Command of the Electromagnetic Spectrum - an Electronic Combat Doctrine for the RAAF (Draft RAAF APSC WP 8, November, 1992)

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1. Introduction

Electronic Combat serves the purpose of gaining control of the electromagnetic spectrum, so that its use may be denied an opponent and thus a substantial military advantage gained. This paper argues the case for treating Electronic Combat as a campaign, with strategic objectives analogous to those sought in the campaign for the Control of the Air, and extends this argument to the proposal for an Electronic Combat doctrine for the RAAF.

Part 1
Command of the Electromagnetic Spectrum
The Case for an Electronic Combat Campaign.

2. Electronic Combat - an Historical Perspective

Electronic Combat has been classed in the AAP1000 as an air role, and primarily associated with the support of offensive air operations. This is understandable when the evolution of Electronic Combat is considered, as Electronic Combat has until recently never been associated with strategic objectives.

The first serious Electronic Combat operations were conducted during the Allied Normandy offensive in 1944, when fighter bombers of the RAF and USAAF struck at German radar sites in a coordinated effort to blind the defenders to the incoming invasion. The use of chaff bombers and airborne deception jammers complemented the hard kill missions, to achieve the strategic objective sought.

Until then, Electronic Combat related sorties were primarily in support of specific operations, such as the larger night bombing raids against Germany. These operations involved chaff bombing, communications jamming and some jamming of acquisition radars. In the absence of a structured and integrated air defence system, a systematic effort against Germany's air defences would have yielded questionable results.

In the context of WW2 therefore, Electronic Combat was largely confined to supporting operations and in nearly all instances, saw very little coordination between its constituent elements.

The Korean War offered even lesser opportunity to develop the art, and most Electronic Combat operations were confined to jamming of early warning and acquisition radars, and communications.

The conflict in SEA on the other hand, offered many opportunities to learn. The Soviet Union deployed and partially manned the first serious instance of an operationally functional integrated air defence system (IADS), in the territory of North Vietnam. This air defence system was built very much in the image of the USSR's Voyska-PVO IADS, utilising many identical pieces of equipment, and importantly operated very much to Soviet air defence doctrine.

The core of the system was a network of early warning and acquisition radars, which supported interceptor aircraft and acquisition and fire control radars associated with batteries of SA-2 Guideline, and later SA-3 Goa SAMs. In addition, radar directed AAA was employed for the point defence of targets.

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Long range area defence was provided by fighters, with immediate area defence provided by SAMs and point defence by AAA. The intention was to provide overlapping coverage of defended airspace with the ability to engage inbound targets over a wide range of altitudes and through a large volume of airspace. This would provide the ability, when properly coordinated, to concentrate a maximum intensity of defensive fire against a given target or group of targets.

In practice the system fell far short of this capability, and its operation could at best be described as sporadic. Engagements typically involved single batteries attacking specific raids or individual aircraft, and NVAF fighter aircraft engaging US aircraft in hit and run attacks. While a number of substantial fighter vs fighter engagements were entered, none of these proved to be decisive for either side.

US Electronic Combat operations were primarily conducted in support of specific strikes, and until the Linebacker II campaign of late 1972, none were aimed at the strategic objective of disabling the IADS and attaining control of the electromagnetic spectrum.

The most significant aspect of the SEA conflict was the deployment, for the first time, of dedicated SEAD assets and air launched anti-radiation missiles, together with the first dedicated escort jamming aircraft deployed by the US Navy. These are the essential capabilities required to conduct a systematic Electronic Combat campaign.

Restrictive RoE, the cause of much of the United States' woes in the SEA conflict, prevented the application of these assets to full advantage, while also providing the communists with the opportunity to evolve defensive tactics and thus avoid substantial attrition over the shorter term.

The Linebacker II strategic bombing campaign saw the first serious effort at the destruction of the IADS. Both USAF and USN strike and SEAD assets systematically attacked elements of the IADS with the intention of inflicting decisive attrition. This, together with the exhaustion of reserve SAM munition stocks, saw the US gain full control of the air, and substantially so, control of the electromagnetic spectrum, in December, 1972.

The Linebacker II bombing campaign is of importance in that it illustrated the decisive effect of inflicting substantial attrition upon elements of an IADS. Another important lesson of the SEA conflict is that a campaign aimed at the control of the electromagnetic spectrum is analogous to a campaign for control of the air. Both are essentially attrition campaigns, where the Lanchesterian models can be applied and concentration of fire yields decisive results.

The Yom Kippur War of 1973 was of some importance, in that it illustrated that substantial attrition could be inflicted upon an attacking air force, even if that air force held and maintained air superiority. While the Israelis had a substantial electronic warfare capability and many dedicated assets, these were not applied systematically and thus control of the electromagnetic spectrum was not attained until land forces overran Arab SAM and AAA batteries, and their supporting radar systems.

