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SATELLITE COMMUNICATIONS IN SUPPORT OF CANADIAN FIGHTER OPERATIONS

by

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Disclaimer

Abstract

Canadian fighter operations in support of NORAD and sovereignty missions span a vast expanse of largely uninhabited terrain. Air Defence infrastructure was optimized to control fighters against external threats, approaching the Air Defence Identification Zone (ADIZ) from outside of the country. With the advent of airliners used as weapons of mass destruction on September 11, 2001, a focus on internal fighter operations revealed a notable beyond line of sight (BLOS) communication deficiency within the voluminous interior of the Canadian AOR. As threats could now appear deep within the nation, effective command and control (C2) within the region's interior became an essential mission element. Fighters no longer just used domestic airspace for transit to the tactical frontage but now were required to tactically execute a time sensitive, communications critical mission there. Satellite communications promise to effectively address a number of the current fighter C2 challenges however, such a solution brings its own set of limitations and vulnerabilities. A thorough understanding of the systems and operating environment is necessary to limit vulnerabilities and increase the probability of mission accomplishment.

The terrorist attacks on the United States of America on September 11, 2001 resulted in the emergence of a new mission set for the Canadian North American Aerospace Defence Command (NORAD) Region. With this mission set, the focus of operations became the interior of Canada as opposed to the exterior. Such a fundamental change in ways demonstrated a notable lack of means to achieve effective command and control (C2) of fighter aircraft via very high (VHF) or ultra high frequency (UHF) radios throughout the vast and sparsely populated area of responsibility (AOR) that the Canadian NORAD Region (CANR) comprises. In early 2008 the Canadian Air Force implemented a satellite communications (SATCOM) capability with its CF-188 fighter aircraft to solve this challenge to operations. As a new capability to Canadian fighter operations, the method of selection, testing, implementation and employment of SATCOM will be analyzed to identify possible areas for improvement.

The CANR was not the only NORAD region to recognize a deficiency in their ability to exercise C2 within their AOR; the American Continental NORAD Region (CONR) faced similar challenges. Accordingly, the NORAD Commander directed a multi-region assessment of the DRS Technologies Fighter Aircraft Command and Control Enhancement (FACE) AN/ASQ-T38 SATCOM system.[1] The United States Air Force (USAF) provided the FACE pod to the Canadian Air Force in late January and early February of 2007 to facilitate an initial operational assessment. The USAF selection of the FACE pod was based on three criteria; its ability to provide beyond line of sight (BLOS) communication without changing operational procedures or modifying fighter aircraft hardware or software.[2]

The pre-September 11, 2001 posturing of the CANR reflected the traditional cold war footing to face a state versus state threat. Military radar and V/UHF communications essentially ringed the periphery of the country to identify threats and control fighter operations to effectively negate them.[3] Civilian air traffic control (ATC) radar and radio communications also provided coverage for medium to high altitude commercial flight operations throughout southern Canada while only voice communications served northern Canadian airways and air routes.[4] Radar coverage in southern Canada continues to be chiefly secondary surveillance radar systems which require the use of aircraft transponders thus tailored to cooperative commercial aviation. The suicide hijacking tactics of September 11, 2001 demonstrated that threats can now appear anywhere within the country demanding tactical employment of fighter aircraft deep within the interior of the region at any place, time or altitude. To respond to the threat and potentially employ up to lethal force, fighters required military C2 where at best only ATC was available and at worst where there was neither any civil or military V/UHF communications nor radar. The FACE pod promised to immediately ameliorate military C2 throughout the vast CANR.

The FACE pod system leveraged existing technology in commercial and military sectors to provide a solution to the problem this new mission posed. The pod is comprised of two IRIDIUM satellite telephones, a low wattage V/UHF radio, associated interfaces and power regulation packaged in a standard Air Combat Maneuvering Instrumentation (ACMI) pod body with a modified nose cone to house SATCOM antennae. The ACMI pod is widely used on nearly all western fighter aircraft, thus providing a mechanical means to mount to the aircraft, taking advantage of existing aircraft wiring and electrical power. The IRIDIUM SATCOM is a stable commercial enterprise offering excellent polar coverage while the V/UHF radio represents definitive maturity in technology. Use of mature, existing and proven technology provides a low risk solution to achieve the three selection criteria previously outlined.

