #1: The 1990s and beyond represent a clear departure from the bipolar world of the past. The strategic environment has changed, among other reasons, because of growing worldwide economic integration, the internationalization of domestic politics, the networking of information resources, the increased frequency of technological cycles, and the relative decline of nation-state power. Consider, for example, the following contrasts between the world of 1988 and the world of today.

The Geopolitical Environment – Old and New

Bipolar (Rigid) vs. Multipolar (Complex)
Predictable vs. Uncertain
Communism vs. Hyper-Nationalism, Religious Intolerance and Ethnic Rivalries
US as Disputed #1 vs. US as the Sole (but Fettered) Superpower
Permanent Alliances vs. Increasingly Temporary/Ad Hoc/Single-Issue Alliances

Threats Faced by the US – Old and New

Overt vs. Covert/Difficult to Trace
Single vs. Diverse (to US Survival)
Clear vs. Unclear (to US Interests)
Deterrable vs. Non-or Semi-Deterrable
Europe-Centered vs. Growing Importance of other Regions
High vs. Low Risk of Military Escalation
Strategic Nuclear Attack vs. Asymmetric Attacks

Proposition #2: Among American political leaders of either major party, any disputes about a proactive or "internationalist" foreign policy will occur largely at the margins (for example, "are humanitarian wars appropriate?"). However, the National Security Strategy that supports a proactive policy will continue to rely on military power as a major vehicle for US involvement. The United States will use this power to assure allies and friends, particularly by helping create favorable balances of military strength in critical areas of the world. It will dissuade future military competition by maintaining or enhancing advantages in key areas of military capability. It will deter threats to US interests, particularly by having a wider range of military options to discourage aggression or any form of coercion. Lastly, the US will decisively defeat aggression if deterrence fails.[7] In other words, it will seek to reduce the prospects and sources of international conflict, to keep local problems local, to ensure its enemies are busy imploding rather than exploding, and to continue preparing now for possible problems in the future.

Proposition #3: In order to engage with the world and sustain American influence properly, the US military must meet its day-to-day readiness requirements AND transform or innovate itself as much as possible. There are, however, true and false forms of innovation. True innovation involves altering and adapting our forces for knowledge-centric, data-intensive warfare. False innovation merely seeks to preserve Industrial Age Warfare, but with new "bells and whistles" added at the margins.

The latter approach is obviously wrong. We cannot tolerate "reality lockout" in our planning and preparations for the future, as the terrorist attacks against New York and Washington sadly illustrated. (One could argue that the success of the attacks was attributable, at least in part, to a lack of US imagination about what could happen in a homeland attack.) At the same time, the US military services cannot appease/straitjacket the future by bolting technological odds and ends onto yesterday's equipment, organizations, or concepts of operation. In particular, the USAF should not trap itself in the fossilized amber of dated doctrines or ideas (including the idea that aerospace power merely provides supporting or preparatory fires — "air fires" — to other forms of military power).

Proposition #4: As briefly suggested earlier, genuine transformations are always comprehensive. They require major conceptual, organizational, and technological changes to be effective. In the 1990s, the USAF redefined itself in all three areas, and therefore — one could argue — was the transformation force in the US Department of Defense during the decade.

However, two caveats on terminology and technological change are appropriate here. In the first case, there are still those who confuse military transformation – either wittingly or unwittingly – with mere modernization. From the USAF's perspective, transformation is not about modernizing forces to support legacy concepts of operation. Instead, it is about the organic and timely combination of advanced weapon systems, new military theoretical guidelines, and suitable force structures to yield a qualitative change in the use of military power.

In the case of technological change, it is important to note that the USAF is not consumed with "technolust," as some of its critics have claimed. Its airmen are not unrealistically enthralled with the technologies of information dominance. They are not involved in an illusory quest to impose certainty on the battlefield. They do not believe technology is a panacea or a "silver bullet." They do recognize the decisive importance of well-trained, highly motivated combatants who are capable of creative thought. They know that an unskilled military is more dangerous and less effective than one with less-advanced technologies. Having said that, however, they also believe in the transformative role of technology in human conflicts. Technology is not a mere garnish or supplement to traditional warfighting methods. It does not merely change things at the margins. It does not merely increase the pace of evolutionary change. Instead, most American airmen believe that technology can significantly change the nature of war and that these changes can be revolutionary rather than evolutionary. In other words, technology can introduce abrupt 45-degree turns in how we use force. Over the last 10-15 years, the USAF has been in one of these "abrupt" transitional periods in history. Its growing C^4ISR capabilities; its increased capacity to conduct over-the-horizon warfare; and its burgeoning ability to integrate air and space operations seamlessly together (to find, fix, and attack any target of significance in the world, for example), are only a few proofs that we live in a revolutionary age.

Proposition #5: In attempting to transform themselves, the four major Services that make up the US military have gone "vertical." Aerospace power has become a key strategic, operational, and/or tactical capability desired by each and every Service. Even the US Army focuses not only on reconfiguring its infantry units and armor, but also on developing long-range weapons and air mobility options. Its wish list of desired military systems includes battlefield missiles, attack helicopters, fixed-wing attackers, and remotely launched cruise missiles. (Despite this telling trend, however, no one should ever assume that there are four air forces in the US military. As in the past, it continues to have three air arms and only one full-service, full-spectrum Air Force – a malleable Air Force that employs air and space power in wide-ranging ways.)

Proposition #6: Everyone in DoD has gone "vertical" because aerospace power finally closed a long-standing promise-reality gap in the 1990s.[8] In a number of ways, it can work now as originally advertised. And because it can work as advertised, the correlation of forces among the US military services has made a dramatic shift from the predominance of land forces facing off across borders to special operations forces and air and space forces operating across the spectrum of conflict today.

This shifting correlation of forces confirms that there is something decidedly new in modern, "post-heroic" warfare and that aerospace power — because it is a quick and wide-ranging military option — now plays a critical role in a New American Way of War.

Modern Conflicts — Comparing the Old with the New: Conflict and the Rise of Aerospace Power.

When comparing the old and the new in modern conflicts, the following points are well worth considering and/or remembering.

- In the old world, the US focused on national defense. In the new world, it focuses on national security (which emphasizes a broader, multi-agency approach to satisfy our defense needs).
- In the old world, the dominant threat was a readily identifiable and specific foe — the hulking, 10-foot-tall "Russian bear." In the new world, our dominant threat is, despite recent events, an abstraction — e.g., a spectrum of conflict that challenges us to handle a variety of contingencies effectively. (Within this spectrum there are foes like Saddam Hussein and Osama bin Laden that pose specific threats.)
- In the old world, our fundamental objective was to contain a virulent "ism" (communism). In the new world, we have at least a twofold objective — to protect the American homeland from another "ism" (terrorism), and to ensure regional bullies or hegemons remain merely a "local" problem.
- In the old world, we basically relied on three traditional instruments of war — the political, economic, and military — to meet our national goals and objectives. In the new world, we (and opponents like Osama bin Laden) now practice "Combination Warfare," which seeks to exploit above-military, military, and non-military forms of war together. These forms of war, in turn, include at least 27 sub-categories, which can migrate from one list to another. In other words, strategists can mix and match these forms of warfare in unprecedented, constantly evolving ways. "Combat" can thus occur in virtually any major sphere of human activity, and purely military options make up only a shifting part of a broader whole (in terms of its scope and importance).

In the case of Osama bin Laden, for example, the United States has used diplomatic warfare + network warfare + intelligence warfare + psychological warfare + technological warfare + financial warfare, etc., to disrupt his operations. In the case of Iraq, US has combined diplomatic warfare + psychological warfare + intelligence warfare + conventional warfare + sanctions warfare + legal warfare + media warfare to quarantine a hostile police state.

- In the old world, nation-states ultimately changed an opponent's political strategy, processes, or objectives by relying on indirect means (e.g., by damaging or even defeating military forces interposed between them and the sources of national power). In the new world, nations or groups can still rely on this labour-intensive, time-consuming method, but aerospace powers can also change an opponent's behavior directly (by threatening the critical centers of gravity of other systems or states).
- In the old world, military operations occurred either in overlapping or isolated "local times." These local times were actual AND subjective. When they overrode, collided, or failed to coincide with each other, they added to the "fog and friction" experienced by combatants. In the new world, however, US military operations are increasingly occurring in "universal time" (because of an increasing amount of near-simultaneous data fusion and information processing, and because of GPS-based positioning capabilities). As a result, widely dispersed combatants can leverage an unprecedented level of "instantaneity." They can share a common operating picture at the same time while coordinating widely dispersed operations.
- In the old world, the US faced conventionally armed militaries. In the new world, it faces "hybrid" militaries or groups that have multi-dimensional capabilities (i.e., industrial age/late-Cold War equipment; ballistic missiles and WMD capabilities; limited stocks of precision weapons; advanced air defense and anti-access capabilities; and the capacity to conduct global information operations). As suggested earlier, these hybrid capabilities can then serve Combination Warfare strategies.
- In the old world, the United States often put its military forces into overdrive to overkill. Even in

Above-Military Forms of War	Military Forms of War	Non-Military Forms of War
Cultural warfare	Nuclear warfare	Financial warfare
Diplomatic warfare	Conventional warfare	Trade warfare
Network warfare	Bio/chemical warfare	Resources warfare
Intelligence warfare	Ecological warfare	Economic aid warfare
Psychological warfare	Space warfare	Legal/moral warfare
Technological warfare	Electronic warfare	Sanctions warfare
Smuggling warfare	Guerrilla warfare	Media/marketing warfare
Drug warfare	Terrorist warfare	Ideological warfare
Deception/fabrication warfare	Concussion warfare	
Information warfare		

Combination Warfare — "10,000 methods Used as One"
"A better means used alone will not prevail over multiple means used together"[9]

maneuver warfare, ultimate success depended on massed forces and/or firepower, and on the ability to attrit, destroy, or even annihilate an opponent. In the new world, the US military can still rely on this blunt method, but it can also rely on a method that has various names — Concussion Warfare, also known as Knowledge Warfare, Hyperwar, Perception Management, Decision Cycle Dominance, etc.