The subsequent Israeli air battle over the Beka'a Valley in 1982 saw a substantial change in Israeli strategy. In 1982 the Israelis chose to pursue a coordinated and systematic Electronic Combat campaign against the Syrian IADS forward deployed in Lebanon. It yielded outstanding results, with the IADS crushed in a matter of hours, through the coordinated use of jamming, anti-radiation missiles and other munitions. Subsequent offensive counter-air operations saw the loss of more than 80 Syrian aircraft to the Israelis, with no Israeli losses in air to air combat.

Significantly, this was the first instance where attaining the control of the electromagnetic spectrum directly and unambiguously influenced the outcome of the battle for the control of the air.

In this respect, the opening phase of the Desert Storm air war merely repeated the same effect. Attaining the strategic objective of control of the electromagnetic spectrum created a situation, where Control of the Air was easily attained and maintained.

3. Electronic Combat as a Campaign

By definition, a campaign is a controlled series of related air operations aimed at achieving a single, specific strategic result [AAP1000 2.73]. Both the Beka'a Valley and Desert Storm Electronic Combat operations satisfied this definition.

In both instances, while not explicitly stated, a single strategic objective existed, this being the attainment of control of the electromagnetic spectrum.

In both instances, also, this result was achieved by a series of related operations, these involving offensive electronic warfare operations, SEAD operations and Air Strike operations against much of the infrastructure used to support the IADS.

Both air wars saw Control of the Air achieved quickly and decisively, with no losses due air to air combat.

The December 1972 phase of the Linebacker II campaign yielded similar results, although it is not clear whether control of the electromagnetic spectrum was sought as a strategic objective, or occurred as a side effect of Electronic Combat operations aimed at supporting the campaign for control of the air, and the air strike campaign.

It is however clear from all three instances that attainment of the control of the electromagnetic spectrum provided a decisive advantage in the prosecution of the traditional campaigns.

The argument for treating Electronic Combat as a campaign, rather than a supporting role, therefore revolves about the issue of whether controlling the electromagnetic spectrum should be considered a strategic objective. Demonstrably the result of the attainment of control of the electromagnetic spectrum is in effect paralysis of the defending side's air and air defence capability at a strategic, operational and tactical level. This in turn creates a highly favourable situation for the attacking side, in its pursuit of the traditional three campaigns. This can without doubt be considered a worthwhile strategic objective. Therefore it follows that there is a strong case for treating Electronic Combat as a campaign.

In two of the three air wars discussed, it is clear that such a strategic objective did exist and was systematically pursued until achieved. It is visibly evident from these three air wars that the attainment of control of the electromagnetic spectrum will provide a major advantage in the prosecution of the traditional campaigns, as the defending party loses the capacity to inflict meaningful attrition upon friendly aircraft.

The fundamental weakness of the traditional approach of treating Electronic Combat as a role is that it may not be aimed at the central objective of achieving control of the electromagnetic spectrum, therefore possibly leaving an opponent with the opportunity to retain control of some parts of the spectrum and thus exploit this to conduct counter air and air defence operations. This in turn will result in substantially more effort needing to be expended in the campaign for the Control of the Air and Air Strike campaign, to achieve their respective objectives.

It is this context that an Electronic Combat Campaign is proposed for the RAAF, as such a campaign offers the greatest payoff in application of resources, and is most general in its effects upon an opponent's capabilities.

4. An Alternative Model for the Conduct of an Air War

The established Western model for the conduct of an air war revolves about the three traditional campaigns, Control of the Air, Air Strike and Combat Air Support.

The primary campaign in the opening phase of the traditional model is the campaign for the Control of the Air, as the attainment of this condition allows the prosecution of the Air Strike and Combat Air Support campaigns with a minimum of attrition inflicted by defending aircraft.

This strategy is based on the fundamental idea that hostile aircraft can inflict the most attrition and therefore their removal from the battle minimises attrition of friendly aircraft and thus allows a maximum commitment of resources to the Air Strike and Combat Air Support campaigns.

The argument over the validity of this model will therefore hinge on the issue of which of the defending side's assets can inflict the most attrition, and under what conditions.

A close look at the major air battles of the last two decades demonstrates that the Surface to Air Missile now rivals the fighter aircraft as the principal cause of attrition of attacking aircraft. Furthermore, the ability of a fighter aircraft to locate and engage its target has becomed closely linked to the capability of its supporting air defence radar, be it ground based or airborne.

The common denominator is in both instances the supporting radar system and communications network, without which both fighter and SAM system lose very much of their potency as means of inflicting attrition.

The strict application of the established model therefore creates a situation where the defending side retains a substantial portion of its capability to inflict attrition, and as long as it possesses fighter aircraft, these may perform to the best of their capability.