The CANR overlies the second largest landmass on the Earth.[5] Canadian fighter operations range from high arctic latitudes to the Canadian/US border and span the entire width of Canadian sovereign territory. Climatic conditions vary widely within the region. It is not unusual to have fighter aircraft transition from extreme cold and dry operating environments to temperate, humid and high salinity coastal conditions in a single mission. All altitude operations and multi-aircraft compatibility are common to the other three desirable USAF requirements used to select the FACE pod system. The ability to reliably withstand a full range of climatic conditions during a single mission while continuing to provide BLOS communications at mid and high latitudes are defining features of Canadian requirements.

The CANR implementation of the FACE pod incorporated an abbreviated Operational Test and Evaluation (OT&E) program in the form of an initial operational assessment. OT&E was preceded by Engineering Test and Evaluation (ET&E) consisting of a limited electromagnetic compatibility (EMC) safety of flight check. Due to the brief availability of the three FACE pods loaned to the CANR and ongoing higher priority wartime projects, the testing was minimal. The Aeronautical Engineering and Test Establishment (AETE) only analyzed EMC between the pod and CF-188 mission critical elements as identified by the Fighter Operational Test and Evaluation Flight (FOTEF) for their follow-on OT&E effort. Such analysis was the absolute minimum required to allow the Canadian Forces Air Technical Authority to issue a Provisional Technical Airworthiness Certificate (PTAC); a prerequisite for flight during subsequent OT&E. AETE's test effort limited "victim system" testing to V/UHF radios, VOR/ILS and TACAN navigation equipment but did not test for EMC with the APG-73 radar, combined interrogator/transponder, radar altimeter or weapon systems. Despite the issuance of a PTAC, AETE noted a significant and unacceptable finding in relation to electrical bonding, static electricity dissipation and lightning protection of the FACE pod.[6]

FOTEF's primary objective during their OT&E was to confirm the operation of the FACE pod "in the low-altitude, [and] northern latitude[s] in simulated NORAD roles and missions."[7] Due to time constraints FOTEF planned and conducted only four missions consisting of eight sorties. One mission was a tactical mission at mid-latitudes (55 degrees north), another was a tactical mission from a northern operating base to higher latitudes (70 degrees north) while the other two missions consisted of test points carried out in transit to and from the northern base. The overall evaluation resulted in twenty-one observations of which eleven noted certain unsatisfactory aspects.[8] Although substantial, none of the unsatisfactory observations resulted in an unacceptable rating of the FACE pod.[9]

The unsatisfactory observations noted during OT&E fall broadly into three categories; (1) ground support, (2) technical clearances and (3) tactical employment. Although the physical operation of the pod from the pilot's point of view is attractively simple – dial the V/UHF frequency into the aircraft radio to which the pod transceiver is tuned and transmit normally – the maintenance procedures for loading *sim* cards and SATCOM software is esoteric. Either formal maintenance training or contractor support is essential to reliably operate the FACE pod.[10]

From a technical clearance standpoint, at a minimum, additional EMC evaluation in relation to weapons, electronic warfare and primary sensors must occur to certify the pod as airworthy for routine use.[11] Additionally, observed resistance measurements between pod components warrant bonding modifications for enhanced protection from static electricity build-up and lightning.[12]

The tactical employment observations fall within ground and air sub-categories. Within the ground category, changes range from minor, such as Air Weapons Controllers use of push to talk instead of voice activated headsets to prevent clipping of verbal communications, to potentially major items, such as the quality of commercial and military phone lines and their availability from the controlling agency to the satellite ground station uplink node. During testing, occasionally communications were only possible via commercial telephone lines to the satellite ground station and a relatively large number of dropped calls occurred while using the military telephone lines and switches when they were available. Finally, persistent background noise when the ground controller communicated with the aircraft requires further investigation to localize its cause.

Airborne tactical observations revolved around the low wattage V/UHF radio contained within the FACE pod and how that impacts fighters that habitually operate in formations of two, or multiples of two. Observations related to the inability of one controller to simulcast to two pods at the same time or that the standard formations and tactics require modification to enable the entire formation's reception from one activated pod are a product of limited experience with a new technology.