The basic assumption behind this alternative method — regardless of what you call it — is that time is your enemy. The longer any conflict lasts, the messier it gets. "Fog and friction" progressively eat into rational planning. The hatreds, passions, and fears triggered by human conflicts only grow in intensity. Murphy's Law increasingly holds sway. And yet, these byproducts of human conflict are not brute forces of nature. We are not — by definition — powerless in their wake. We can mitigate or possibly modulate their effects (as one turns down a rheostat). The way to do this, however, is not to rely on the Mastodon warfare of the past. Instead, the US military needs to rely on decisive force rather than overwhelming force. It needs, for example, to be able to conduct wide-ranging, simultaneous strikes against dozens upon dozens of targets in a radically compressed period of time. In doing so, we then trigger in our opponents a choking of the senses; a disturbance in perception; a mental stroke; a loss or unwanted manipulation of one's situational awareness; a sense of isolation – physically, mentally, morally – from the external world; and feelings of uncertainty, doubt, confusion, self-deceit, indecision, fear, panic, discouragement, or perhaps even despair.

Therefore by being the "firstest with the mostest," and by deliberately introducing continuous and unpredictable change into conflicts, military forces can so befuddle, disorient, and confuse an opponent that they may well free themselves from the tired practices of the past. Friendly forces act while their opponents increasingly fail to act. As a result, "fog and friction" may not disappear, even in what should be increasingly unequal struggles, but their scope and duration may well decrease. And if that occurs, political and military leaders may have more decision options available to them than they might have otherwise. (Let's never forget that after four years of attrition warfare in World War II, the Unites States essentially had only one political option remaining — the unconditional surrender of Germany and Japan.)

A warfighting strategy characterized by Combination Warfare, direct effects, universal time, and "firstest with the mostest" operations represents a fundamental departure from the past. There are, however, five additional points we need to make in relation to this strategy.

- In the old world, speed and the deliberate compression of military operations in time were a liability. The nuclear menace loomed so large that any emphasis on speed raised the inherently destabilizing specter of preemptive attack or launch on warning. In the new "hybrid" conflicts of today, speed is of the essence, and technology is the essence of speed. Without immediate, real-time operations — which special operations forces and aerospace power can provide — "rapid halt" activities are not really possible.

- In the old world, time and space were equally important in military operations. Seizing and controlling territory was often the arbiter of victory. In the new world, manipulating time effectively may often be more important than controlling space. Military success, after all, may not necessarily rely on the taking and holding of territory. Controlling an opponent's processes and strategies may yield broader and more immediate successes, particularly in increasingly important man-made "territories" (cyberspace, etc.).
- In the old world, military success depended on the day-in and day-out support of a military-industrial complex. In the new world, an airman's "instantaneous subjugation potential" will depend on a military-information complex that improves his or her ability to "read" large areas on a "24/7" basis (and therefore find, fix, track, and perhaps attack terrorist targets, etc.).
- In the old world, specialized military services (including airpower) merely supplemented or supported traditional military methods. They were mere "garnish on a plate." In the new world, these specialized services have come of age. They now sit as equal partners at the joint table. They can provide independent and broad-based support to joint operations. And as a result, they legitimize one approach to joint operations — e.g., use the right tool at the right place at the right time.
- In the old world, the US relied more on overseas presence than on power projection to meet its security obligations. In the new world, advanced conventional munitions and long-range systems permit it to rely increasingly on power projection. This possibility poses a problem for the US, however. In the old world its adversaries focused on defeating US forces already in theater. In the new world, their aim is to slow, disrupt, or outright prevent theater access by American units. (Asymmetric strategies; threats of protracted conflict; and *fait accompli* strategies, where an opponent changes the stakes of a local confrontation before the US actually intervenes, are ways he or she can undermine America's ability to project power.)

To summarize the above section properly, all we need to stress is that the "post-heroic" warfare of today represents a departure from the past. Where once the United States concentrated on national defense, today it worries about national security. Where once it faced a concrete, readily identifiable foe, today it faces foes within an overarching abstraction (the spectrum of conflict). And where it once sought to contain a hostile global "ism," today it attempts to keep troublemakers "in a box," while also promoting an international order that is not overtly hostile to American interests. The US performs these functions by relying on traditional military methods, but it also relies on new tools such as Combination and Knowledge Warfare. In confronting increasingly "hybrid" foes, these nontraditional methods often combine a variety of means in novel ways. They often focus on manipulating an opponent's knowledge and perception instead of seizing his or her territory. They use "instantaneity" to try and rapidly halt aggression, to induce entropy or paralysis in others, and to adapt to what remains a casualty sensitive world. Additionally, they rely on the benefits provided by "universal time," effects-based targeting, and the ability to assault an opponent's strategies or objectives directly. In this world — a world that continues, despite fears of terrorism, to be characterized by limited wars by limited means for limited ends — large-scale ground combat is an option, not an inevitability, and the focus of the US military's "Joint Team" is now divided between homeland defense, forward presence, and power projection missions. To succeed in this brave new world, however, the US military must develop a military-information complex that fuses its collective efforts together. Aerospace Operations Centers are part of this process.

The above changes are significant. The context of human conflict has changed in the last 10-15 years, as has its means and ends (including aerospace power). But what is actually new about modern aerospace power? Well, consider the following.

- As a specialized service, American airpower was once mere "parsley on a plate." It prepared battlefields for other military forces and then supported these forces in follow-on engagements. Its contributions to "victory" were peripheral and uncertain at best. Today, however, aerospace power can establish the preconditions for success. Depending on the circumstances, it shapes, determines, and on occasion even defines environments. As a result, military operations that follow in its wake can be less costly than they would be otherwise. (They may be less onerous in terms of lives squandered, opportunities lost, time spent, and treasure wasted.)

One obvious example of airpower's environment-shaping and/or outcome-determining capabilities was the "sanitizing" of northern France by American bombers in 1944. By seriously curtailing the German war machine's freedom of movement, American airpower isolated coastal defenders from desperately needed supplies and reinforcements during the D-Day invasion. It also ensured that the Luftwaffe did not rain bombs on the heads of Allied troops landing in Normandy. Omaha and Utah Beaches may have been bloody, but they would have been much bloodier without the environment-determining role played by 8th and 15th Air Force bombers prior to, during, and after D-Day.

Desert Storm is another instance where aerospace power determined the course and outcome of events. In this war, Allied air forces destroyed the command and control system of an enemy state; closed down its lines of communication, neutralized and demoralized the 6th largest air force in the world; allowed only two significant moves by the Iraqi Army (Al Khafji and the withdrawal from Kuwait); destroyed two-thirds of Iraq's armored forces; and ensured a successful four-day ground operation against the 4th largest army in the world, all at the cost of 615 Allied deaths. In short, aerospace power systematically neutralized an opponent's instruments of power and enabled other military forces to perform their remaining tasks with minimum losses or difficulties.

- Desert Storm and most recently Kosovo illustrate yet another virtue of modern aerospace power. In the past, the air weapon was merely the "bird dog" for the true force of decision — ground power. Yes, airpower harassed enemy forces and enfeebled them, but basically it just prepared them to experience a final and decisive blow at the hands of ground forces. In the 1990s, however, we saw aerospace and ground power routinely reverse roles. The air weapon administered the killing stroke while ground forces (including the Kosovo Liberation Army) acted as the "bird dog." This "yin-yang" dynamic, where aerospace and ground power alternatingly act as decisive agents or as preparatory, supplementary, or follow-on forces, is an important advantage that US airmen and special forces units will increasingly exploit in their war against organized terrorism.

The above advantage, in turn, points to several other truths about 21st century aerospace power.

- It is the only military tool that holds all other forms of military power at risk. (By increasingly denying an opponent the use of darkness and bad weather to close with friendly forces, for example; by providing a top down perspective that is simultaneously global, regional, and local in scope; by providing rapid target recognition and re-strike capabilities; and by seizing the initiative and massing effects.)
- In higher and even smaller-scale contingencies, aerospace power can attrit or neutralize surface forces faster than they can accumulate mass, which still matters in current conflicts. (Precision guided weapons, however, can create their own mass, and with exceptional effects.)
- As suggested earlier, "borderless" aerospace power has become malleable enough — could any other form of military power have adapted to the political fits and starts of Operation Allied Force as effectively?[10] — to operate routinely in multiple strategic directions at once, and thereby menace enemy assets either through "remote grappling" operations, or through close-in "yin-yang" activities with ground units. (They are also capable of consistently generating strategic-level effects while operating at the tactical level; or vice versa, as the Berlin and 1973 Yom Kippur airlifts illustrated.)