Controlling the electromagnetic spectrum on the other hand debilitates both fighter aircraft and surface based air defences, providing a decisive advantage initially in the pursuit of the Control of the Air, and subsequently in the pursuit of the Air Strike and Combat Air Support campaigns.

An alternative model is therefore proposed, as follows:

The primary campaign in the opening phase of the air war should be a an Electronic Combat campaign with the strategic objective of attaining the control of the electromagnetic spectrum, which will if successful produce a decisive advantage for the prosecution of the campaign for the Control of the Air, and subsequently also the Air Strike and Combat Air Support campaigns.

This does not diminish the importance of the campaign for the Control of the Air, the established rule of concurrency between the campaigns is retained. What must change is the initial commitment of resources. Until control of the electromagnetic spectrum is attained, the enemy will retain the capacity to fight for the Control of the Air. Once electromagnetic superiority is achieved, the enemy will be placed in the situation of conducting a defensive rather than offensive air war, and this will act as a force multiplier for the attacking side when prosecuting the campaign for the Control of the Air. Invoking Lanchester's Laws for attrition warfare this yields a decisive advantage for the attacking side.

The implementation of this model can take a range of forms. The most practical proposition at this time is to equip multirole fighter aircraft with the capability to locate and destroy hostile radar systems, be they surface based or airborne. The use of multirole fighter aircraft which can be swung from counter-air to strike missions has proven its worth in the established model, as these allow the application of a maximum concentration of force in each of the respective campaigns. Expanding the capabilities of multirole aircraft to encompass Electronic Combat merely extends this principle to achieve an analogous objective.

While the use of multirole aircraft will allow the maximum weight of fire to be applied in the opening phase of a campaign, their use will not diminish the need for specialised assets such as SEAD platforms equipped with Emitter Locating Systems and ARMs, or Support Jamming platforms capable of disrupting the operation of radar equipment and communications. Rather the combined use of the two classes of asset will allow for maximum concentration of force as required, while retaining the capability to deal with particularly sophisticated threats where necessary.

Whether an air force chooses to adopt Electronic Combat as a campaign, or treat it as a supporting role, there is no doubt that the pursuit of control of the electromagnetic spectrum is a worthwhile strategic objective which offers considerable payoff in the subsequent pursuit of the established campaigns.

Part 2
An Electronic Combat Doctrine for the RAAF

5. Introduction

The RAAF's AAP 1000 Air Power Manual treats Electronic Combat (EC) as as the two disjoint roles of Electronic Warfare and SEAD, supporting the three traditional campaigns. As it has been previously argued, the greatest impact upon an opponent's warfighting capability is achieved by the systematic and coordinated application of Electronic Combat operations toward the central objective of commanding the electromagnetic spectrum. This central objective can be be structurally divided into lesser but typically mutually related objectives.

6. Objectives of Electronic Combat Operations

The principal objectives of Electronic Combat operations are to deny an opponent the use of the electromagnetic spectrum and to prevent the opponent from denying the use of the electromagnetic spectrum to the RAAF. Electronic Combat operations will focus on the following specific objectives:

• disruption or destruction of the opponent's command, control and communications links and facilities (C3).

• disruption or destruction of the opponent's electromagnetic surveillance capabilities.

• disruption or destruction of the opponent's electromagnetic acquisition and targeting capabilities.

• disruption or destruction of the opponent's electronic combat capabilities.

7. Relationship of Electronic Combat to the Major Campaigns

Electronic Combat operations serve the purpose of creating a combat situation where the RAAF's opponent cannot utilise his electromagnetic means of communication, surveillance, targeting and electronic combat and thus cannot conduct a air control, air strike and combat air support campaign or electronic combat operations in support of these.

In relation to the Air Control campaign (OCA/DCA), Electronic Combat operations will concentrate on the following general objectives:

• Deny the opponent the use of ground to air, ground to ground and air to ground communications used to support offensive and defensive counter air operations. The opponent will thus lose the ability to coordinate and control offensive and defensive air operations, thus rendering his aircraft susceptible to RAAF counter air operations, both on the ground and in the air.

• Deny the opponent the use of radar surveillance and early warning of all frequency bands, airborne, shipborne and ground based. The opponent will thus lose the ability to detect RAAF aircraft flying counter air operations against the opponent's airborne aircraft, aircraft on the ground, air base facilities, air defence facilities and air operations support infrastructure.

• Deny the opponent the use of fire control sensors of all frequency bands, airborne, shipborne and ground based. The opponent will thus lose the capability to acquire, track and target RAAF aircraft engaged in counter air operations.

• Deny the opponent the use of weapon guidance systems in all frequency bands. The opponent will thus lose the capability to engage RAAF aircraft with airborne, shipborne and ground based guns, missiles and directed energy weapons.

Electronic Combat operations will aim to achieve the following strategic and operational objectives in relation to the Air Control campaign:

• Render the opponent incapable of conducting all air operations under any form of control other than prebriefed small unit operations, thus reducing the concentration of the opponent's offensive and defensive air capability.