Procedural solutions can ameliorate the noted airborne tactical observations. By using the internal relay function of the two ARC-210 V/UHF radio sets onboard the CF-188, the fighter with the activated pod can automatically relay the SATCOM audio over its second, higher powered, radio. Likewise, all received transmissions on the second radio automatically relay to the other radio tuned to the FACE pod frequency, rebroadcasting to the pod and SATCOM. This allows transmission of the SATCOM audio at a much higher wattage increasing the effective communications reception range to well over sixty nautical miles instead of only five. As a result, all fighters, tankers and mission support aircraft on the controlling frequency for the mission can communicate via a single FACE pod. As elegant as this solution seems, it was not employed during testing as it is entirely contrary to standard operating procedure. Typically, the “external” frequency such as the controlling agency is set on the primary radio while the “internal” formation frequency is set on the second radio.[13] When utilizing the relay feature, the formation will monitor three frequencies amongst two fighters and the controlling agency will be on the primary radio in the first fighter and on the second radio in the second fighter. As creatures of habit, a departure from the norm can cause confusion at inopportune times without a clear understanding and routine practice.

Based on the FOTEF report the Canadian Forces must take additional tactical, procedural and support measures to most effectively integrate SATCOM with fighter operations. Notably absent from the OT&E effort was the inclusion of solar weather. Heightened ionosphere scintillation in the polar-regions, polar cap and auroral zone absorption events, delayed particle effects in the nighttime sector, solar flare and sunspot induced noise must factor into operations planning as a routine support activity. Forecasted and actual ionospheric conditions impacting SATCOM must be available to aircrew and controllers. An appreciation of solar conjunction as well as delayed and immediate effects of heightened solar activity, coronal mass ejection and the eleven year solar cycle should be included in standard fighter pilot and weapons controller occupation training as well as mission specific preparation and planning.

EMC testing with sensors, emitters and weapons is essential to assure effective satellite based C2 throughout peace, transition and wartime operations. Additionally, correlating solar weather with test results will help to explain dropped calls and poor communication quality allowing for focused and effectual progress towards communications improvement. Isolating solar environmental effects from infrastructure shortfalls will assist in determining whether military telephone lines and switches require additional maintenance, and whether the production of a Canadian ground node would enhance communication quality or whether the continued use of the Hawaiian ground node is adequate.

Procedurally, a standard radio relay SATCOM plan must be documented and practiced regularly by fighter pilots and controllers. It must factor in the loss of SATCOM. Whether from a dropped call due to solar weather, a satellite collision such as that which occurred between an IRIDIUM and derelict satellite on February 10, 2009 or due to acts of aggression such as exo-atmospheric detonation of a nuclear device charging the Van Allen belt, SATCOM loss must be anticipated.[14] Although a completely redundant capability that duplicates the breadth of IRIDIUM's reach is impractical, some overlap is available through existing Northern Warning System (NWS) air defence sites, ATC antennae and military air defence domestic ground entry sites (GES).

The strongest communication plan will allow for the simplest reversion between means of communication. Characteristics of such a plan would include a standard FACE pod frequency for use throughout the AOR, relay operations to expand the range of a single pod, selecting the applicable NWS/GES tactical frequency as the primary relay frequency and employment of the third available frequency for ATC co-ordination.[15] Under such a plan, loss of SATCOM would find the fighters already on the applicable NWS/GES C2 frequency allowing for the best chance for the controllers reaching the pilots via V/UHF radio. This also provides for many mission dependant options where controllers could transmit to a tanker or AWACS via High Frequency (HF) frequency for retransmission on NWS/GES V/UHF frequencies or fighters could employ a stacked formation for better V/UHF reception while prosecuting lower altitude targets.