Lastly, it's important to note that modern aerospace power provides secondary benefits that often go unappreciated. To cite but a few examples, it can make upper- and middle-tier conflicts more predictable (see the previous discussion of Knowledge Warfare), and thus possibly more "rational"; it can reduce the amount of hardware and personnel needed in an operation; it can reduce the amount of casualties and damage suffered by <u>both</u> sides in a conflict; it can lessen the number of strikes and re-strikes needed to neutralize targets, and much more.

To support its overall "Transformation" theme, this article has now accomplished two of its three stated goals. First, it highlighted six working assumptions about the post-Cold War world that have bounded and directed the USAF's self-transformation as a military service since the late-1980s. Second, it highlighted what is old and what is new in modern conflict, and what are some of the more salient features of modern aerospace power. With these goals accomplished, the

- Hold emerging strategic capabilities in developing states at risk, while being prepared to defend against limited missile attack.
- Deploy sufficient, quality forces worldwide to be able to deter or defend [against aggression].
- Assure access to any region via air, maritime, and space supremacy.
- Assist international efforts for relief, peacekeeping and drug interdiction.
- And sustain a research and industrial base sufficient to keep our technology edge.

The above documents cast a long shadow over the thinking of Air Force leaders, but when it came to providing generic principles and/or working propositions of aerospace power, they were ultimately too utilitarian and plans-oriented. What the USAF needed were "ivory tower" efforts to close the loop.

An example of the latter was the Air University (AU) Strategic Aerospace Warfare Study Panel, which formalized a list of "indispensable" aerospace assumptions and beliefs that later appeared in AU's influential *Air Force 2025* Report (June, 1996). The list subsequently became a staple in professional military education curricula and includes the following. (As in the previous *Reshaping for the Future* White Paper, please note the pride-of-place given to burgeoning ISR capabilities).

- Aerospace power can deter, constrain, or inhibit an adversary's operations via surveillance and aerospace dominance.
- It can disrupt/destroy an opponent's operations through precision strikes against that opponent's instruments of power.
- It can narrow, deny, or eliminate enemy options/war aims.
- It can directly attack an enemy's strategy or weaknesses, and therefore reduce his or her capacity to resist our will.
- It enables "friendlies" to operate within an opponent's decision cycles. (See below.)
- It achie(en to bem),im T bemppo-
    - It elr eze.7(lhat lTwdama.7(g)2g[(w)24

[illegible]

range planners developed a new Service Vision — *America's Air Force: Global Vigilance, Reach, and Power* (2000) — that insisted on dominant situational awareness that was not geographically bound, and that would permit expeditionary forces to find, fix, track, and engage any target of significance within minutes rather than hours. Additionally, the planners identified 14 desired "Critical Future Capabilities" for the Air Force that are now are part of its *Strategic Plan, Volume 3*. These Critical Capabilities deliberately "flesh out" the six Core Competencies and three additional support areas. In the case of Information Superiority, the Strategic Plan commits the USAF to . . .

- Provide continuous, tailored information within minutes of tasking with sufficient accuracy to engage any target in any battlespace worldwide;
- And, in conjunction with joint and national capabilities, to ensure our unhindered use of the information domain from all attempts to deny, disrupt, destroy, or corrupt it and exploit or neutralize any adversary's ability to use the information domain.

Ultimately, theories or concepts of aerospace power, whether simple or complex, require a firm foundation made up — at a minimum — of two fundamental ingredients — clearly articulated assumptions/beliefs and appropriately defined capabilities. Without these ingredients, airmen can't know who they are, and they certainly can't conceptualize further about the preferred attributes of aerospace power (including ISR). Fortunately, the USAF has defined its most fundamental beliefs and capabilities in the past and it will continue to do so in the future. The same holds true for its higher-level thinking about aerospace power.

New Thoughts on How to Use Aerospace Power and the Aerospace Operations Center — Part 2: Theories of Airpower and their Impact on ISR Development.

With codified beliefs and preferred USAF capabilities now identified (including the desire for global situational awareness, dominant battlespace knowledge, etc.), we can next consider evolving theories of aerospace power and — given the overall theme of this volume — the impact they had on the development of our ISR-related capabilities. Prior to Desert Storm these theories almost always fell into one of three broad categories.

Category # 1 argued that airmen needed to attack and terrorize populations to the point that they openly rebelled against their own government. Giulio Douhet, Billy Mitchell (in his later, post-1930 writings), and Arthur "Bomber" Harris advocated this approach.

Category #2 argued that long-range aircraft needed to attack economies or infrastructures and cause them to collapse (ideally by disrupting or destroying key nodes). The US Army Air Corps Tactical School's "Bomber Mafia" most notably articulated this approach in the 1920s and 1930s.

Category #3 argued that fielded military forces, and the war materiel factories that immediately supported them, were the preferred targets. Gianni Caproni, Nino Salveneschi, John Slessor and the London-based Committee of Operations Analysts (in World War II) advocated attriting these targets whenever and wherever possible.[11]

With varying degrees of acceptance, these three targeting schools are still with us today (although massively attacking populations is not a viable legal or moral option when conducting limited wars by limited means for limited ends). By the mid- to late-1980s, however, some airmen became increasingly troubled by what they saw as the USAF's outdated concepts of operations. They understood, for example, that dividing air attacks into three types — strategic, operational, and tactical — was now passé. The effects or consequences of future operations would not be necessarily defined by the nature of the target struck, the method of attack, or the platform used. As a result of this particular concern and many others, the Service's forward-looking thinkers initiated a conceptual transformation that one can break down — for purposes of illustration — into five "waves." Each wave, in turn, created a demand for ISR-related capabilities that now comprise <u>the</u> transformational goal for DoD — e.g., a networked, real-time "24/7/365" Global Information Grid that can detect and respond to "windows of opportunity" that fleetingly last for a matter of minutes.[12]

The *first conceptual wave* began in the mid- to late-1980s and included progressive airmen who drew their inspiration, at least in part, from Soviet thinking on Reconnaissance Strike Complexes. By the time Desert Storm arrived, first wave thinkers such as Colonel John Warden had popularized the following ideas.

- Airmen should use <u>conventional</u> airpower in <u>independent</u> air campaigns <u>directly against strategic and theater-levels centers of gravity</u> (COGs). (Astonishingly, the "nuclear shadow" that existed in the Cold War was so pervasive that John Warden's 1986 National War College thesis — *The Air Campaign* — was the first major text to argue this point in the nuclear age!)[13]
- Airmen should conduct "hyperwar" (also known as "Parallel Warfare") against their opponents. In other words, they should radically compress the pace of their operations to create "shock and awe" in an opponent, particularly through the simultaneous application of force in time, space, and at each level of conflict, and against as many target sets as possible.

These target sets include centers of gravity (a metaphor borrowed from the linear, Newtonian physics of the 18th century) and/or key nodes that — if struck properly — would create wide-ranging and cascading effects throughout entire systems. (These systems could include almost any organized activity — telecommunications, transportation, energy grids, and even — John Warden argued — terrorist networks.) Some of the benefits of these types of effects include tactical-level surprise, a larger span of influence, fewer casualties, enemy paralysis or entropy, and a shorter amount of time required to impose effective control over fast-moving events.

Despite identifying and pursuing these very real benefits, "first wavers" were not above promoting contradictory beliefs. They recognized that the value of a key node or COG waxes and wanes. Its value may depend on time (should we strike it early or later?); its range (do we need to strike targets only within range of aerospace power?); its position in space; its vulnerability to attack; and/or its potential for collateral damage. And yet, John Warden also argued that the value of a COG is not necessarily situational. First among equals, he insisted, is the leadership (single or plural) of a state or organization. By "decapitating" or isolating leaders from their own sources of resistance or power, we may well be able to paralyze them from the "inside out". Attriting or destroying their forces, in contrast, is a highly inefficient "outside in" way to fulfill one's goals, or so first wavers like Warden argued.

Nevertheless, when it came to the development of US ISR-related capabilities, squabbles about the relative importance of one COG over others were ultimately irrelevant. By advocating Parallel or Hyper Warfare, first wave thinkers like John Warden helped focus US intelligence, surveillance, and reconnaissance needs. In particular, they created an enduring need to identify potential COGs and/or key nodes, both systematically and comprehensively.

The infamous John Boyd, otherwise known — depending on the exasperated source — as "Genghis John," or the "Mad Colonel," single-handedly inspired *the second wave* of USAF conceptual innovations. (Boyd's ideas actually came first chronologically, but their impact on USAF thinking became widespread — and largely from the bottom up — after Desert Storm.)

