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AEROSPACE Electronic Warfare Doctrine



PREFACE

This manual provides electronic warfare (EW) doctrine for Canada's Air Force. This manual has been designed for use by the following:

- a. Canadian Forces (CF) schools and academies training, indoctrinating and developing personnel in EW;
- b. CF aerospace units and headquarters; and,
- c. Other CF elements working with, or supporting, aerospace EW capabilities.

This manual is presented in two chapters:

- a. Chapter 1 Aerospace Electronic Warfare Doctrine: Today; and
- b. Chapter 2 Aerospace Electronic Warfare Doctrine: Tomorrow.

The manual is to be used in conjunction with:

- a. B-GA-400-000/FP-000, Canadian Forces Aerospace Doctrine; and
- b. The series of B-GA-400 keystone aerospace doctrine manuals.

Recommendations for amendments to this publication are welcome and should be forwarded to the Canadian Forces Aerospace Warfare Centre, attention: Doctrine Development Branch.

The Commander 2 Canadian Air Division is the ratification authority for this doctrine.

KEYNDTES

These keynotes are the fundamental beliefs upon which this doctrine publication is built.

- 8 Control of selected portions of the electromagnetic spectrum (EMS) is critical for enabling communications, ensuring weapon systems effectiveness, and protection of air assets.
- In order to satisfy Defence missions, the Air Force requires the capability to operate effectively today and have the capacity to do so into the future. This necessitates EW sovereignty, or the authority and mechanisms required to respond to mission exigencies in a timely manner.
- 8 Felectronic warfare is any military action to exploit the EMS. Electronic warfare is a force multiplier that operates on multiple levels of a conflict, from self-protection to operational attack plans. When EW actions are properly integrated with other military operations, a synergistic effect is achieved, losses are minimized, and effectiveness is enhanced.
- 8 → Air Force decision making is supported by personnel from a wide variety of disciplines and areas of responsibility.
- Electronic warfare impacts personnel in many disciplines, including flight operations, air weapons, communications, intelligence, maintenance, security, and other operations and support activities.
- 8 Electronic warfare is an integral element in the successful execution of all Air Force functions, capabilities, roles, missions, and tasks.
- 8 Electronic warfare capabilities (equipment—hardware and software, and operating procedures) are mission and threat dependent requiring continuous assessment. Mission readiness is achieved through a comprehensive threat review and follow on preparation of a platform and systems maintenance cycle.
- 8 Air Force EW capabilities are implemented through a collaborative effort within the Air Force, the Department of National Defence (DND) / CF and between them and Canada's coalition partners and allies. External collaboration requires both informal and formal knowledge sharing agreements.
- Electronic warfare is a fundamental consideration to both force generation and force employment of Air Force capabilities.
- **9** An understanding of EW principles and applications is a fundamental requirement for Air Force decision making at all levels of command.

8 As the Air Force develops and becomes reliant upon a network-centric warfare (NCW) approach, the usage and reliance on a broader range of the EMS will emerge. Therefore, EW elements, electronic warfare support (ES), electronic protection (EP), and electronic attack (EA), across the broader EMS will become essential NCW considerations. And as such, those agencies external to DND who control and regulate the usage of the broader EMS will need to be included in the collaborative effort to implement Air Force EW activities.

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SECTION I – BACKGROUND STRATEGIC CONTEXT: CONNECTING THE DOTS / POLICY TO DOCTRINE

In order to establish where and how EW fits into CF aerospace activities, it is necessary to consider the strategic context, beginning with Canadian Defence policy.

The *Canada First Defence Strategy* identifies three roles for the CF: defending Canada, defending North America, and, contributing to international peace and security. And while these roles have been expressed this way by the current government, their essence has been, and always will be, fundamental to the CF: defence of the homeland, regional defence with our neighbours, and participation in operations abroad at the behest of the government of the day.

Defending Canada requires the CF to be aware of anything going on in or approaching our territory, providing surveillance of air, maritime, and space approaches. Defending North America requires the CF to have joint and combined interoperability. Moreover, contributing to international peace and security requires the CF to maintain combat-capable units with the right mix of equipment so they can function on their own or with allies in the continuum of operations.¹

The *Canada First Defence Strategy* articulates the six core missions addressing the continued reality of the potential for regional tensions to escalate into conflict and natural disasters to turn into humanitarian crises. Thus, Canada requires a military with the flexibility to respond to such challenges while continuing to carry out essential day-to-day missions. As such, the government has directed that the CF maintain the ability to respond to the following missions, potentially concurrently:

- a. conduct daily domestic and continental operations, including in the Arctic and through North American Aerospace Defence Command (NORAD);
- b. support a major international event in Canada;
- c. respond to a major terrorist attack;
- d. support civilian authorities during a crisis in Canada such as a natural disaster;
- e. lead and/or conduct a major international operation for an extended period; and
- f. deploy forces in response to crises elsewhere in the world for shorter periods. $^{2}\,$

National Defence and the Canadian Forces, *Canada First Defence Strategy*, http://www.forces.gc.ca/site/pri/first-premier/ June18_0910_CFDS_english_low-res.pdf (accessed February 1, 2011).
Ibid., 3.

To accomplish these missions, the government recognizes the need for the CF to be fully integrated, flexible, multi-role and combat capable. The means to achieve this capacity is articulated as four pillars that form the foundation of military capability: personnel, equipment, readiness, and infrastructure. The personnel pillar acknowledges the requirement to provide world-class technical training and advanced education, and the continued development of a knowledge-based workforce. The equipment pillar acknowledges the requirement to strengthen Canada's multi-role, combat-capable force, providing the right tools and equipment to get the job done to be a modern, flexible, and interoperable force capable of defending Canada and Canadian interests well into the future. The readiness pillar acknowledges the requirement for the resources to maintain equipment, conduct training, and prepare units for operations. The infrastructure pillar acknowledges the requirement for the facilities needed to support operational requirements.³ Draft CF EW policy, and by extension Air Force EW policy and Aerospace EW doctrine, are nested within and supportive of these essential elements of Defence policy.