• Prevent the opponent from understanding the strategic and operational situation in real time and near real time to force the opponent to react inappropriately or not to react at all to RAAF OCA operations.

• Prevent the opponent from concentrating air defences at a strategic and operational level to hinder RAAF OCA operations.

• Prevent the opponent from interfering with the operation of ADF surveillance and targeting sensors.

Electronic Combat operations will aim to achieve the following tactical objectives in relation to the Air Control campaign:

• Provide RAAF aircraft flying OCA operations with the element of surprise and deny the opponent the understanding of the tactical situation at hand, ie introduce a maximum of confusion in the planning and implementation of offensive air and air defence operations.

• Prevent the opponent's airborne and surface based air defences from functioning properly and thus disadvantaging them in direct engagements with RAAF aircraft flying OCA operations.

In relation to the Air Strike campaign, Electronic Combat operations will concentrate on the following general objectives:

• Deny the opponent the use of ground to air, ground to ground and air to ground communications used to support defensive counter air operations. The opponent will thus lose the ability to coordinate and control defensive air operations, thus rendering him unable to engage RAAF aircraft conducting Air Strike operations.

• Deny the opponent the use of radar surveillance and early warning of all frequency bands, airborne, shipborne and ground based. The opponent will thus lose the ability to detect RAAF aircraft conducting Air Strike operations.

• Deny the opponent the use of fire control sensors of all frequency bands, airborne, shipborne and ground based. The opponent will thus lose the capability to acquire, track and engage RAAF aircraft conducting Air Strike operations.

• Deny the opponent the use of weapon guidance systems in all frequency bands. The opponent will thus lose the capability to directly engage RAAF aircraft with airborne, shipborne and ground based missiles, directed energy weapons and radar or electrooptically aimed guns.

Electronic Combat operations will aim to achieve the following strategic and operational objectives in relation to the Air Strike campaign:

• Render the opponent incapable of conducting all air defence operations under any form of control other than prebriefed small unit operations, thus reducing the concentration of the opponent's defensive air capability.

• Prevent the opponent from understanding the strategic and operational situation in real time and near real time to force the opponent to react inappropriately or not to react at all to RAAF Air Strike operations.

• Prevent the opponent from concentrating air defences at a strategic and operational level to hinder RAAF Air Strike operations.

• Prevent the opponent from interfering with the operation of ADF air to ground weapon delivery sensors.

Electronic Combat operations will aim to achieve the following tactical objectives in relation to the Air Strike campaign:

• Provide RAAF aircraft flying Air Strike operations with the element of surprise and deny the opponent the understanding of the tactical situation at hand, ie introduce a maximum of confusion in the planning and implementation of air defence operations.

• Prevent the opponent's airborne and surface based air defences from functioning properly and thus disadvantaging them in direct engagements with RAAF aircraft flying Air Strike operations, or fighter escorts covering such aircraft.

The relationship between Electronic Combat operations and Combat Air Support is similar to the relationship between Electronic Combat and Air Strike, in that the disruption or removal of surveillance and air defence capabilities will hinder the enemy's attempts to counter RAAF operations in these areas.

8. Technical Means

The technical means for conducting systematic Electronic Combat operations can be functionally divided into the following categories:

9. Defensive Electronic Warfare Equipment:

Defensive Electronic Warfare equipment serves the purpose of warning aircraft of impending attack, or attack in progress, and defeating the attacking system's sensors by electromagnetic means. Because of the often complex nature of the modulations imposed upon electromagnetic emissions specific to given threat systems, and the presence of ECCM or OECCM capabilities in these systems, defensive Electronic Warfare equipment must be specifically configured to deal with these systems. While generic Electronic Warfare techniques can be used, their effectiveness is most often lesser than that of specific techniques, tailored to the idiosyncrasies of the threat system to be dealt with.

Therefore it is preferable that the opponent's Electronic Order of Battle (EOoB) is known beforehand and specific threat system parameters accounted for in the configuration of Defensive Electronic Warfare equipment and systems. This configuration can be by means of hardware changes or software changes. In most instances, generic Electronic Warfare hardware can be configured to deal with particular threat emitters by introducing threat specific changes to the software which controls the hardware of such Defensive Electronic Warfare equipment or systems.

Defensive Electronic Warfare equipment and systems can be broadly divided into the following categories:

• **Radar Warning Receivers (RWR) and Radar Homing and Warning Systems (RHAWS)** are devices which detect, analyse and classify emitters, to provide the crew of an aircraft with an indication of the type, direction or location and operating mode of the emitter. This information can provide the pilot with a warning of an impending attack or an attack in progress, to allow the use of DECM, expendables or evasive manoeuvre. Where a homing capability is present, the aircraft can also locate an emitter for defensive counterattack. Many RWRs can also provide this information to onboard DECM systems or countermeasures dispensers to assist in defeating the emitter.