According to the "Mad Colonel," the success or failure of human conflicts do not automatically turn on death or destruction, or even on seizing territory. What ultimately matters in these conflicts is "decision cycle dominance" — e.g., the ability to make appropriate decisions more expeditiously than your opponents do.[14] As Boyd observed, when combatants make decisions, they do four things — they observe, orient, decide, and act. The combatants then loop around and repeat this decision-making process — now familiar to many as the "OODA Loop" — again and again. But what if you work through your OODA Loops faster than your opponent? What if you are on you fifteenth decision cycle and your slower moving nemeses are on their fifth iteration? Do they — at least in relation to your actions — increasingly become disoriented, befuddled, and confused? Have their situational awareness or sense of reality collapsed? According to Boyd and his many supporters, the answers to these questions are a resounding "yes."

What the above possibilities illustrate, or so Boyd argues, is that you can deliberately disrupt or incapacitate an adversary's ability to cope with changing events, particularly if you "fast transition" from one operational state or condition to another. "Fast transitioning," in other words, forces your opponents to operate at tempos that stress their ability to respond effectively to continuous, unpredictable change. Either their decision cycles remain too slow, or they become increasingly uncoordinated and/or fragmented. (It's all about "dumping and pumping energy," Boyd famously said.) In either case, you increasingly exercise decision cycle dominance over others through deliberate perception management techniques. (See the previous discussion of Knowledge Warfare, which is heavily indebted to Boyd's ideas, as are multiple US Joint Doctrine publications and Joint Forces Command's evolving Rapid Decisive Operations concept.)

If first wave thinkers created an enduring ISR-related need to identify potential COGs and/or key nodes, then Boyd's second wave insistence on decision cycle dominance required a complementary set of capabilities — integrated command and control and battle management.

The *third conceptual wave*, which appeared in the mid- to late-1990s, included Ben Lambeth, a respected RAND Corporation analyst.[15] As prefigured in our previous discussion of what is old and new in aerospace power thinking, Lambeth argues that the air weapon is no longer a mere supplement to traditional methods. Although it can do what it has always done — prepare conflict areas for other military forces and then support them in follow-on operations — it can also have a governing influence on events from the very outset. It can, in other words, establish the preconditions for subsequent military success. Depending on the circumstances, Lambeth argues, aerospace power can shape, determine, and on occasion even define environments. As a result, military operations that follow in its wake can be less costly than they would he otherwise, as illustrated not only by the sanitizing of Northern France for the D-Day invasion and the psychological devastation of Iraqi troops in Operation Desert Storm,[16] but also by the Battle of France (May-June 1940), the Battle of Britain (August-September 1940), Anzio (January-February 1944), the Pusan Perimeter (July-September 1940), Linebacker I (March-June 1972), the Battle of Khafji (January 1991), and Bosnia (September 1995), to name just a few.

Third wave thinking on aerospace power is "joint friendly." Few American ground power enthusiasts — regardless of how troubled they might be over the repeated and preferred use in the 1990s of once "peripheral" US Air and Naval forces — deny the utility of shaping environments in modern conflicts. However, using aerospace power to accomplish this anticipatory and even preemptive goal spurred the need for yet another set of ISR-related tools. Not only must the USAF be able to catalog critical COGs or nodes effectively, and integrate its C2 and battle management capabilities together, it must also be able to dynamically assess, plan, and execute its missions.

The *fourth conceptual wave* appeared in 1997 and originated with Major General Charles Link, who spearheaded the USAF's Quadrennial Defense Review efforts at the time. As part of his responsibilities, Maj Gen Link reviewed existing US warfighting strategies and plans, and he was disturbed by what he saw. The existing "legacy constructs" required US forces to respond to aggression, but as they continued to defend against it, they also had to pause and build up combat power. Only after sufficient ground forces were finally in place would they mount a decisive counteroffensive and achieve their war aims. What disturbed General Link about this three-step process was that it was sequential and not particularly time-urgent. The first two steps — "halt" and "build up" — were mere "warm ups" to the counteroffensive, and the "decisive point" in the process was nestled somewhere between the second and third steps (that is to say, weeks or even months after the aggression began).

General Link responded that to delay the decisive or culminating point until ground forces were ready to stage a counterattack was an example of "old think." Today's conflicts were nothing if not time urgent, especially in the case of cross-border aggression. The only logical response, General Link concluded, was to move the decisive point in our war plans earlier "to the left" — e.g., to the initial halt phase. More specifically, US forces needed to stage rapid halt operations in order to seize the initiative, and thereby influence, manipulate, and/or halt an adversary's ability to act offensively. That these requirements put a premium on control of the air, and on shock-oriented air attacks against enemy surface maneuver, soon troubled advocates of "boots-on-the-ground,"[17] as did some of the expected benefits of rapid halt operations.

- The operations might constrain or deny opposing land forces their freedom of action.
- They could introduce greater unilateralism in conflicts (by making an opponent increasingly deaf, dumb, and blind to your own actions).

They might allow you to regain the initiative quickly, and thereby minimize the amount of territory you either have to control or — even more importantly — recover.

- They could maximize the number of choices available to you (in contrast to the increasingly narrow options available to those whose culminating point is chronologically too far "to the right").
- In fact, rapid halt operations provide several gifts of time, or so its advocates argued. Not only would they give you more choices, they might also afford you sufficient time to spin up and deploy reserve ground forces (instead of more costly active duty units). Finally, rapid halt operations would almost certainly minimize the politico-military tensions (or outright divisions) in your alliances or coalitions (again, by securing early successes and thereby avoiding the cumulative costs of Murphy's Law, "fog and friction," and/or shifting political circumstances).

While the benefits of rapid halt operations remain questionable to military traditionalists, no one disputes that the concept intensified the need for ISR-related capabilities in the USAF. Rapid halt forces not only required focused ISR, integrated C2/battle management, and dynamic assessment, planning and execution capabilities, they also demanded unprecedented sensor fusion and sensor-to-shooter links, particularly if they were to establish a new "culminating point" in modern conflicts.

The conceptual waves represented by John Warden, John Boyd, Ben Lambeth, and Chuck Link played an important role in the transformation of the United States Air Force. The varying techniques and approaches they represent not only complicate enemy planning, they also provide important vectors for the development of innovative ISR-related capabilities. Having said that, *the fifth and most current conceptual wave* is ultimately the most important.

New Thoughts on How to Use Aerospace Power and the Aerospace Operations Center — Part 3: Providing a "Brain" for USAF Capabilities.

According to influential individuals such as General James McCarthy, USAF (Ret.),[18] and seminal texts such as *Joint Vision 2020,* the ideal way for US forces to stay one military-technical revolution ahead of their nearest rivals is through Information Superiority, which unavoidably depends on dominant C2ISR capabilities. These capabilities will increasingly provide a fused and correlated "Common Relevant Operating Picture" (CROP) for joint and coalition forces. (Depending on the source, the CROP is also characterized as a "Global Information Grid" or even as a "Family of Interoperable Pictures."[19]) In any case, the capabilities will link space and airborne ISR to the homeland and the cockpit. They will tap a new generation of multi-mission satellites with markedly improved loiter times and area coverage. They will provide enhanced opportunities for nodal attacks, particularly against weapons of mass disruption, and exploit a growing number of unmanned platforms to provide unprecedented levels of persistence. Information Superiority, in short, will permit US forces to exploit a set of capabilities — global coverage, freedom of access, continuous presence, global perspective, improved reachback, etc. — to establish decision cycle dominance over others, to anticipate events rather than merely react to them, and to transition from "knowing to doing" in nimble-footed ways. [20] Lastly, and perhaps most importantly for the United States Air Force, Information Superiority will improve its ability to conduct precise, real-time targeting against mobile and fixed targets.

All the above capabilities — whether already in place or in various stages of development — are both consequences of and solutions to the five conceptual waves highlighted in this article. As the following figure shows, the capabilities build on each other and point to a C^{2}ISR architecture that will support "yin-yang" aerospace-ground force operations, and ideally lead to disproportionate, cascading effects that everyone can exploit.[21]

At this point, our transformation-centered text has accomplished all but one of its stated goals. It has highlighted six working assumptions about the post-Cold War world that have bounded and directed the USAF's self-transformation since the late-1980s. It stressed what is old and what is new in modern conflict, and what are some of the more salient features of modern aerospace power. It described the core beliefs and operational concepts that not only vectored the USAF over the last decade, but also spurred the creation of a C^2ISR grid that will remain a top priority over the next two decades. The only requirement we have left is to describe the role of the Aerospace Operations Center (AOC) as the integrated "weapon system" (e.g., the "eyes, ears, hands and legs") that will guide expeditionary aerospace forces in the future.

As a work-in-progress, the AOC is an integral part of how the USAF will prepare for and conduct future expeditionary operations. It is a weapon system — made up of people, capabilities, and equipment — through which Joint Force Air Component Commanders (JFACC) exercise command and control of aerospace forces. More specifically, the JFACC should employ the AOC "to maneuver and mass overwhelming aerospace power through centralized control and decentralized execution to produce desired operational and strategic effects in support of the Joint Force Commander's campaign."[22] The AOC, in other words, is a tailored, fixed or deployable "war room" that does much more than manage Air Tasking Orders. It serves as an aerospace operations planning, execution, and assessment system for the JFACC. (In the first case, the AOC develops the aerospace operations strategy and planning documents needed to meet JFACC objectives and guidance. Then it tasks and executes day-to-day aerospace operations and provides the rapid reaction and positive control needed to control different weapon systems.)