Since the advent of radar, modern militaries have placed an increasing reliance on expanding their knowledge and use of the EMS as the medium of exploitation to permit their forces to achieve and maintain the initiative. Implicit in CF and Air Force EW policy statements is the EW tenet of control. Control of selected portions of the EMS is critical for enabling communications, and for ensuring weapon systems effectiveness and protection of air assets. Direct or indirect control of the EMS permits the Air Force to exercise initiative in exploiting the EMS to an advantage, while protecting the force from exploitation by adversaries, thus enhancing the ability to successfully accomplish Air Force roles and missions. Electronic warfare is the means with which aerospace forces seek to dominate this medium.



"Progressively it, EW, has emerged from a shadowy and highly specialised world into the mainstream of current operations. It is all but impossible to imagine an operation today, from Crisis Response Operations to high intensity conflict, where EW does not have a major, even critical role. From warnings and indicators, through force, area and platform protection to decisive electronic attack, EW is central."⁴

In describing the strategic environment in which the CF must operate, the *Canada First Defence Strategy* acknowledges the proliferation of legacy and advanced weapons, the potential emergence of new adversarial states, and the ongoing build-up of conventional forces around the globe.⁵ It is within this context that Air Force EW policy and Aerospace EW doctrine is articulated to express the requirement for the capability to operate effectively today and the capacity to operate effectively into the future. This necessitates EW sovereignty, or the authority and mechanisms required to respond to mission exigencies in a timely manner. It follows that a fundamental requirement that would permit the Air Force and DND/CF to respond is a thorough knowledge and understanding of the EW environment and the ability to validate, verify, and reprogram, when and where required, the capabilities of the systems needed to operate within that environment.

CANADIAN FORCES ELECTRONIC WARFARE POLICY

This document establishes the policy for development, generation, and employment of EW capability by the CF and supports the CF Information Operations Policy. It establishes the roles and responsibilities of various CF organizations implicated for all aspects of CF EW.⁶

The policy defines EW as:

- a. Military action to exploit the electromagnetic spectrum encompassing interception and identification of electromagnetic emissions, the employment of electromagnetic energy and directed energy to reduce or prevent hostile use of the electromagnetic spectrum, and actions to ensure its effective use by friendly forces. The subcomponents of EW are:
 - (1) **Electronic Warfare Support (ES).** The division of EW involving actions tasked by or under direct control of an operational commander to search for, intercept, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic energy for the purpose of immediate threat recognition, targeting, planning and conduct of future operations. Note: ES provides information required for decisions involving EW operations and other tactical actions

⁴ AJP-3.6(A) Allied Joint Electronic Warfare Doctrine, December 2003, ix.

⁵ Canada First Defence Strategy, 6.

⁶ NDHQ Policy Directive P21, 27 Jan 1977, Canadian Forces (CF) Electronic Warfare Policy, ratification draft, 4 May 07, 1.

such as threat avoidance, targeting and homing. ES data can be used to produce signals intelligence (SIGINT), providing targeting for electronic or destructive attack, and produce measurement and signature intelligence (MASINT).

- (2) **Electronic Protection (EP).** The division of EW involving passive and active means taken to protect personnel, facilities, and equipment from any effects of friendly or enemy employment of EW that degrade, neutralize, or destroy friendly combat capability.
- (3) **Electronic Attack (EA).** The division of EW involving the use of electromagnetic energy, directed energy, or anti-radiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability. Note: EA includes actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum, such as jamming and electromagnetic deception, and employment of weapons that use either electromagnetic or directed energy as their primary destructive mechanism (lasers, radio frequency weapons, particle beams).⁷

Electronic warfare focuses on the EMS or the medium, and identifies measures taken to exploit and protect it, as a critical element of CF operations. Thus far doctrinally, EW has resided within the context of information operations (IO). The IO is defined as actions taken that influence decision makers through the exploitation and protection of information and/or information systems. The IO has two major components: defensive IO and offensive IO. The CF IO policy defines defensive IO as including actions to protect one's information and that of one's allies, and to ensure friendly decision makers have timely access to necessary, relevant, and accurate information. It defines offensive IO as actions taken to influence an adversary's decision makers by affecting an adversary's use of or access to information and information systems.⁸

Since IO focuses on the ends (information and information systems), and EW, like psychological operations and deception operations, focuses on the means (the EMS), EW is an element of IO. Electronic warfare contributes to the success of IO by using offensive and defensive tactics and techniques in a variety of combinations to shape, disrupt, and exploit adversarial use of the EMS while protecting the use of the EMS. However, the integral role of EW in the application of combat power and the protection of those platforms so engaged goes beyond the bounds of IO and is a fundamental element of all of the Air Force functions.

"[Electronic Warfare] is any military action used to exploit the EMS. [Electronic Warfare] is a force multiplier that operates on multiple levels of a conflict, from selfprotection to operational attack plans. When EW actions are properly integrated

7 Ibid., 1.

8 B-GG-005-004/AF-010, CF Information Operations, 15 Apr 98.

with other military operations, a synergistic effect is achieved, losses minimized, and effectiveness enhanced."⁹ This quotation, taken from United States Air Force (USAF) EW doctrine, is consistent with their extensive capability. The USAF plans for and executes a wide range of EW missions across all three elements of EW. Historically, the EW context for the Canadian Air Force has, out of necessity, focused largely on EW self-protection measures, EP. These measures enable or contribute to mission success. Clearly, as Air Force EW capabilities expand with the addition of new platforms and technologies that include ES and EA capabilities, there will be a requirement to establish ways and means of planning and executing EW missions in a joint and combined process that is compatible with Canada's allies and partners. Accordingly, EW doctrine will expand to include those ways and means.