• **Optical Warning Receivers (OWR)** are devices analogous to RWRs, but operating in the optical frequency bands. These are typically laser warning receivers, designed to detect the emissions of pulse mode laser rangefinders used in airborne or surface based fire control systems (eg contemporary systems such as the Fulcrum and Flanker fighters, or some point defence missile systems), or the emissions of laser beamriding SAM guidance systems.

• **Missile Approach Warning Systems (MAWS)** are devices which employ optical or radar means to detect the approach of guided missiles. Optical MAWS will typically detect the emissions from a missile plume and yield angle information only, whereas radar MAWS will actively transmit radar pulses to detect a return off the missile itself, yielding angle and range information. The selection of a specific type of MAWS will depend strongly upon the nature of the missile threat, as the functional advantages of radar based systems must be balanced against their greater detectability through emissions.

• **Defensive ECM (DECM)** are devices which defeat threat emitters by electronic means. Defensive electronic techniques can be be divided, broadly, into noise jamming techniques which conceal the aircraft's radar return, or trackbreaking techniques which interfere with the angle and range tracking facilities of a threat system, to deny a fire control solution. DECM equipment will typically perform the trackbreaking function, but may also use combined trackbreaking and noise jamming techniques.

• **Defensive OptoElectronic CounterMeasures (DOECM)** are analogous devices to DECM devices, but

operating in the optical frequency bands. These devices typically apply trackbreaking techniques against the optoelectronic trackers used in missile seekers or in fire control systems.

• **Expendables** are items which are ejected from an aircraft to either seduce a threat system, as in the instance of flares or expendable repeaters, or conceal the friendly aircraft, as in the instance of chaff. Expendables may defeat electromagnetic sensors in the radar and optical bands.

• **Towed Decoys** are typically deception repeaters designed to seduce the seekers of homing missiles, thereby causing them to home in on the decoy and detonate at distances where their warheads cannot inflict fatal damage on the towing aircraft. Compared to expendables, towed decoys have the advantage of presenting the threat seeker with identical dynamic characteristics to the moving target, thereby defeating ECCM features based on target velocity.

• **Proximity Fuse Jammers** are devices which emit signals designed to cause premature detonation of a missile's warhead. These typically operate against radio or radar proximity fuses, and can be described as a form of deception jammer.

• **Low Observable Technology** or **Stealth Measures** are those means which reduce the detectability of an aircraft to hostile sensors. These are typically airframe shaping and detail shaping combined with the use of Radar Absorbent Material for skins and structures, to defeat radars, and engine exhaust design features which conceal the hot end of the engine and cool the exhaust efflux, to defeat optoelectronic sensors in the infrared band. Camouflage paint can further assist in concealing the aircraft to visible band sensors, by reducing contrast ratio against the background.

10. Offensive Electronic Warfare Equipment:

Offensive Electronic Warfare equipment and systems are those items which are applied specifically to the purpose of conducting offensive Electronic Combat operations. Much like defensive Electronic Warfare equipment and systems, these perform best when threat emitter specific.

• **Electronic Support Measures (ESM)** are reconnaissance and targeting sensors. These are typically sensitive long range receivers with the ability to detect, identify, locate and classify emitters, and record emitter parameters for either post mission analysis, or real time targeting.

• **Support Jammers (SJ)** are devices or device equipped platforms equipped with jamming equipment. These jammers are typically designed to counter early warning, surveillance and acquisition radars with noise jamming and false target generation techniques. Support jammers are a means of disrupting or inhibiting the function of an air defence system at a strategic, operational and tactical level.

A specialised class of SJ systems are escort jammers, which are tactical aircraft fitted with SJ devices and tasked with penetrating contested airspace together with aircraft conducting OCA and Air Strike operations.

• **Communications Jammers (ComJam)** are devices or device equipped platforms specialised for the purpose of jamming communications links in given frequency bands. Communications Jammers are a means of disrupting air defence operations at a strategic, operational and tactical level.

• **ElectroMagnetic Pulse Weapons** are devices which produce a localised intensive EMP effect to disable or damage electronic equipment. The effect of EMP is of a temporary hard kill, requiring repairs to equipment, but not destroying equipment in the manner of conventional munitions. Non-nuclear EMP weapons are at the time of writing items still in development.

11. SEAD Equipment

Equipment applied to the SEAD role within Electronic Combat operations are those items with capabilities specialised to the purpose of locating emitters for direct attack. Again, these perform best when threat specific.

• **Emitter Locating Systems (ELS)** are specialised ESM devices designed to not only detect, identify and classify emitters, but also to precisely locate their position in real time for the purpose of direct attack with guided or unguided munitions.