If a JFACC hopes to accomplish the above ends via an AOC, he or she needs cross-cued, multi-sourced, and real-time C^2ISR systems. These systems provide, among other things . . .

- Threat status awareness.
- Netted command and control.
- Dynamic, real-time predictive battlespace awareness.
- Intelligence preparation of the battlespace.
- Responsive weather forecasting.
- Precise and predictive effects-based targeting (via the ability to find, fix, track, target, engage, and asses targets).
- En-route tasking, real-time analysis of attacks, and dynamic re-tasking,
- Retrospective and prospective effects-based assessment.

However, if the United States Air Force is going to exploit its C^2ISR systems to maximum effect, it has to "baseline" key parts of the AOC. In particular, it has to codify AOC doctrine, training, and modernization policies for the 19 "entities" the Service has identified so far. (These entities include two fixed, four deployable, and four support AOCs. They also include four Augmentation Units and five Operations Centers that are all designed -- depending on the requirement -- to operate in Southwest Asia, Korea, Europe, the United States -- as Homeland Defense Centers -- and elsewhere.)

Doctrine: The USAF has already made significant progress in developing AOC-related doctrine. Air Combat Command issued a formal AOC Concept of Operations (CONOPS) on 9 March 2001. The CONOPS provides basic guidelines on how to organize, train, and equip AOCs. Additionally, it focuses on the operational level processes

required to command and control aerospace forces, and it provides a baseline from which programmers can build AOC-related acquisition and modernization strategies. The CONOPS, however, is not the only document that details the principles by which an Aerospace Operations Center should operate. At a lower level, Air Combat Command is also developing Process Manual "Tactics, Techniques and Procedures" Series that focus on operational-level tactics (the 2-1 series) and unclassified references (the 2-3 series). Finally, the USAF has updated the operational procedures contained in Air Force Instruction, 13-1, AOC Volume 3 (Operational Procedures -- Aerospace Operations Center).

Training: AOCs need to be staffed by the best and most experienced operators the US Air Force can develop. At present, however, the Service does not have enough experienced C^2 operators to satisfy its requirements — e.g., it has a talent pool diluted across different AOCs. To solve this problem, the USAF has to train significant numbers of individuals who will effortlessly flow back and forth between their primary weapon system and the AOC. One solution to this requirement is to send these individuals to a series of C^2-related training courses as they progress through their careers.

The standardized series, as presently structured, begins with the captain-level Joint Aerospace Command and Control Course (JAC^{2}C), which focuses on the C^2 of joint air operations in a theater battle at the operational level of war. Mid-career officers then attend the Command and Control Warrior Advanced Course (C^2WAC), which prepares selected individuals to perform duties requiring advanced knowledge, skills and ability in the C^2 processes that support the JFACC, again at the operational level of war. Thirdly, lieutenant colonels and colonels attend the Joint Air Operations Senior Staff Course (JSSC), which provides an overview of the planning, coordination, integration, employment and implementation of air operations strategy in joint operations. Finally, general officers attend the Joint Forces Air Component Commander Course (JFACC), which prepares potential JFACCs for theater-level responsibilities.

The above training scheme will ideally create a "war room" staffed by a hierarchy of experts. At the pinnacle will be Senior Leaders who are highly experienced in AOC operations. Next are Process Owners, who are the linchpins of the AOC team. They understand the various parts of the AOC and — most importantly — they know how to use them as parts of a "horizontal" and "vertical" system of systems. (Given this level of expertise, the Process Owners are the natural instructors and supervisors of the AOC). Third in the hierarchy is the Core Cadre, who are permanently assigned to the AOC and are fully certified in specific tasks and functions. Lastly, the AOC will have Dedicated Augmentees, who are fully qualified individuals at specific positions, and Non-dedicated Augmentees, who will most likely require additional "top-off" training to accomplish a specific AOC task.

Modernization: CONOPS and well-trained personnel are critical to an AOC's success, but so are improved technological capabilities. To evolve in this area, the USAF has adopted for the AOC the same block development concept (with intra-block increments) it uses for other weapon systems.

Block 10 improvements, for example, focus on producing and disseminating coalition Air Tasking Orders, creating and distributing coalition air pictures, disseminating intelligence products among coalition partners, and reducing hardware footprints (past AOCs have included a hefty 28-30 servers and 150-200 workstations, for example).

Block 20 enhancements, in turn, seek to provide improved crisis action planning capabilities, enhanced unit-level use of the Theater Battle Management Core System, and a web-enabled version of the same system for the AOC.

Lastly, "next generation" or Block 30 capabilities will support Global Strike Task Forces (preferably by 2006) and provide the following:

- A full and yet scaleable AOC with less than 100 people.
- Robust distributed collaborative links to supporting command and assessment centers.
- An integrated infrastructure that permits "plug & play" applications.
- Self-configuring LANs and laptop workstations.
- The ability to "publish and subscribe" like-type information capabilities.
- Automated tasking orders or appropriate en-route weapon pairing and control.
- The ability to perform automated and timely effects-based assessments, and much more.

The "Combined Aerospace Operations Center — Experimental," popularly known as CAOC-X, is the primary vehicle the USAF has developed to "operationalize" the AOC quickly (including the Block 10-30 improvements cited above). More precisely, the goal of CAOC-X is to modernize the current collection of AOC systems into a single integrated architecture made up of "best-of-breed" hardware, software, and processes. These technologies and procedures will then support three different types of AOCs — "Full" units, with complete block and coalition capabilities; "Training Plus" organizations, which will have less than full operational options; and strictly "Training" AOCs, which will have only limited operational functions.

When it is all said and done, however, the fundamental challenge remains money. At present, the USAF has not adequately funded a host of AOC requirements — e.g., unit standardization, operator training, the fielding of Block 10 or Block 20 technologies, maintenance equipment, and more. The Service needs to dedicate additional funds to support Block 20 and 30 developments, particularly if it is going to ensure its commanders have the tools they need to exploit new aerospace capabilities in support of new concepts of employment in a new military era. When the USAF accomplishes this last step, it will have transformed itself yet again, and it will be in large part because of the order-of-magnitude advantages provided by C^2ISR-based Aerospace Operations Centers.

Endnotes

1. The opinions, conclusions, and recommendations expressed or implied in this article are solely those of the author and do not necessarily represent the views of the United States Air Force, the US Department of Defense, or any other US government agency.

2. The United States Army, for example, largely assumes the latter. Its transformation will be complete with the appearance of its lighter and yet more lethal Objective Force within the decade.

3. See *Transforming Defense: National Security in the 21st Century*, Report of the National Defense Panel, Washington, D.C., December 1997, and *Report of the Defense Science Board Task Force on DoD Warfighting Transformation*, Office of the Undersecretary of Defense for Acquisition and Technology, Washington, D.C., August 1999.

4. These aircraft were the F-117, F-111, and F-15E.

5. LANTIRN is an acronym for Low Altitude Navigation and Targeting Infrared for Night.

6. This number refers to all USAF F-16s, Block 30 and above, cc-coded only (AC+RC): FK/52: 18+15; FJ/50: 156+0; FH/42: 0+45; FG/40: 192+15; FF/32: 0+15; FE/30: 84+180.

7. For a discussion of these four US Defense Policy Goals, see Chapter 3 of *Transforming America's Defense for the 21st Century: Report of the 2001 Quadrennial Defense Review*, Washington, D.C., 30 September 2001.

8. This gap was not only attributable to the verbal bombast of early air theorists and the limited air technologies actually available to support their claims, but also to the constraining effects of supporting an overarching "Fulda Gap" strategy for over 40 years.

9. See *Unrestricted Warfare* by Qiao Liang and Wang Xiangsui (Beijing: PLA Literature and Arts Publishing House, February 1999).

10. See Ivo H. Daalder and Michael E. O'Hanlon, *Winning Ugly: NATO's War to Save Kosovo* (Washington, D.C.: Brookings Institution Press, 2000).

11. See Count Gianni Caproni, *Memorandum on "Air War"*, 1917, US Air Force Historical Research Agency (AFHRA), Maxwell AFB, AL, File No. 168.66-2; Nino Salvaneschi, *Let Us Kill the War: Let Us Aim at the Heart of the Enemy*, 1917, AFHRA File No. 168.661-129; and John C. Slessor, *Air Power and Armies* (London: Humphrey Milford, 1936). Salvaneschi was an Italian journalist who popularized the theories of Douhet and Caproni in World War I. As a result, *Let Us Kill the War* accurately reflects their thinking at the time.

12. The "waves" are not based on when a notion or idea first appeared, but on when it actually received significant attention and recognition.

13. See John A. Warden, III, *The Air Campaign: Planning for Combat* (Washington, D.C.: National Defense University Press, 1988).

14. For a discussion of Boyd's ideas, see Grant T. Hammond, *The Mind of War: John Boyd and American Security* (Washington, DC: Smithsonian Institution Press, 2001), and Major David S. Fadok, USAF, *John Boyd and John Warden: Air Power's Quest for Strategic Paralysis* (Maxwell Air Force Base, Alabama: Air University Press, February 1995).