AIR FORCE ELECTRONIC WARFARE POLICY

Air Force EW policy is subordinate to CF EW policy and tasks Canada's Air Force to develop and generate coherent ES, EP, and EA capabilities to meet Air Force operational requirements.¹⁰

Air Force decision making is supported by personnel from a wide variety of disciplines and areas of responsibility. As Air Force EW policy articulates, development and generation of coherent Air Force EW capabilities is a shared responsibility across many departmental and CF organizations, including 1 Canadian Air Division and 2 Canadian Air Division staffs and subordinate units. Air Force EW policy delineates the roles and responsibilities of these organizations. A primary mission of the Canadian Forces Aerospace Warfare Centre (CFAWC) is the development of operational-level aerospace doctrine. In this context, describing how the Air Force satisfies EW policy direction. For tactical-level EW doctrine, the development and writing is done by the various capability groups, but CFAWC is the coordinating agency and entity that staffs such doctrine through the Aerospace Doctrine Committee for ratification by the Aerospace Doctrine Authority. Electronic warfare impacts personnel in many disciplines, including flight operations, air weapons, communications, intelligence, maintenance, security, and other operations and support activities.

This handbook will provide guidance for the process of developing a relevant EW capability, recognizing that the governance structures required that effectively satisfy this requirement demand a collaborative network approach as opposed to a single command hierarchy.

As described in the B-GA-400-000/FP-000, *CF Aerospace Doctrine*, the Air Force functions are structured along the CF functional domains of Command, Act, Sense, Sustain, Shield, and Generate. A weakness in, or failure of one function will negatively impact not only the other five functions, but also the force's ability

⁹ Air Force Doctrine Document (AFDD) 2-5.1, 5 Nov 02.

¹⁰ Canadian Air Force Electronic Warfare Policy, 11 Mar 08, 2.

to achieve the desired end state. Electronic warfare is an integral element in the successful execution of all Air Force functions, capabilities, roles, missions, and tasks. As such, Aerospace EW doctrine will address those EW aspects that are pertinent to each function in terms that are relevant for each function within the keystone doctrine handbook, respectively. This handbook provides a single source document for Aerospace EW doctrine in terms of an operational process.



SECTION II – ELECTRONIC WARFARE DOCTRINE: THE BIG PICTURE CURRENT STATE

The policy describes the roles and responsibilities of the organizations responsible for Air Force EW. It answers the question: what is to be done and by whom is it to be done? In order to understand how Air Force EW policy is satisfied, it is necessary to start at the end: what is the current state? From there, how does the Air Force ensure that the current state remains relevant?

As described previously, the first priority for the Air Force is the defence of Canada. In order to defend Canada we must be aware of anything going on in or approaching our territory by providing surveillance of Canadian land, space, air, and maritime approaches. Awareness and surveillance is the realm of intelligence, surveillance and reconnaissance (ISR). Through ES, EW provides a means to contribute to the Sense function.

The second priority for the Air Force is the defence of North America. To be interoperable with our neighbours and partners in the NORAD agreement, Canada requires compatible systems capable of finding and dealing with incursions into North American air and maritime approaches. There are elements of ISR and ES in maintaining the capability to find incursions. There are elements of both EA and EP in having the capability to deal with these incursions.

The third priority for the Air Force is contributing to international peace and security. This mandate encompasses operations across the spectrum of conflict, from peacetime military support, to major combat operations, to war. As Defence policy acknowledges, the potential for conflict to change or escalate requires that the Air Force maintains the capability to operate effectively across the full spectrum of conflict, ensuring the ability to exploit the EMS and deny the adversary the ability to do the same. Because of the broad range of potential scenarios it is difficult to accurately predict the specific force mix that would be required. Conceptually, the Air Force could be tasked to employ any combination of its range of capabilities, from unmanned aerial systems (UAS), to rotary-wing, to fixed-wing aircraft, to space-based systems. As such, all Air Force platforms must be capable of operating throughout the EMS, in a joint and/or combined context. This represents a broad range of capabilities across the three subcomponents of EW: ES, EA, and EP. **Force generation (FG): Personnel.** To prepare our personnel,¹¹ the Air Force formally educates and trains its officers and non-commissioned members (NCMs) in the theory and practice of EW concepts and technology, as well as aircraft fleet specific tactics, techniques and procedures (TTP). The Canadian Forces School of Aerospace Studies (CFSAS) provides EW professional development while CFAWC is responsible for coordinating EW specialty training. Aircraft fleet specific TTPs are the responsibility of the various operational training units (OTUs) and operational squadrons. Air Force EW flying training is accomplished through a variety of Air Force, joint, and combined exercises and training opportunities.

FG: Equipment. To equip our personnel, the Air Force has incorporated ES, EP, and EA systems on-board several aircraft fleets. ES systems include radio frequency (RF), electro-optical (EO), and infrared (IR) sensors on-board fighter and longrange patrol aircraft, maritime and tactical aviation helicopters, and UASs. The EP/ EA systems have been incorporated in most rotary- and fixed-wing aircraft. These systems include defensive EW suites (DEWS) that may employ a mixture of RF and EO/IR receivers and countermeasures to conduct EP and protect personnel, facilities, and equipment from any effects of friendly or enemy employment of EW. Additionally, these systems may also conduct defensive EA using chaff, flares, and on-board EO/RF jammers to protect against adversary attacks through the denial of the EMS to effectively guide and/or trigger weapons, thus enabling Air Force platforms to successfully execute their assigned tasks and missions. As well, EP measures include aircraft RF and IR EMS signature reduction, and EA measures include directed infrared countermeasures (DIRCM) and RF jamming systems on-board both rotary- and fixed-wing aircraft.

These EW components or systems can be incorporated as additions to existing aircraft systems in the form of mission kits, as post-production additions to an existing fleet, or integrated into the aircraft systems as part of the original design considerations. The Air Force has used all approaches in the past, but is trending more toward the inclusion of EW capabilities as part of the initial purchase when new aircraft are procured. To ensure EW sovereignty, as described on page 3, a thorough knowledge and understanding of these components or systems is a fundamental requirement in new acquisitions. The same is true of the ability to validate, verify, and reprogram the EW capabilities of the systems when and where required.