Tactically, every fighter on air defence alert should be loaded with a FACE pod. To accommodate breakage and equipment failure, a standard fighter configuration will allow for the implementation of the communication plan regardless of fighter serviceability or what combination of fighters is ordered airborne. Without standardized configurations, the complexity of the communications plan increases exponentially. Additionally, by standardizing configuration, FACE pod preparation and maintenance can be limited.[16] The FACE pod satellite antennas need to by physically adjusted depending on what weapon station the pod is loaded – limiting fighter configuration limits pod configuration allowing for hasty replacement of a malfunctioning pod. Configuration management must include ballast; FACE pod ballast prevents unnecessary flight performance restrictions.[17] For antenna visibility the FACE pod mounts on a wingtip LAU-7 weapons station. The loss of this weapon station can be offset by employing an under wing mounted LAU-115, double LAU-7 configuration, adding two additional AIM-9 missiles. The increase to the drag index, fuel consumption and decrease in range is relatively small below transonic Mach numbers and the weight increase is inconsequential while preserving weapons load options for the Commander.[18]

SATCOM promises to be an elegant solution to the challenges Canada faces in controlling fighters within its vast AOR. A thorough understanding of solar weather phenomena will allow fighters pilots and controllers to differentiate vagaries and failures from characteristics and develop robust, yet simple, plans to provide for graceful system degradation during times of peace and conflict. FOTEF and AETE have provided an excellent basis for the FACE pod's introduction to service but further testing, support, procedural and tactical measures are necessary to fully exploit the extant capabilities of the FACE pod IRIDIUM SATCOM. The future of SATCOM will not end with the CANR's comprehensive implementation of the FACE pod, though. As usage matures, research into facilitating high rate data, jam resistant and secure communications will strengthen operational excellence within the CANR.

[1] FOTEF Report F-2005-005, Executive Summary, 2.
[2] Operating Manual for Prototype and Production for the AN/ARC-235, 1-1.
[3] Transport Canada TP 14371E, Aeronautical Information Manual, 22 October 2009, 104.
[4] Ibid., 173.
[5] World Statistics, http://www.mongabay.com/igapo/world_statistics_by_area.htm (accessed 21 March 2010).
[6] AETE Technical Note 2005-042, 5.
[7] FOTEF Report F-2005-005, 4.
[8] Ibid., 10.
[9] The terms "Unacceptable" and "Unsatisfactory" are used as defined in 1 Canadian Air Division Orders as they pertain to airworthiness. 1 Canadian Air Division Order 1-623, Operational Airworthiness, 21 March 2006.
[10] Operating Manual for Prototype and Production for the AN/ARC-235, 5-2.
[11] 1 Canadian Air Division Order 1-623, Operational Airworthiness, 21 March 2006, 4/11.
[12] AETE Technical Note 2005-042, 5.
[13] B-GA-583-001/FT-001, Fighter Force Tactics Manual Volume 1 – Amendment List 4, 10 November 2005, 2-3/8 and 3-4/6.
[14] Analytical Graphics, Inc. "Spacecraft Digest – Iridium 33 Destroyed." http://www.stk.com/resources/scdigest/viewnamerecord.cfm?radiobox+Iridium%2033 (accessed 19 February 2010).
[15] Proposed SATCOM Communication Plan, Annex A.
[16] Operating Manual for Prototype and Production for the AN/ARC-235, 5-4.
[17] AN/ARC-235 FACE Pod CF-188 Provisional Technical Airworthiness Clearance, Annex A.
[18] C-12-188-NFM/MB-001, Aircraft Operating Instructions – Change 5, 01 February 2005, 1-17-4 and 4-3-7.

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Figure 1 – FACE Pod Communication Plan Overview