15. See Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University Press, 2000). Although this volume did not appear until 2000, its basic themes were familiar to a considerable number of US Air Forces leaders and thinkers in the 1990s. In fact, many of them commented on early drafts of the text, as its preface makes abundantly clear.

16. See Stephen T. Hosmer, *Psychological Effects of US Air Operations in Four Wars, 1941-1991: Lessons for US Commanders* (RAND Project Air Force, MR-576-AF, 1996).

17. See, for example, *Clashes of Visions: Sizing and Shaping Our Forces in a Fiscally Constrained Environment*. The Center for Strategic and International Studies (CSIS) published this 87-page edited transcript after a formal exchange between Major General Link, Lt Gen Paul Van Riper, (USMC, Ret.), and Maj Gen Robert Scales, USA in October, 1997.

18. General McCarthy was a member of the National Defense Panel (1997) and subsequently led two ISR-related USAF Senior Advisory Board (SAB) studies — one *on Building the Joint Battlespace Infosphere* (1998) and the other on providing *Information Management to Support the Warfighter* (1999). (See http://www.sab.hq.af.mil/Archives/index.htm for these reports). As head of the Transformation Panel in Secretary Donald Rumsfeld's recent Defense Review (spring 2001), Gen McCarthy repeated a number of the themes first struck by the NDP and SAB studies, including the inescapable need for comprehensive global awareness.

19. In an internal 22 September 1999 memorandum, Mr. Arthur Money, Assistant Secretary of Defense for C^{3}I, defined the Global Information Grid as "The globally interconnected, end-to-end set of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating and managing information on demand to warfighters, policy makers, and support personnel." Advocates of the Family of Interoperable Pictures, in turn, characterize it as a multi-service effort to provide the warfighter with a coherent, consistent, tailorable, and unambiguous view of the battlespace with actionable, decision-quality information. The result of such a view, they argue, will be clear decision-making superiority over others.

20. Naturally, the US military's quest for Information Superiority also poses new challenges. How will the US military automate its joint data/imagery processing? How will it avoid being sensor rich and information poor? How will it expand and integrate its automatic target recognition and classification methods? How will it protect its information, or manage it in networked, coalition-friendly ways? The US military will have to answer these and many other questions before Information Dominance becomes a reality.

21. These types of effects can be psychological or physical, logistically centered, infrastructure centered, cyberspace/space centered, or leadership oriented. They can also focus on an opponent's security, mobility, and/or political capabilities.

22. Lt Col Richard G. White, *Concept of Operations for Aerospace Operations Center (AOC)* (United States Air Force: Air Combat Command, 9 March 2001).

THE ROLE OF AIR OPERATIONS CENTRE IN AN ISR-DEPENDENT FORCE

Lieutenant-Colonel Dennis Margueratt, Deputy Director Aerospace Studies

INTRODUCTION

Increasingly, the importance of intelligence, surveillance and reconnaissance (ISR) in providing the air commander a real-time picture of the battle space, with sufficient fidelity to ensure accurate strategic and operational decision making, will force ISR into a position of prominence within the Air Operations Centre (AOC) structure. As witnessed during operations Deliberate Force and Allied Force, commanders need and want to be directly involved in the planning and conduct of operations to ensure issues of collateral damage, casualties, target legalities, and national and international interests are addressed before weapons are released. The only way commanders can hope to achieve this level of interaction with operations is through a clear, intelligible picture of the battle space. In operations other than total war, there is no longer a place for Clausewitzian fog.

INFORMATION MANAGEMENT

As Figure 1 illustrates, current USAF doctrine places ISR at a specialty function level within the AOC.

As a specialty function, ISR personnel are distributed throughout the various divisions within the AOC to provide advice and assess information for their part of operations within their respective division. ISR personnel are under the direction of a team leader, but effectively work for their assigned division much the same as staff with a space or information warfare specialty might function. The difference with ISR, in comparison to other specialty teams, is the focus this organization brings to the commander's battle-space perspective and the impact ISR derived information has on the commander's ability to make time-critical decisions. For this reason, ISR must be elevated to the level of Core Team, much as was done with Air Mobility, to reflect ISR's core responsibility to deliver time sensitive information to the commander in the same manner as other war fighting divisions of the AOC.

The air commander exercises "operational art" through his strategic vision designed to defeat the enemy's centre of gravity (C of G), which he articulates through the air campaign.[2]

<table>
<tr><td colspan="4">AOC Director</td></tr>
<tr><td colspan="4">Core Teams</td></tr>
<tr><td>Strategy Div</td><td>Combat Plans Div</td><td>Combat Ops Div</td><td>Air Mobility Div</td></tr>
<tr><td colspan="4">Specialty Teams (ISR)</td></tr>
<tr><td colspan="4">Support Teams</td></tr>
</table>

Figure 1 – AOC Structure[1]

The "art" aspect of this action is achieved through the assessment of strategic outcomes determined from an accurate picture of the effects his air operations are having against the enemy's C of G. Achieving this accurate picture is the role of ISR, which explains its rise in prominence during recent operations in the Balkans.

A Return to the Days of Napoleon

In addition to ensuring defeat of the enemy's C of G, a Commander must remain cognizant of his own C of G and how best to protect it. During operation Deliberate Force, Lieutenant-General Michael Ryan quickly identified his C of G as coalition unity and public opinion. He determined that protecting his C of G meant ensuring limited collateral damage and ensuring the legitimacy of every target identified for attack. This led him to take the unusual position of personally selecting targets for the Guidance Apportionment and Targeting process within the Combat Plans Division. Such action on the part of a commander was a return to the 18th century Napoleonic Model of war in which the commander personally directed operations. In Napoleon's day, one individual could manage and command such battles, assuming he had the experience and genius to miss few details, anticipate events at least better than his counterpart in the opposing army, and exploit the rudimentary command and control systems of the time.[3] Achieving the necessary level of detail needed for this form of command depended heavily on the commander's ability to access timely information. Following the Napoleonic era, the complexity of battle and the inability to quantitatively analyze information inputs, drove commanders to a decentralized command and control structure first introduced by the Prussians as the Moltkian Model. The Prussians called this system wherein senior commanders issued broad orders to subordinates who were responsible for and capable of acting with independent initiative *Auftragstaktik*.[4] This decentralized system worked extremely well in general war where the consequence of error were unlikely to have the devastating effect on operations possible in today's constrained operational environment.

An example of constraining effect can be found in Operation Allied Force as the campaign's focus turned from attacks on fielded forces to that of Serbian domestic infrastructure. As Lieutenant-General Michael Short noted following the accidental strike on the Chinese Emabassy: "We were restricted by enormous concern for collateral damage and unintended loss of civilian life". During the last days of the campaign, "that was the litmus that we used to pick a target."[5] Once again, decentralized control gave way to centralization as an apparent error in targeting focused the mind of the commander on specific target generation.

Air commanders are increasingly being required to return to the hands-on direction of battles reminiscent of Napoleon in order to ensure complete scrutiny of every target. Modern commanders must exhibit a level of operational oversight that allows few details to be missed. This need for refinement is only possible with real-time, systematically filtered information that is known to be beyond reproach. Achieving this level of fidelity can only occur at the hands of specialized staffs, working as an integrated team, who are able to reach across the spectrum of sensors arrayed over the battle-space and access information vital to the commander's decision making process. Without a cohesive ISR team, serving not as specialist advisors but as a homogeneous AOC unit, commanders will once again be forced to adopt the Moltkian style command and control structure with its potential consequences.

CONCLUSION

Information has always been an important commodity for the commander and one that has often seemed illusive. Making decisions with imperfect information is seen as the test of true command genius. But modern warfare is not a test that any commander wishes to fail. As General Michael Ryan, the current Chief of the United States Air Force, recently observed: "[There is a] necessity to keep information flowing at lightening speed to everyone who needs it". He went on to note that command and control, as well as intelligence, surveillance, and reconnaissance capabilities of the force, is "something we have to pay a lot of attention to."[6] Flowing accurate and timely information to the commander can only be achieved by dedicated professionals capable of synthesizing multi-source inputs into a coherent intelligence picture from which the commander can make decision crucial to operational outcomes.

While the current AOC construct has managed well with ISR as a specialty function positioned principally in an advisory capacity, the nature of modern operations other than total war demand greater responsibility within the AOC structure. Information provided by the ISR team will increasingly become the centre-piece of AOC activities. Consequently, ISR must be raised to a core level to give it the prominence required for Napoleonic decision making by the modern air commander.

Endnotes

1. JAOC Jumpstart Version 1.0, USAF C2 Warrior School, Hurburt Field, Fl.

2. Owen, Col Robert C. *Deliberate Force, A Case Study in Effective Air Campaiging* Air University Press, Maxwell AFB, January 2000, P69.

3. *Ibid*, p. 352.

4. *Ibid*, p. 354.

5. Tirpak, John A. "Short's View of the Air Campaign," *Air Force*, www.afa.org/magazine/watch/0999watch.html.

6. Tirpak, John A. "Lessons Learned and Re-Learned," *Air Force*, www.afa.org/magazine/watch/0899watch.html

The Revolution in Military Affairs: Is the Emperor Ready for His New Clothes?