Force generation of equipment is a dynamic activity. Electronic warfare systems are designed to meet current operational requirements that are based on the current capabilities of the systems of interest operating in our areas of interest. Equally important is the capacity to continually assess, expand, modify, or improve our EW systems' ability to deal with emerging or changing capabilities in those systems of interest. This is why EW was once defined, in part, as consisting of electronic

¹¹ See B-GA 407-001/FP-001, Air Force Personnel Doctrine for further discussion on force generation and personnel.

countermeasures (ECM) and electronic counter-countermeasures (ECCM). The weakness in this approach to defining EW was in this fixed expression of two activities that in reality were never fixed; for every measure there would be a counter and for every counter, there would be a counter-counter, and so on. Electronic warfare capabilities (equipment—hardware and software, and operating procedures) are mission and threat dependent requiring continuous assessment. Mission readiness is achieved through a comprehensive threat review and follow-on preparation of a platform and systems maintenance cycle.

Meeting the current state requirements, then, includes having the capability to operate today and the capacity to operate tomorrow. To meet this requirement, a number of ways and means are in place and will be illustrated in the following examples. It should be noted that there is a fine line between force generation and force employment in these examples, because in some cases generation overlaps employment. This overlap illustrates the potential for complicated and potentially conflicting coordination and control issues affecting decision making.

EXAMPLE ONE. DEFENDING CANADA: ARCTIC SOVEREIGNTY

As the polar ice recedes and the North West Passage (NWP) becomes open to shipping for extended periods of the year, a number of nations commence usage of the NWP for their own purposes. The Government of Canada has designated the NWP as Canadian waters and demonstrates its resolve in support of this interpretation through an increased physical presence in the Arctic. Among CF tasks in support of the government's intent, the Air Force is tasked to conduct ISR flight operations in the Arctic. In preparation for this task, the maritime air community requests a mission data list (MDL) for the anticipated electronic emitters associated with various vessels of interest anticipated to be transiting through Arctic waters. This list is extracted from an electronic signal library and then programmed into the ES systems on-board their aircraft, enabling the electronic identification of these vessels of interest. This MDL is derived, programmed, tested and validated in the laboratory, and time permitting, on a live EW range, and then released for use on the aircraft tasked in support of the mission. MDL performance is monitored and adjusted in the field to ensure desired performance, and feedback is provided to ensure the knowledge base remains current and accurate. An equally important aspect of this potential Air Force mission is the ability to communicate effectively with other CF forces, making joint EW interoperability a key consideration for the Air Force.

EXAMPLE TWD. DEFENCE OF NORTH AMERICA: NORAD

Country X has been reported in the open press to have upgraded the fire-control system on its long-range strike aircraft as part of its publicly acknowledged military modernization programme. These aircraft have the capability of reaching continental North America. Country X has demonstrated hostile intent neither explicitly nor implicitly, and is therefore no immediate threat to North American security. However, the capability cannot be ignored. To ensure it remains capable of defending North America into the future, the fighter community requests an update to its on-board self-protection equipment. This includes an update to its radar warning receiver (RWR) user data file (UDF), and the determination of the potential effectiveness, or limitations to the effectiveness, of its self-protection radar jammer(s) and any requisite update/upgrade. This effort requires the coordination, collaboration and assistance of organizations both within the CF and between the CF and its partners in the defence of North America mission.

EXAMPLE THREE. CONTRIBUTING TO INTERNATIONAL PEACE AND SECURITY: STABILIZATION OPERATIONS IN COUNTRY Y

Canada agrees to provide forces in support of United Nations Security Council Resolution 1234 in Country Y. Among other CF tasks, the Air Force is tasked to provide tactical aviation, tactical transport, and UAS ISR in Country Y. Canada also agrees to provide embarked maritime helicopter support as an integral element of the Canadian Navy role in Canadian Task Force (CTF) 999 in the maritime approaches to Country Y. An implied task associated with the deployment is sustainment and re-deployment of these operational forces through inter-theatre airlift between Canada and Country Y. The process for updating and upgrading the various EW systems on-board the array of Air Force assets assigned to provide support to this operation is consistent with the previous two examples. However, given the time constraints there is no opportunity to conduct formal operational test and evaluation (OT&E) prior to commencing operations. To ensure optimum system performance, EW operational support (EWOS) employs data recording devices to permit deployed analysts to conduct in-theatre modifications to the updates and upgrades accomplished prior to deployment of forces, based on actual experience. EWOS reaches back to CF EW Centre (CFEWC) and other organizations as required to permit further analysis and updates to the knowledge base, if required.

Air Force EW capabilities are implemented through a collaborative effort within the Air Force, DND/CF, and between them and Canada's coalition partners and allies. External collaboration requires both informal and formal knowledge-sharing agreements.

Despite the initial impression that EW equipment is the Air Force's primary concern, education and training underpin all aspects of the process described above. They ensure that the Air Force has the capability to operate today and the capacity to operate tomorrow. Electronic warfare is a fundamental consideration to both FG and force employment of Air Force capabilities. Education and training make up the foundation upon which rests critical coordination and collaboration essential to the continued delivery of EW capability and capacity. Due to the pervasive nature of EW across the Air Force and the variety of organizations that are implicated, it is education and training that will enable a coherent and coordinated approach to Air Force decision making. The breadth of EW collaboration supports the expectation that public servants engaged in Air Force EW activities will also have the requisite education, knowledge and understanding of EW to contribute effectively. An understanding of EW principles and applications is a fundamental requirement for Air Force decision making at all levels of command. Infrastructure provides the linkage between education and equipment and consists of both facilities and people. It must be sufficiently robust to meet the demands of today's tasks while having the flexibility to adapt to the changing support requirements as EW continues to dynamically evolve. Additionally, there will always be a demand for support from various organizations, each involving numerous man-hours, often utilizing specialized computer, laboratory, and information management equipment. Conditions for housing this specialized equipment must be closely controlled and will require appropriate installations. In all likelihood, future platforms will require an increased support infrastructure footprint, including connectivity with our coalition / allied partners and mission-specific planning systems. Seldom would the Air Force employ only one platform type. Electronic warfare support infrastructure must be prepared to meet the demands of multiple fleets concurrently.