• **Anti Radiation Missiles (ARM)** are a means of direct attack on radiating emitters from standoff ranges, with rapid response times to deny the operator time to decide on a shutdown. The use of ARMs allows selective attack on emitters without the requirement to close to visual range for direct attack with conventional PGMs or unguided munitions. ARMs may attack directly, or loiter via aerodynamic means in the vicinity of a shut down emitter to engage it when it commences emitting again.

Other munition types may also be adapted to the task of attacking emitters by fitting them with passive anti-radiation homing seekers. Anti-radiation cruise missiles, bombs or glidebombs offer the potential for greater killing capability than ARMs by virtue of larger warheads, but may be penalised in kill probability by virtue of longer flight times to impact. Such munitions can benefit from the application of hybrid seekers, using a passive anti-radiation device to cue a television imaging or thermal imaging seeker. The imaging seeker would then use contrast lock techniques to track the emitter if it goes off the air.

12. Airframes

The small number of RAAF air assets will always be a constraint to the development of a dedicated Electronic Combat capability. Therefore careful consideration must be applied to the selection of new aircraft types, and to capability upgrades in existing types, to ensure that a nominated fraction of airframes in the inventory can be fitted or are fitted with equipment to support Electronic Combat operations.

Basic ESM systems for instance can be fitted to all maritime recce airframes, with some receiving additional equipment to further enhance their capabilities, such as Comint receivers and precision emitter locating systems. There is a case for fitting out a small number of airframes as dedicated Elint platforms, and if possible concealing the appearance of these to emulate the basic aircraft.

All tactical airframes should be capable of carrying specialised SEAD weapons such as ARMs or other weapons with anti-radiation seekers. A small fraction of the fighter force, preferably two seat aircraft, should be further equipped with an Emitter Locating System with substantially better direction finding and homing capability than the RWR/RHAW system fitted to the standard aircraft. Integration of such an Emitter Locating System with whatever is the standard ARM in use would be essential.

The use of low observable technology airframes for Air Strike operations is preferable to the adoption of multirole conventional airframes, as low observable airframes reduce the need for supporting DCA and SEAD operations during the initial phase of the Air Control campaign. This allows SEAD assets to be tasked with targets of strategic importance, rather than diverting them to cover strike assets, similarly assets tasked with DCA may be more productively applied to OCA.

Low observable technology airframes may also be productively used in SEAD operations, as their ability to evade radar and optical defensive systems allows them to penetrate deep into contested airspace without prior warning of approach, allowing them to destroy assets such as AEW, strategic C3 sites and strategically important air defence sites.

13. Operations

The conduct of Electronic Combat operations requires both careful preparation and concurrency in execution. Preparation for operations will require reconnaissance and intelligence activity to establish the enemy EOoB, to allow the specific configuration of DECM, SJ, ComJam and munitions to the expected hostile capabilities. As the lead time in updating the software in Electronic Warfare systems can be considerable, and knowledge of threat systems may be incomplete, establishing the EOoB is of paramount importance so as to maximise the effectiveness of RAAF Electronic Combat capabilities.

14. Electronic Reconnaissance

Electronic Reconnaissance serves the purpose of gathering information on the composition, deployment and operational usage of hostile electronic assets. Electronic Reconnaissance is comprised of Elint and Comint operations.

15. Elint Operations

Elint operations are the primary means via which the enemy EOoB is established. Elint operations involve positioning ESM equipped platforms so that these may monitor hostile emissions, to establish the geographical location and type of hostile equipment deployed. An opponent well versed in Electronic Combat techniques will be reluctant to disclose his EOoB by activating equipment, therefore it may be necessary to feint tactical operations or violate contested airspace to force him to do so.

Elint operations therefore involve an essential element of provocation, therefore they must be controlled at a strategic or operational level so as to ensure that their effects are not interpreted as the initiation of full scale hostilities.

Elint operations will be aimed at sensor emissions, and in addition to yielding information on the EOoB, may also yield useful information on enemy operational procedures and state of readiness at a strategic, operational and tactical level.

The information gained through Elint operations must be consolidated in a systematic fashion, to ensure that a comprehensive picture of enemy capability is produced, and any uncertainties in the types of hostile equipment deployed can be unambiguously established. This applies particularly to the identification of unknown systems, as the ability to counter these with specific techniques is lesser and therefore they represent a potentially greater level of threat to RAAF platforms.

16. Comint Operations

Comint operations are the primary means via which enemy communications frequencies and the location of fixed transmitters are established. Comint operations will typically be conducted concurrently by platforms carrying out Elint operations. As with Elint, the productive situations for collection of Comint are during periods of peak air defence activity, and therefore are subject very much to the same constraints as Elint.

In addition to yielding information on the composition and deployments of hostile communications equipment, Comint may further yield incidental intelligence through the content of the transmissions intercepted and thus can also be a means of Sigint, although this is not its primary purpose.