Robert Martyn

INTRODUCTION

A quick perusal of any current military journal will provide bewildering array of technological marvels. It would do James Bond's R&D man proud (read "Buck Rogers" or "Power Rangers" depending upon your generation). The Revolution in Military Affairs (RMA) brings its own jargon, acronyms, and perhaps the occasional snake-oil salesmen that accompany most miracle cures. Recent advances and posited future capabilities undoubtedly leave one awestruck. Yet something seems missing from most RMA discussions, including those occurring at this 2001 Air Symposium. It is easy to get caught up in technology and its astonishing promise, to the detriment of the people, their organization and employment. This sidebar observation to the symposium proceedings will therefore attempt to illuminate some of these "missing" elements.

There are a number of "givens" as the start-state of this message. Canada is, and will remain, a close military, economic, and diplomatic partner of the United States for the foreseeable future. There is no doubt that the Americans are among a very limited number of countries at the leading edge of technology. The advances in requisite supporting operational concepts, or empowering lower-levels of command to exploit these advances, remains subject to debate. Yet, if Canada wishes to operate as a high-ranking partner in any US-led coalition, we are obligated to move in tandem with American progress. At the most basic level, this would require technologically compatible aircraft, troops, and ships. This, of course, presupposes that, a) Canada will continue to deploy as part of multinational coalitions, and b) if the US participates, it leads. I cannot imagine strenuous argument against these premises. This does, however, produce a number of questions that need to be addressed in the course of the RMA debate. The reality remains that the US is leading in the technological aspects of the RMA. I purposely specified the *technological* because RMA requires more than mere scientific, technical, or industrial advances. As cited in the VCDS's on-line RMA primer, the tank did not create a blitzkrieg revolution. Rather, it required a driving technology (large armour formations with tanks and personnel transport of equivalent mobility and protection), in concert with "supporting technologies (i.e., radios), organizational changes (combined arms formations and tactical air support), new operational concepts (air superiority and deep, knife-like thrusts), and command changes (mission oriented tactics)."[1] To provide a semblance of a framework for the comments here, I will explain my arguments and concerns within the VCDS outline of necessary RMA conditions.

DRIVING TECHNOLOGY

Computers and digital connectivity instigated today's revolution. But, has the driving technology come to fruition? Is Canada willing to make the investment? Arguably, future trends in intelligence, surveillance and reconnaissance (ISR) were made abundantly clear, often via CNN, during the Gulf War. The capability to identify targets and conduct precision deep-strike with almost simultaneous battle-damage assessment was presented to media audiences and potential adversaries alike. Putative foes considering lessons from this conflict will likely move in two opposite directions. One, a technically advanced and economically sound enemy (for the RMA is not going to come cheap), may attempt to match scientific advances – a digital arms race. This creates a prospective situation wherein technological benefit is offset by an equally advanced countermeasure, or else simply nullified by an opponent possessing similar capability to use against our forces. Conversely, a prospective belligerent may choose to strike using asymmetrical means.

Asymmetrical attack refers, in this simplified instance, to not conducting aircraft on aircraft battles. Rather, more subtle strategies are employed. Our deployment of a combined-arms brigade, supported by fighter-ground attack aircraft and an offshore naval blockade is met with assassinations or terrorist attacks with biological weapons in our domestic capital.[2] In some circumstances, having the most technologically advanced military may provide little practical value. During the Gulf War, for example, A-10s comprised only 140 of 1,800 fighter aircraft in theatre, yet accounted for almost 70 percent of the tanks claimed by the Air Force. In contrast, the $28 billion (US!) worth of B-1B bombers sat grounded, unserviceable, while almost 40 year old B-52s conducted the bombing offensive.[3]

The air symposium was not dedicated, however, to war fighting *per se*, but specifically to the aspects of intelligence, surveillance, and reconnaissance. As such, the key RMA aspects are those dedicated to finding and fixing an enemy. Determining the utility of newly developed surveillance and reconnaissance systems in asymmetric warfare situations is consequently a high priority.

For the Air Force, major systems in this field are generally defined as a specific intelligence-supporting aircraft, such as JSTARS, or the recently famous (among China-watchers), EP-3. Below the level of dedicated, role-specific aircraft are the capabilities provided by systems, such as the various imagery pods, which can be fitted to a non-surveillance aircraft. This option tends to be a less expensive and more flexible option, but comes with its own set of negative side effects. For example, an *AN/AAS-38B* FLIR pod will increase the CF-18's capability by expanding the operating parameters and mission types. It is planned to augment these FLIR pods with *Nighthawk/Lightning* pods, which include greater image magnification and a laser designation function, thus making a more formidable ISR platform.[4] While these improvements are laudable, they produce a very real risk that increased specialization will come at the expense of withdrawing aircraft thus fitted from their primary war-fighting role, either air-to-air or bombing. In Kosovo, aircraft returning from bombing sorties would be diverted to investigate air activity in Serbian airspace.[5] The Canadian Air Force provided added value to the force package because it retained this multi-role capability. Will emphasizing an ISR role, to the exclusion of more expensive, ordinance-carrying missions, cost us this flexibility? Kosovo also pointed out the clear differences in skill sets between senior and junior CF-18 pilots, given budget-driven training cutbacks.[6] Increasing ISR skills will likely come at the cost of further diminished, basic war-fighting competence.

A popular expression posits "information is the ultimate high ground." If one accepts this saying's veracity, then it begs the question, is the Air Force willing to forego aircrew in favour of *Global Hawk*-type UAVs or even *Radarsat*-type satellite systems? But even that is not a simple either/or problem. While both systems have certain advantages in acquiring information, they lack any deterrence value. Feints and demonstrations will always have military utility, to say nothing of the capability to destroy the enemy if necessary. Thus we return to the requirement to balance the shrinking number of aircraft with the expanding roles and missions being demanded.

SUPPORTING TECHNOLOGY

The supporting technology to exploit the ISR RMA is rapidly becoming available. The communications and analytical software to maximize information provided is increasingly appearing through civilian business ventures. Naturally, commercial-off-the-shelf (COTS) systems bring their own inherent concerns. That COTS providers are outside of direct government control creates a potentially tenuous situation. Anyone with unquestioning faith in Alternate Service Delivery need only recall the catastrophic results of French dependency on an intermittent, contracted air cargo service at Dien Bien Phu in 1954.[7]

A related problem, which is recurring theme in any discussion of Canadian Forces wide issues, is the problem of "rice bowls." Effective RMA demands seamless interoperability. There can be no dotted line dividing mud, coast and sky. The information acquired through these technological advances must pass quickly from sensor to analysis to those capable of acting upon the intelligence. The stated goal of sensor-to-shooter is unlikely achievable, except in the lowest tactical scenario, given political constraints in the form of positive confirmation of hostile activity in most Rules of Engagement. So, despite the present inevitability of some degree of assessment, we must still get the information in a usable format to the shooter in minimal time. The army has been fielding a Tactical Command, Control and Communications System (TCCCS – fittingly pronounced "Ticks," as in "bugs") since the early 1980s.[8] As of mid-2001, not all field units have received it. There remain many difficulties in its advertised capabilities of encrypted frequency agility and data transmission. I mention this within an air force symposium context due to the "rice bowl" factor. This army system is not interoperable with any communications systems in the Canadian air force or navy, or any of our NATO allies' services. While electronic connectivity is a *sine qua non* of battlespace dominance, the number of non-compatible systems continues to grow.[9] Work is clearly required before we cast aside our present system in favour of the RMA's promises.

ORGANIZATIONAL CHANGE

The overarching reality of budgetary constraint influences all Canadian Forces discussions. Simply put, current resources preclude maintaining our "second wave" military while creating a "third wave" force.[10] Does this argue for creating a niche military? That is, having accepted that our navy cannot patrol the northern one-third of our coastline, or that the army is out of the paratrooper business, can the air force just hang out a shingle saying "aerial reconnaissance only"? Is this not in keeping with the government's Soft Power approach of emphasizing moral suasion within "temporary 'coalitions of the like-minded.'"?[11] The Air Force has acquired and discontinued operational roles in the past. Dedicating our fighter aircraft to surveillance would likely be more politically palatable than the earlier CF-104 nuclear strike role. Hopefully, any government pondering such a niche option would also consider the full ramifications of limiting the scope of available responses by disarming the air force.

Another organizational change in the effective employment of ISR technologies would be a requisite flattening of the present hierarchical command structure. Technology, in the form of Multi-functional Information Distribution System (MIDS), can theoretically provide the same real-time information and target imagery to the pilot in the cockpit as to Air Command's Operations Centre.[12] How many redundant levels of command can this eliminate? How much time is lost, thus degrading time-sensitive intelligence on mobile targets, by repetitive planning as the information moves through multiple headquarters' staffs? Some may challenge this premise, saying that planning is already decentralized, thus eliminating the problem. Nonetheless, there was an overwhelming majority of air force officers at the symposium holding at least the impression that the reins continue being held quite tightly at higher headquarters. Whether this is reality or just a faulty but widespread sensitivity, this hierarchic structure negates many ISR advantages promised by the RMA.