FUTURE STATE

The previous section describing FG and force employment in the near term uses the concept of the current state. The future state describes those activities that prepare the Air Force for potential operations across the spectrum of conflict, as articulated in Canadian Defence Policy, as a result of emerging advances in technology that create potential capability gaps. For example, with advances in technology and the move toward NCW, there is the potential for a broader use of the EMS as non-traditional ISR (NTISR) methods and means emerge. NTISR is described in greater detail in B-GA-402-001/FP-001, *Aerospace Sense Doctrine*. In a nutshell, it is the concept of using sensor information not generally associated with ISR in a coherent approach to better establish a more complete operating picture. As the Air Force develops and becomes reliant upon an NCW approach, the usage and reliance on a broader range of the EMS will emerge. Therefore, EW elements, ES, EP, and EA, across the broader EMS will become essential NCW considerations. And as such, those agencies external to DND who control and regulate the usage of the broader EMS will need to be included in the collaborative effort to implement Air Force EW activities.

Having the capacity to operate tomorrow means there is an ongoing requirement to look ahead, anticipate, and prepare for advances or changes in technology and procedures to ensure the Air Force can continue to exploit the EMS and to deny its exploitation by potential adversaries. This is accomplished through a collaborative effort from a variety of organizations within DND and among Canada's allies and partners. CFAWC is uniquely placed to provide a coordinating role and a focused, coherent approach to Air Force EW activities. To illustrate the breadth and depth of this collaborative effort, consider that Country Z is reported in the open press to be developing a new fire-control radar for a weapon system to be brought into service as a component of its integrated air defence system modernization program. While not an immediate or direct threat to Canadian interests, Country Z exports arms to a variety of potential adversaries.

Combined intelligence efforts are able to determine some of the characteristics, technologies, and proliferation of this new radar. The study of characteristics and technologies are undertaken by the science and technology (S&T) community. The implications for the range of Air Force platforms and systems that may be affected by this advance in technology are analysed. Potential changes to Air Force EW systems are recommended for consideration. In order to close the loop and determine the effectiveness of current systems and/or validate these potential changes, Air Force platforms and systems are physically tested. This effort is the translation of the theoretical to the practical, and determines the continued viability of Air Force platforms and systems in the evolving air defence environment. The result of such collaborative efforts provides substantiation for the upgrade or replacement procurement process, and helps guide S&T related projects. Consequently, as the coordinating organization, CFAWC is involved throughout the entire cycle of activity.

Combined intelligence efforts involve the Canadian intelligence community and EW organizations within Canada and between Canadian allies and partners. This sharing of EW knowledge is being facilitated by the establishment of exchange and/or liaison officer positions with Canada's allies.

The study of **characteristics and technologies** encompasses the collaborative effort of the S&T community, such as defence research scientists and Directorate of Technical Airworthiness and Engineering Support (Assistant Deputy Minister [Materiel] / DTAES) engineers. The S&T efforts range from conceptual and theoretical to testing and analysis, and include the usage of various assessment capabilities such as modelling and simulation (M&S), bench testing, and/or flight

testing. This involves collaboration with CFEWC and Defence Research and Development Canada (DRDC) Ottawa and Valcartier.

Potential changes involve 1 Canadian Air Division because there will often be air apportionment issues at play, as OT&E within the Air Force or in collaboration with Canada's allies and partners may be required. Potential changes also have implications for modification or revision of EW education and training, a 2 Canadian Air Division responsibility.

Determining the effectiveness involves the collaboration of 1 Canadian Air Division, the test and evaluation flight or flights, if multiple fleets are implicated, the standards evaluation and training for the fleet or fleets implicated, the operational training units, the operational and training squadrons, the CFSAS and CFAWC because **validating potential changes** includes changes to TTPs and potential changes to training and education, and the S&T community as required. Furthermore, all software changes shall be assessed for airworthiness implications by the appropriate fleet weapon system manager (WSM) who shall be in the loop as the technical authority to approve software and/or any associated hardware airworthiness-related changes. The OT&E process involves flight trials against radar simulators, emulators, or actual threat systems.

Upgrade or replacement procurement brings the air requirements staff into the process to complete the loop. And finally, the process has strategic implications for the future Air Force. As such, force development and air strategic plans staffs are also involved in this process.

SECTION III – ELECTRONIC WARFARE DOCTRINE: Relationships and process Relationships and process

As has been illustrated in the previous section, there are a variety of EW activities that require the active collaboration of organizations across the CF and between the CF and external agencies. In this section, Figures 1-2 and 1-3 are used to illustrate those collaborative relationships within the context of the examples articulated in Section II.



Figure 1-2. EW Activity Cycle: Maintaining the Current State

The ability to maintain a relevant current state, or the capability to operate today, is enabled by the EW activity cycle, which assesses, expands, and modifies EW system capabilities when required, and then validates, verifies, and certifies those modifications in response to operational requirements. A request for support from the operational community initiates the process and is coordinated by CFAWC.

As Figure 1-2 depicts, there are a variety of organizations that play an important role in the EW activity cycle. The cycle flows counter-clockwise in a hub-and-spoke exchange. There is analysis and knowledge sharing in the determination of the technical aspects of potential changes to EW systems. This is followed by the validation and verification of those changes prior to certification for use on Air Force platforms. Finally, there is continuous feedback between the concerned organizations which ensures that all aspects of the knowledge base are also updated.

Additionally, there is also a requirement for the Air Force to have the capacity to operate effectively into the future. Although there are a variety of potential scenarios to illustrate the relationships and process in dealing with emerging requirements, they are, generally speaking, longer-term endeavours having strategic implications that require higher-level decision making to establish the level of effort, resource allocation, and procurement prioritization. And while the relationships and process involved are similar to those illustrated in Figure 1-2, there is often more emphasis on S&T, M&S, and collaborative partnering with our allies in conducting OT&E.