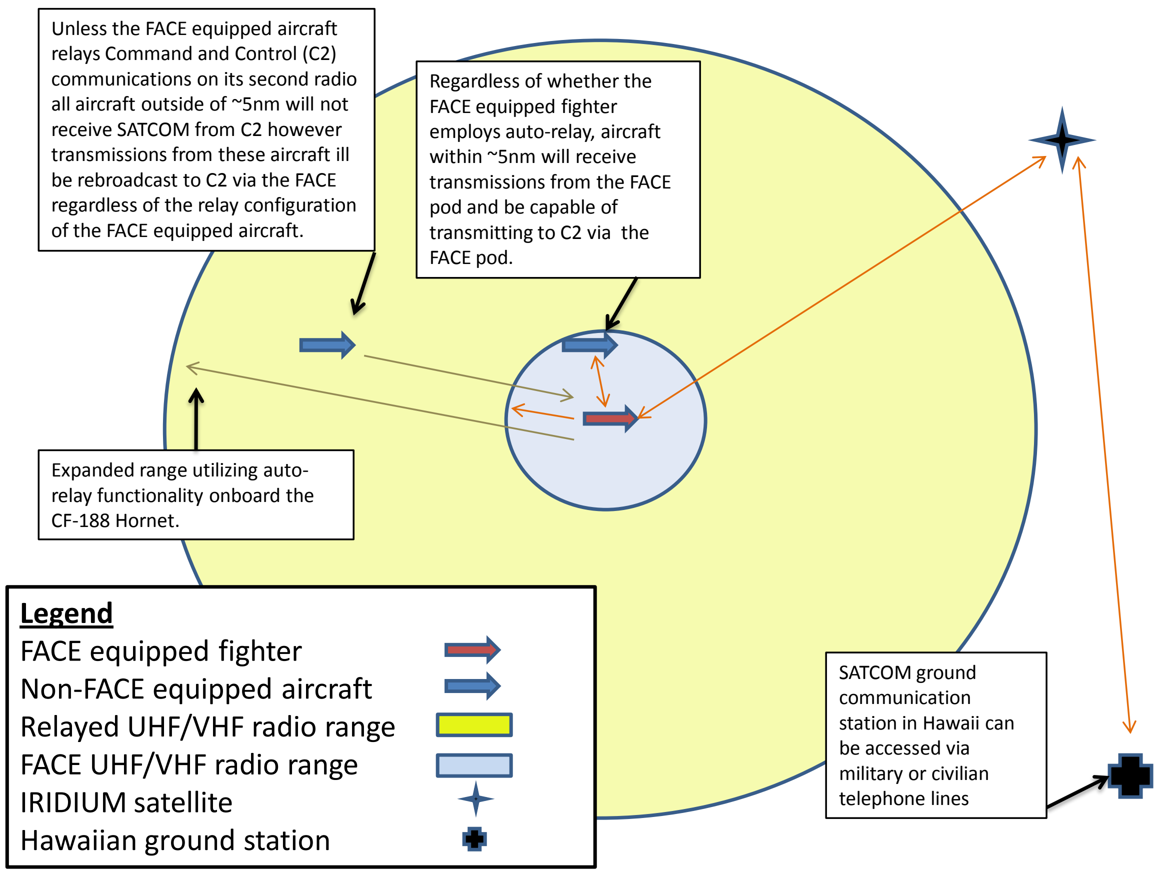

Figure 2 – Suggested FACE Pod Radio Management Plan

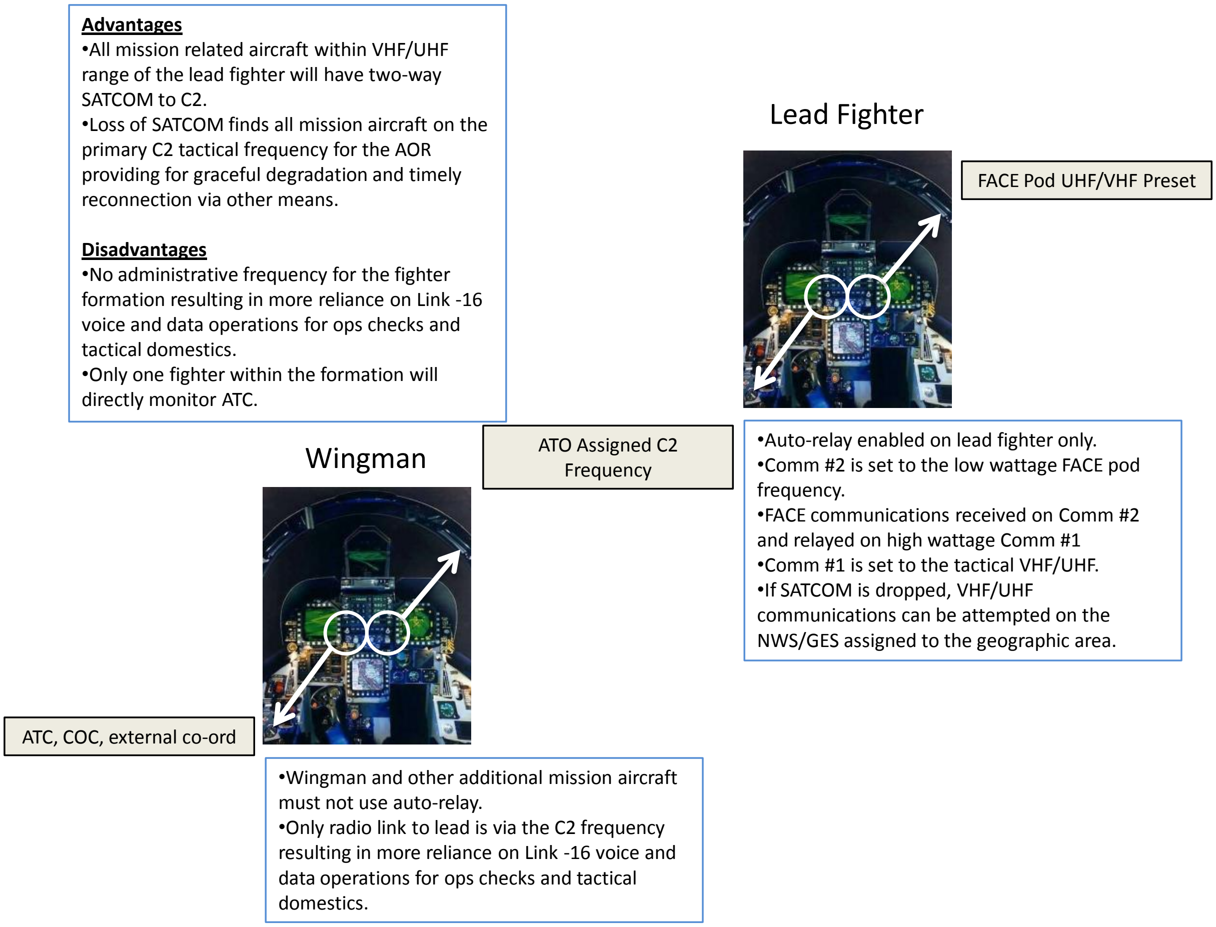

Figure 3 – Canadian Secondary Surveillance Air Traffic Control Radar and VHF Radio Coverage as depicted in Transport Canada TP 14371E, *Aeronautical Information Manual*, 22 October 2009, page 173.