NEW OPERATING CONCEPTS

Closely related to the layering of command, is the time-honoured disconnect between different coloured headquarters; "light blue" and "brown" simply do not fight the same battle. This basic conceptual difference is not new, nor is it likely to change given the conditions of human nature. Prior to World War I, America's only six-star general, "Black Jack" Pershing, saw aircraft as merely an "excellent and efficient means of getting oats to the horses."[13] Flyers naturally saw their role much differently. Yet almost ninety years later, there remains disagreement on aviation's most effective employment. In the Balkans for example, AFSOUTH, through 5 Allied Tactical Air Force, decreed the anti-air threat necessitated aircraft staying above 18,000 feet. Further, Air Force information requirements took precedence over requests coming from soldiers actually in-country. Consequently, air reconnaissance missions targeted surface-to-air sites or ammunition dumps in support of contingency planning potential future strikes, rather than seek out belligerent factions surrounding UN camps. Tactical Air Reconnaissance remained non-responsive to the UNPROFOR Commander's needs.[14]

This UN example also illustrates the relevance of what type of "war" the air force intends to fight. With rapidly increasing global urbanization, US Marine Corps' Commandant General Krulak describes future warfare in the context of a "three block war."[15] The scenario envisages the requirement to provide humanitarian assistance on one block, conduct traditional peacekeeping operations on a second, while fighting a vicious conventional battle in a third part of the city. Many writers are positing this as warfare's future, in which Sarajevo, Grozny and Mogadishu are the norm.[16] Although the "weapon system" of choice in urban conflict is the lone sniper, a symposium participant asserted that ISR requirements could nevertheless be met by properly equipped CF-18s. This proposition, dubious in itself, was not so troubling as the uniform agreement within the auditorium.

Regrettably, solutions remain elusive since service participants in all facets of the RMA debate are likely to see their way as the "obvious" way out. The air force, despite truly admirable technical advances, has not yet developed a stand-alone war-winning capability. Joint operations must be supported enthusiastically by all of the services. Syndicate discussion during the conference posited that the army and navy would be the chief beneficiaries of ISR; therefore, they should willingly eliminate artillery, tanks, or frigates to fund air force acquisitions. During discussions concentrating on an air-reconnaissance niche, it was pointed out that discerning targets without controlling assets to strike those targets was a logically ineffective. Yet, having the army mothball their warfighting equipment so that the air force could fund target acquisition technology, supposedly for the army's benefit, did not elicit a similar response. That no one came forward to offer any of their service's assets suggests "rice bowls" will remain a key issue to be resolved.

Despite the best efforts of our strategic and doctrinal theorists, militaries tend to fight in accordance with their "corporate culture."[17] This common perception tends to be bred in wartime, thus any modification is more likely to result from operational experience, than what appears in the latest doctrine-writers' tome. Therefore, despite much ink being spilled on RMA, the Air Force is apt to continue operating with attitudes acquired flying out of Doha and Aviano.

COMMAND CHANGES

So if written doctrine cannot be depended upon to guide operations, we must turn to our command structures if we hope to influence the way future operations are conducted. Perhaps this is the weakest link in the RMA discussions; theorists tend to focus on the technology and machines, to the exclusion, or at best, minimization of personnel factors. At a generalized level, a physically fit commander who presents a calm demeanor in adversity will naturally garner respect. A distant, dismissive commander, or one unable to accept bad news will critically undermine operations. The capability of quickly grasping fundamental details, visualizing the information requirements, and responding effectively is critical to the leadership process. But is this how commander's are presently selected? Two Canadian Defence Scientists, Carol McCann and Ross Pigeau, have done stalwart work in creating a useful analytical model to assess command abilities (see Figure 1).[18] Their model's three-axis Command Capability Space illustrates where commensurate levels of competency, authority and responsibility produce a Balanced Command Envelope. These three factors end up "merely amplifying inadequacy or mediocrity and thus becoming a force divider and minimizer."[19] This is the crux of the competency issue. The military must put unprecedented effort into developing and promoting commanders, with both technical and personnel skills, who can think in flexible terms within physically and intellectually demanding situations.

Commanders, however, are not the only ones adapting to present and forecast changes. The personnel being led are also evolving, which will further complicate the command organization. It is generally assumed that the air force requires, and attracts, the lion's share of technically astute Non-Commissioned Members (NCM). While this facilitates the introduction of increasingly complex systems, it also suggests squadron or wing organizations transition to a work environment capable of maximizing the NCM strengths. NCMs constitute approximately 40 percent of those seeking degrees through Royal Military College of Canada's Continuing Studies Program, with additional people utilizing the University of Manitoba's CF Program or local universities.[20] As the NCM education level and technical competencies increase, and they acquire additional functions, the current leader/led, officer/NCM schema will become skewed, creating further dissonance for those unable to adapt to the RMA-generated conditions.

CONCLUSIONS

In the end, there remain several hurdles to overcome before Canada can deploy a third wave military. One key aspect is the elusive matter of timing and technology fruition. In the late 1920s Italy had the most advanced air force in Europe, if not the world. Yet by 1940 it was catastrophically outdated. It will take a wise staff to judge when the CF budget, technology and the international situation align for the most judicious investments. Nor does this technology discussion even begin to consider such diverse factors as alliance commitments or regional development spinoffs. The issue is basically "how much bang do we need for our buck"?

As noted by Lester Grau, in his article "Bashing the Laser Range Finder with a Rock," the ultimate weapon or weapon system has not been and probably will not be invented.[21] For every technological advance, a counter is developed. War and preparation for it are dialectical processes involving actions and counteractions between contesting sides. A herd of sheep can effectively clear an antipersonnel minefield. Increasingly sophisticated dummies and mock-ups can draw precision-guided munitions. In the real-world situation of time-compressed and sleep-deprived operations, deceptive craters can still be painted on functional runways. I4.9-upat.9-upr
ds aomprlteny snaee y shea ths
mechnological acloting ts atill bi the rtailr

3. Col. (ret'd) David Hackworth, "The Lessons of the Gulf War," *Newsweek,* 24 June 1991, pp. 22-23.

4. Discussion with LCol (ret'd) Vance Millar, NDHQ/DAR 5-4 (CF-18 Weapons), 30 May 2001.

5. LCol David Bashow, et al, *Mission Ready: Canada's Role in the Kosovo Air Campaign,"* Canadian Military Journal, vol. 1, no. 1, (2000), p. 57.

6. *Ibid*., p. 57.

7. The American/French crews occasionally refused to fly for several days. Bernard Fall, *Hell in a Very Small Place,* NY: JB Lippincott, 1967, p. 169, 241. This work remains a classic on this issue. Frédéric Lert, *Wings of the CIA*. Paris: Histoire & Collections, 1998, pp. 55-56, 58.

8. See www.dnd.ca/commelec/nwslettr/vol40/tcccs_e.htm.

9. Roger Beaumont, "the Paradoxes of C3," *Military Leadership*. James Buck and Lawrence Korb, eds. (London: Sage, 1981), p. 127.

10. For "wave" parameters, see Alvin Toffler and Heidi Toffler, *War and Anti-War: Making Sense of Global Chaos*. NY: Warner Books, 1993.

11. Dean Oliver, "Soft Power and Canadian Defence," Strategic Datalink #76. Toronto: Canadian Institute of Strategic Studies, 1999. See also Joseph Jockel, *The Canadian Forces: Hard Choices, Soft Power*. Toronto: Canadian Institute of Strategic Studies, 1999.

12. Discussion with LCol (ret'd) Vance Millar, NDHQ/DAR 5-4 (CF-18 Weapons), 30 May 2001.

13. Cited in BGen Robert Stewart, "New Technology: Another Way to Get Oats to the Horses?" *Army,* vol. 45, no. 1 (1995), p. 26.

14. Author's experience, and discussion with 5 ATAF Intelligence personnel.

15. General Charles Krulak, "The Three Block War: Fighting in Urban Areas," presented at the National Press Club (Washington DC), 10 October 1997. *Vital Speeches of the Day,* 15 Dec 97, p. 139.

16. Three better works in this area are: Samuel Huntington, *The Clash of Civilizations: Remaking the World Order*. NY: Simon & Schuster, 1998; Robert Kaplan, *The Coming Anarchy: Shattering the Dreams of the Post Cold War*. NY: Random House, 2000; or more specifically militarily, Ralph Peters, *Fighting for the Future: Will America Triumph?* Mechanicsburg, PA: Stackpole Books, 1999.

17. Paul Johnston, "Doctrine is Not Enough: The Effect of Doctrine on the Behavior of Armies," *Parameters,* vol. 30, no. 3 (2000), pp. 30-39.

18. Ross Pigeau and Carol McCann, "What is a Commander?" Unpublished paper prepared for "The Human in Command" Workshop, (5-8 June 2000, Breda, The Netherlands), pp. 4-8, 11.

19. Roger Beaumont, "The Paradoxes of C3." *Military Leadership*. James Buck and Lawrence Korb, eds. (London: Sage, 1981), p. 131.

20. Camile Tkacz, "Canadian Forces Non-Commissioned Members Professional Development System," *Backbone of the Army: Non-Commissioned Officers in the Future Army*. Douglas Bland, ed., Kingston: McGill-Queen's Press, 2000, p. 107.

21. Lt Col (ret'd) Lester W. Grau, "Bashing the Laser Range Finder With a Rock," *Military Review,* vol. 77, no. 3 (1997), pp. 1-8.