The foregoing has also assumed a passive start state. Nothing happens until a request comes from the operational community, or something is detected by intelligence, or action is triggered by open-press reporting. It does not take into account the kind of proactive approach that is ongoing to characterize the operating environment. Figure 1-3 illustrates the ongoing cycle used to address capability gaps. Intelligence efforts are focused through the collaborative effort of Defence Scientific and Technical Intelligence and Director Air Strategic Plans (D Air SP) to establish a global, systems matrix. This matrix lists all the potential systems the Air Force could encounter in conducting Defence missions and is categorized by type and is used to verify what is known about the systems and what projects ought to be advanced to satisfy shortfalls in knowledge. The EW Capability Advisory Group (EW CAG) uses the systems matrix to recommend the focus of Air Force EW activities to reduce capability gaps. Electronic warfare capability development and validation (EW Cap D&V) uses the matrix to determine equipment capabilities and shortfalls, and among other things, to recommend OT&E activities to satisfy shortfalls in knowledge. Each of these governing bodies collaborates on prioritization of efforts to address capability gaps. The Director General Air Force Development (DG Air FD) acts for the Chief of the Air Staff (CAS) through the Aerospace Electronic Warfare Oversight Committee (AEWOC) to direct coherent and coordinated action to satisfy shortfalls in knowledge and capability. At any given time, the systems matrix can be applied across the range of air force platforms that may encounter those systems during operations. The combined outcome of current status and ongoing activities to satisfy knowledge/capability shortfalls can then be used to assess Air Force readiness, providing a capability status report. This readiness assessment tool can be used to facilitate Air Force decision making for FG, force employment, and procurement prioritization.



Figure 1-3. EW Activity Cycle: Preparing for the Future

Figure 1-3 depicts the EW activity cycle from the perspective of the type of activity being performed to deal with potential capability gaps.

GOVERNANCE

The relationships depicted and processes described above are all enabled by several governance elements. These governance elements are formalized through the promulgation of Air Command Orders (ACOs) and can be found in Figure 1-5.

Air Electronic Warfare Oversight Committee. The AEWOC, chaired by DG Air FD, coordinates and manages the activities of the EW CAG, and the EW Cap D&V program and provides better visibility of the activities of such at the very senior levels of the Air Force.¹²

Electronic Warfare Capability Advisory Group. The EW CAG exists as a forum to monitor and coordinate EW issues within the Air Force. This is accomplished by operational users (through fleet-specific EW advisory groups) providing a clear outline of their short- and long-term goals. These goals establish a "way ahead" which meets Air Force EW Policy objectives, which in turn guide EW

^{12 1150-1 (}D Air SP 5-2) Briefing Note for ACAS, *Creation of the Air Force Electronic Warfare Oversight Committee and the AF EW Governance Structure*, February 2009 (signed by the releasing authority, Lieutenant-General Watt, 30 Apr 09).

requirements, procurement, engineering and scientific efforts toward fulfilling operational needs.¹³

Electronic Warfare Capability Development and Validation. The EW Cap D&V program is an evolving process that was formerly called Countermeasures Development and Validation. Its original scope was to focus on the operational requirement to ensure Air Force platforms equipped with DEWS had effective EP capabilities. But as the Air Force expands its use of and reliance on the EMS across all three elements of EW—ES, EP, and EA—the program scope has also expanded. Electronic Warfare Cap D&V coordinates operational, acquisition, intelligence, training, technical engineering, and developmental/operational test and evaluation to capture operational requirements, articulate operational vulnerabilities or capability gaps, develop technical solutions, and capture lessons learned to minimize capability gaps. Funding for EW Cap D&V resources, which are required to support the operational activity assigned to the equipment managed by the Aerospace Equipment Program Management (AEPM) Division, is determined and then approved by the Aerospace Management Committee Secretariat and Aerospace Management Committee, respectively. Internal governance and implementation of the EW Cap D&V program has yet to be determined.¹⁴

Air Force Development Committee (AFDC). Force development is the planning and conceptualizing associated with the creation, maintenance, and adaptation of military capabilities in the face of changing security and resource circumstances. Ideally, force development should be holistic; that is, it should encompass the entire range of considerations associated with creating, maintaining, and adapting military capability. The AFDC is the senior Air Force body charged with providing pan-Air Force advice to the CAS, through the Air Board, on Air Force development issues. It focuses on the medium to long term (i.e., Horizon Two: 15 years in the future, and Horizon Three: 30 years in the future).¹⁵

Air Force Science and Technology Oversight Committee. The AFSTOC is the single Air Force forum for senior working-level oversight and coordination of Air Force research, technology and analysis (RTA) and concept development and experimentation (CDE) activities. The program enables the evaluation, maturation, and transition of technologies with the potential to deliver identified capability needs; supports the science-based and engineering-based investigation of service issues; and, on occasion, supports the targeted development of technological or system solutions to meet specific needs. A more detailed description can be found in ACO 1000-6.¹⁶

^{13 1} Cdn Air Div Orders, Vol. 1, 1-624, Capability Advisory Groups-Terms of Reference, Amended 21 Jun 08.

¹⁴ Air Force EW Capability Development and Validation (EW CAP D&V) Program, draft version 6.0, http://kms.kingston.mil.ca/kms/CentralInstance.aspx?Type=SupportMaterial&Id=3813, (accessed February 1, 2011).

¹⁵ ACO 1000-10, Air Force Development Committee (AFDC) - Policy, http://airforce.mil.ca/dairsp/subjects/afdc/meeting13/afdc/ACO%201000-10_Amdt%201_e.doc, (accessed February 1, 2011).