An important aspect of Electronic Reconnaissance operations is timely distribution of its results to concerned users, as the EOoB is by its nature dynamic in time. The frequency of Elint and Comint sorties must be adjusted to the opponent's capacity to move assets, to ensure that the time interval between sorties is shorter than the time to redeploy the assets. Ideally Nyquist's sampling theorem should be applied in such situations.

The use of spaceborne platforms can be of great use, particularly if these occupy a geostationary orbit, as these may monitor the area of interest continuously.

17. Offensive Electronic Warfare Operations

Offensive Electronic Warfare operations serve the purpose of disrupting the function of hostile communications and sensors, at a strategic, tactical and operational level. Offensive Electronic Warfare operations must be performed concurrently with SEAD operations, to maximise the effect of mutual support. Concurrency also applies to OCA and DCA operations, which will also mutually support offensive Electronic Warfare and SEAD operations.

The execution of offensive Electronic Warfare operations can involve standoff jamming and deception, or alternately the penetration of contested airspace by suitably equipped Electronic Warfare platforms.

Noise jamming techniques can be applied against early warning radar, surveillance and acquisition radar, communications and navaids to degrade the operation of these devices or systems. Deception techniques can be applied against radars to produce the illusion of aircraft or formations thereof where none exist, to confuse the opponent or to force him to commit his defences unproductively. Deception techniques can also be applied to communications, by retransmitting commands or transmitting false commands, with similar objectives. Navaids may also be productively jammed by deception techniques, to cause the opponent unpredictable navigation errors and hence disrupt the conduct of air operations. NH Decoys, RPVs and Autonomous Vehicles

Offensive Electronic Warfare operations can be further supported by the use of decoys, Remotely Piloted Vehicles and Autonomous Vehicles, which simulate real aircraft. This is essentially a deception technique, designed to force an opponent to commit his defences unproductively, and to activate defensive systems to betray their location and type for the purpose of SEAD operations. Decoys, RPVs and Autonomous Vehicles may be ground launched or air launched. While ground launched devices are cheaper to operate, they suffer a range penalty in comparison with air launched devices, which may be air delivered to the boundaries of contested or hostile airspace.

18. SEAD Operations

SEAD operations are an essential element of Electronic Combat operations, as they are the means via which attrition is inflicted upon the opponent's air defence assets and other supporting electronic assets.

SEAD operations will be conducted by tactical aircraft fitted with suitable emitter locating systems and equipped with munitions appropriate for the target. Emitters may be attacked with ARMs or with other guided or unguided munitions. Air defence equipment may be attacked with a combination of munitions, using the ARM to disable the system and then using other munitions to destroy it and its associated equipment, such as AAA or SAM systems.

A necessary principle of SEAD operations is establishing a priority for targets.. The first priority is to destroy early warning and acquisition radars, then to destroy area defence SAM radars and systems and finally to destroy point defence systems. This achieves the dual objectives of disrupting the function of the hostile air defence system from the outset, and of destroying first those systems with the greatest capacity to deny the use of airspace.

A fundamental rule can therefore be established: the first priority in SEAD operations is the destruction of systems of importance at a strategic level, followed by systems of importance at an operational level and finally by systems of importance at a tactical level.

Priority must be therefore be accorded to the destruction of AEW platforms and airborne command posts, as these systems are the opponent's most effective early warning and C3 assets and must be considered strategic assets.

Concurrency with offensive Electronic Warfare operations is essential, as the opponent's capacity to concentrate his weight of fire is degraded or inhibited by the effects of offensive Electronic Warfare operations. This will force the opponent to activate a larger number of his electronic assets to overcome the effects of offensive Electronic Warfare, thereby exposing these assets to RAAF aircraft conducting SEAD operations.

Concurrency with OCA operations is also essential, in that the opponent will be forced to commit assets to engage aircraft conducting offensive Electronic Warfare and SEAD operations, this providing an opportunity for RAAF aircraft conducting OCA to engage these aircraft under favourable conditions of degraded GCI capability and operational situational awareness.

SEAD operations must be actively prosecuted until the opponent loses the capability to inflict meaningful attrition upon RAAF air assets. Once this is achieved, aircraft designated for the SEAD role may, if suitable, be applied to Air Strike and Counter Air operations.

19. The Use of Defensive Electronic Warfare Equipment

While the application of offensive Electronic Warfare operations will disrupt or inhibit the function of an air defence system, they need not prevent individual hostile systems from engaging RAAF aircraft involved in the conduct of offensive Electronic Warfare, SEAD, combat air support, OCA and DCA operations.

Therefore all aircraft must be equipped with suitable defensive Electronic Warfare equipment to minimise the likelihood of losses to hostile fire. Aircraft tasked with penetrating hostile airspace or contested airspace must have the capability to detect attacks by radar guided and optically guided weapons, this by means of suitable RWR, OWR and MAWS devices. Similarly all aircraft so tasked must also carry suitable DECM and DOECM devices to defeat probable threat systems.