Figure 1.1 – Transponder Airspace

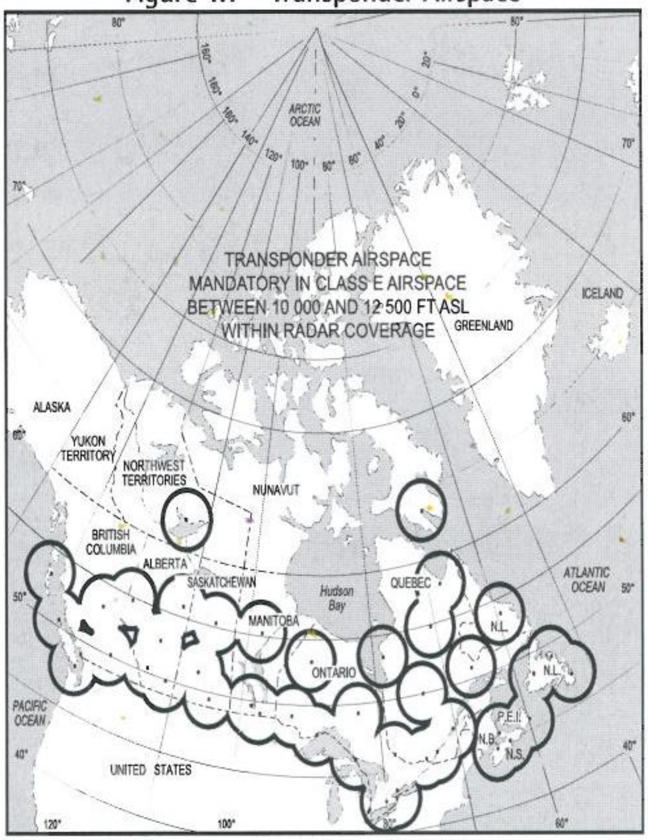

Figure 4 – Approximate Canadian Northern Warning System Primary Radar Surveillance and V/UHF Radio Coverage as depicted in Transport Canada TP 14371E, *Aeronautical Information Manual*, 22 October 2009, page 104.