¹⁶ ACO 1000-6, Air Force Research & Development, Operational Research, and Concept Development & Experimentation Coordinating Committee (AFROCCC) – Policy, 27 Apr 06 (to be renamed Air Force Science and Technology Oversight

Thrust Advisory Group (TAG). The formulation of the RTA program within DRDC is based on the concept of RTA Thrusts. Central to the operation of an RTA Thrust is the TAG. The TAG advises on requirements leading to RTA projects (Horizon 2 and 3). Maximum effort is made to transfer developed knowledge and/or technologies from RTA to development-engineering-evaluation and implementation of a selected technology or Canadian unique solution as required.¹⁷

Aerospace Capability Initiatives Forum (ACIF). The ACIF identifies, defines, guides, and prioritizes all Air Force research and development (R&D), operational research (OR), and CDE projects by examining proposals in detail, ensuring consistency with higher guidance. ACIF will convene stakeholders in force development, including representatives from the Air Staff, 1 Cdn Air Div HQ, CAGs, CFAWC, DRDC (including research labs and the Centre for Operational Research and Analysis [CORA]), and others, to brainstorm Air Force challenges and opportunities for the future. The Aerospace Capabilities Initiatives List will be a central mechanism to identify, track, and prioritize Air Force development needs and to match those needs to suitable resources, including S&T, OR, and CDE activities.¹⁸

The collective interaction of these governance bodies, depicted below, combines to ensure the Air Force has the capability to conduct effective operations in support of Defence missions today, and has the capacity to continue do so into the future. DG Air FD acts under the authority of the CAS to direct current and long-term EW activities.



Figure 1-4. EW Capability Development and Validation Cycle

Air Force R&D Program, http://drdc-rddc.mil.ca/air/overview_e.asp, (accessed February 1, 2011).
Ibid.

Committee (AFSTOC).



Figure 1-5. EW Governance Structure

The EW governance activity cycle illustrated in Figure 1-5, indicates the basic decision-making cycle for the various governing bodies and the requisite sequencing through the calendar year. The EW Cap D&V cycle (Figure 1-4) is constrained by the fixed timings of combined OT&E. For planning purposes, this OT&E must factor into the governance-body decision cycle well in advance of its commencement.



Figure 1-6. EW Governance Activity Cycle

Effective implementation of EW activities across the Air Force involves a variety of units and organizations within the Air Force, DND/CF, and between Canada and its allies and partners. It requires a collaborative effort. The governance structures illustrated above in Figure 1-6 are the organizational constructs required



TOMORROW

SECTION I - ELECTRONIC WARFARE ORGANIZATION

As the Air Force expands its EW capacity through the modernization of existing platforms and the acquisition of new platforms, bringing both an ES and EA capability, it will be necessary to establish the appropriate doctrine to address EW

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organization and planning. This chapter will outline in broad terms the nature of EW organization and planning doctrine that will need to be developed.

The Air Force is organized on the aerospace tenet of centralized control and decentralized execution. Air Force resources, including EW, would be employed as part of the air component and exercised at the lowest level. Therefore, EW knowledge must be available to Air Force decision makers at all levels of command where EW coordination, planning, and tasking occur.

The Air Force rarely acts alone, and as such, it is necessary to develop the means for integrating EW activities into joint and combined plans. EW activities have the potential to impact external agencies as well. It is essential that EW activities are effective and do not interfere with friendly forces or those other agencies that require unfettered access to the EMS. This would ensure maximum support with minimum interference and provide security. This coordination and deconfliction of air- and space-based EW support to operations would be accomplished at the joint or combined air operations centre (JAOC/CAOC) which works in coordination with higher-level headquarters, like the joint task force (JTF). The EW considerations must include the impact on C2, IO, and interrelated EMS requirements.

Doctrine would be established to describe how JAOC/CAOC is organized to ensure that EW is planned and integrated into the air tasking order (ATO) generation and execution monitoring process. As well, the organizational construct that permits effective and efficient integration with IO staff within the JAOC/CAOC and the tactical- or wing-level execution of ATO tasks would need to be developed. The doctrine would also describe the roles and responsibilities of the EW planners that support the air component commander (ACC) and other headquarters.

SECTION II – ELECTRONIC WARFARE PLANNING

Electronic warfare planning demands a sound knowledge of adversary and friendly capabilities, tactics, and objectives. This facilitates the successful employment of EW assets in support of the commander's planning effort.

Electronic warfare planning, like any other planning activity, answers some basic questions: What do we need to know? What needs to be done? How can we do what needs to be done? In an EW context, the electromagnetic (EM) environment needs to be characterized. This involves intercepting, identifying, and locating EM signals of interest: an ES role. With an understanding of the commander's intent, EW planners can determine where EW effort needs to be focused, from both a

defensive and offensive perspective. Potential means of executing defensive (EP) and offensive (EA) courses of action are considered and the commander decides on a preferred option to neutralize, jam or deceive, listen and/or exploit, or disrupt and/or destroy. The effective employment of EW capabilities can have a significant and potentially disproportionate effect on the adversary, yielding a tremendous advantage to friendly forces. Therefore, a sound understanding of EW and the intended objectives of its employment is a fundamental decision-making tool for all commanders.

Electronic warfare has the potential to generate effects regardless of the nature of the conflict or the portion of the EMS being used by the adversary. A properly constructed force package, including EW, increases the probability of mission success and the security and survival of friendly forces.

GLOSSARY

The definitions contained in this glossary are derived from a number of sources. Where this publication is the source of a definition, no source is indicated. Definitions taken from other sources are indicated in parentheses at the end of each term, utilizing the following abbreviations:

DTB - Defence Terminology Bank found online http://terminology.mil.ca/term-eng.asp)

NDHQ P21 – NDHQ Policy Directive P21, dated 27 Jan 77, *Canadian Forces* (*CF*) *Electronic Warfare Policy*, ratification draft, 4 May 07.

Act

The operational function that integrates manoeuvre, firepower and information operations to achieve the desired effects. (DTB record 26165)

Command

The operational function that integrates all the operational functions into a single comprehensive strategic, operational or tactical level concept. (DTB record 26166)

electronic attack (EA)

The division of electronic warfare involving the use of electromagnetic energy, directed energy, or anti-radiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability.

Note: 1. An electronic attack is considered a form of fire.

Note: 2. EA includes actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum, such as jamming and electromagnetic deception, and employment of weapons that use either electromagnetic or directed energy as their primary destructive mechanism (lasers, radio frequency weapons, particle beams). (NDHQ P21)

electronic warfare (EW)

Military action to exploit the electromagnetic spectrum encompassing interception and identification of electromagnetic emissions, the employment of electromagnetic energy and directed energy to reduce or prevent hostile use of the electromagnetic spectrum, and actions to ensure its effective use by friendly forces. (DTB record 4164)

electronic protection (EP)

That division of electronic warfare involving passive and active means taken to protect personnel, facilities, and equipment from any effects of friendly or enemy employment of electronic warfare that degrade, neutralize or destroy friendly combat capability. (DTB record 37260)

electronic warfare support (ES)

The division of electronic warfare involving actions tasked by, or under direct control of, an operational commander to search for, intercept, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic energy for the purpose of immediate threat recognition, targeting, planning and conduct of future operations.

Note: ES provides information required for decisions involving EW operations and other tactical actions such as threat avoidance, targeting and homing. ES data can be used to produce signals intelligence (SIGINT), providing targeting for electronic or destructive attack, and produce measurement and signature intelligence (MASINT). (NDHQ P21)

electronic warfare sovereignty

The authority and mechanisms provide the means to achieve a thorough knowledge and understanding of the EW environment and the ability to validate, verify and reprogram, when and where required, the capabilities of the systems required to operate within that environment.

force development

A system of integrated and interdependent processes that identifies necessary changes to existing capability and articulates new capability requirements for the CF. It is driven by changes in policy, actual or projected, changes in the security environment and lessons learned from operations. Force development comprises capability based planning, capability management and capability production. (DTB record 32172)

force employment

The command, control and sustainment of generated forces on operations. (DTB record 32173 modified)

force generation

The process of organizing, training and equipping forces for force employment. (DTB record 32171)

force generation concept

Principles and fundamentals that dictate how the force will be generated. As such, it is the foundation for force development. (DTB record 22571)

Generate

The function that develops and prepares an aerospace force to meet force employment requirements. (DTB record 37251)

Move

The function that exploits global reach and speed of aerospace power to rapidly deploy and manouevre personnel and materiel to achieve desired effects. (DTB record 37252)

Sense

The operational function that provides the commander with knowledge. Note: This function incorporates all capabilities that collect and process data. (DTB record 26167)

Shape

The function that optimizes agile manoeuvre and integrated information operations in the delivery of kinetic and non-kinetic aerospace power to achieve desired effects. (DTB record 37254)

Shield

The operational function that protects a force, its capabilities, and its freedom of action. (DTB record 26169)

Sustain

The operational function that regenerates and maintains capabilities in support of operations. (DTB record 26170)

LIST OF ABBREVIATIONS

ACIF	Aerospace Capability Initiatives Forum
ACIL	Aerospace Capability Initiatives List
ACO	Air Command Order
ADC	Aerospace Doctrine Committee
ADM MAT	Associate Deputy Minister (Materiel)
AEPM	Aerospace Equipment Program Management
AEWOC	Aerospace Electronic Warfare Oversight Committee
AFDC	Air Force Development Committee
AFSTOC	Air Force Science and Technology Oversight Committee
AM	amplitude modulation
AMC	Aerospace Management Committee
ATO	air tasking order
CAG	capability advisory group
CAOC	combined air operations centre
CAS	Chief of the Air Staff
CDE	concept development and experimentation
CF	Canadian Forces
CFAWC	Canadian Forces Aerospace Warfare Centre
CFEWC	Canadian Forces Electronic Warfare Centre
CFSAS	Canadian Forces School of Aerospace Studies
CMD&V	countermeasures development and validation
comd	commander
coord	coordination
DAR	Director Aerospace Requirements
D Air SP	Director Air Strategic Plans
DEE	development – engineering - evaluation
DEWS	defensive electronic warfare suites
DG Air FD	Director General Air Force Development
div	division

DRDC	Defence Research and Development Canada
DSTI	Defence Scientific and Technical Intelligence
DTAES	$Directorate \ Technical \ Airworthiness \ \& \ Engineering \ Support$
E&ST	Education and Specialty Training
EA	electronic attack
ECM	electronic countermeasures
ECCM	electronic counter countermeasures
EM	electromagnetic
EMS	electromagnetic spectrum
EO	electro-optical
EP	electronic protection
ES	electronic warfare support
EW	electronic warfare
EWAG	Electronic Warfare Advisory Group
EW CAG	Electronic Warfare Capability Advisory Group
EW Cap D&V	EW capabilities development and validation
EWOS	electronic warfare operational support
FC	Company and the second s
FG	force generation
FIVI	frequency modulation
INTEL	intelligence
IO	information operations
IR	infrared
ISR	intelligence, surveillance, and reconnaissance
JAOC	joint air operations centre
LCMM	life cycle materiel manager
M&S	modelling and simulation
MASINT	measurement and signature intelligence
MDL	mission data list

NATO	North Atlantic Treaty Organization
NCM	non-commissioned member
NCW	network-centric warfare
NORAD	North American Aerospace Defence Command
NTISR	non-traditional intelligence, surveillance and reconnaissance
NWP	North West Passage
Op	operation
OR	operational research
OT&E	operational test and evaluation
OTU	operational training unit
PG3	Partner Group 3
RF	radio frequency
RTA	research, technology and analysis
S&T	science and technology
SARAL	Strategic Aerospace Research, Assessment and Liaison
SET	Standards, Evaluation and Training
SIGINT	signals intelligence
SOI	systems of interest
sqn	squadron
TAG	Thrust Advisory Group
TTP	tactics, techniques and procedures
TV	television
UAS	unmanned aerial system
USAF	United States Air Force
WSM	weapon system manager

LIST OF REFERENCES

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