The use of defensive Electronic Warfare equipment provides another element of concurrency in the conduct of Electronic Combat operations, by degrading or inhibiting the function of individual hostile systems, thus preventing them from defending air defence assets or themselves.

20. The Application of ECCM and OECCM

The conduct of Electronic Combat operations may not prevent an opponent from conducting his own Electronic Combat operations, therefore RAAF systems must be provided with ECCM and OECCM capabilities appropriate to the threat at hand. Because an opponent's Electronic Combat capability may not be apparent from Elint operations, other sources of intelligence will be required to supplement those available through the conduct of Electronic Combat operations.

It is imperative that instances of target acquisition sensors and seekers failing to operate correctly be treated seriously, to reflect the possibility that the opponent has acquired ECM or OECM capable of defeating these systems. Should such instances prove repetitive, Elint or special operations to capture hostile equipment must be carried out to establish the cause.

An inability to introduce suitable ECCM and OECCM in target acquisition sensors and weapon seekers may render these unusable, therefore RAAF acquisition policy must require not only full disclosure of the technical parameters of such equipment by the vendors, but also provision of software and where possible also hardware support domestically.

The RAAF should aim to have the means of rapidly introducing ECCM or OECCM in those systems which are used in significant numbers.

21. Emission Control (EMCON)

The control of friendly emissions is of great importance, to deny an opponent information on the RAAF's EOoB, and on the conduct of operations in progress. Controlled use of emissions can also be used as a deception technique against hostile Elint operations, to create a false image of the actual RAAF EOoB.

A fundamental aspect of the controlled use of emission for deception is that it be controlled at an operational or strategic level, to ensure that the target of the deception receives the correct input. Successful deception will require multiple channels of mutually supporting deception, therefore additional items such as dummy radar systems may be required to defeat optical reconnaissance or land based intelligence operations.

22. The Use of Deception

The use of deception at a strategic, operational and tactical level should be encouraged. Deception can involve controlled use of emissions (4.7) but can also involve selective application of force to create a false impression of the RAAF's intentions at a strategic, operational and tactical level.

The availability of offensive Electronic Warfare equipment provides a powerful means of enhancing conventional operational or tactical deceptive measures by focussing the opponent's attention on chosen areas, or by degrading the performance of early warning and acquisition radars such that they cannot see all inbound aircraft.

23. Command and Control of Electronic Combat Operations

The strategic nature of much of Electronic Combat operations requires its control at a strategic level, to ensure that concurrency with the OCA and strategic strike components of the Air Strike campaign can be maintained.

The need to coordinate with these campaigns and their respective components dictates the requirement for a command structure which can flexibly task assets to maximise the benefit of concurrency, and ensure that the objectives of Electronic Combat operations and the Air Control campaign are prosecuted first and foremost. Diversion of assets to other campaigns could dangerously reduce the weight of fire applied to Electronic Combat operations, which must be followed through until the opponent is fully open to air attack, to derive the fullest benefit from the commitment of resources.

The need to integrate Electronic Combat operations with strategic deception further dictates the requirement for centralised control.

The organisational structure must include a specialised organisation to evaluate intelligence acquired through Elint, Comint and conventional means to ensure that this information is provided to users in a structured and useful format. This organisation would provide support to Electronic Combat Officers at a squadron level, who would also be responsible for gathering Electronic Combat related intelligence at this level and forwarding it to the central organisation.

24. Technical Support of Electronic Combat Operations

The nature of Electronic Combat is technological and the RAAF should aim to keep abreast or ahead of contemporary operational and technological practices in the discipline to ensure that the qualitative advantage is not lost. In supporting systems in use the RAAF should have the capability to modify all software used in such systems and where appropriate, provide for a domestic capacity to manufacture or modify specific items of hardware.

The capability to fully support the internal software employed in equipment used for Electronic Combat operations is a basic requirement for the successful conduct of operations, as it provides the ability to adapt to an opponent's evolving ECCM and OECCM capability, and his acquisition of newer assets. The aim should be toward the capability to introduce software changes in a timescale comparable to the time to modify the program and test it, all of which must be conducted in a secure environment.

Failure to provide such a capability could result in effective block obsolescence of some systems upon the opponent's introduction of new capabilities, as the timescale to have such changes introduced overseas by the original suppliers may be comparable to or greater than the duration of the conflict to be fought. In the context of a larger confrontation, even if less likely, the original suppliers' priorities will be oriented toward his own capabilities and this will further extend the timescale for modifications.

A long term objective must be the development of an integrated environment in which the results of Electronic Reconnaissance and combat experience can be evaluated rapidly, and configuration changes to equipment implemented immediately where possible. This requires both central infrastructure and suitably trained personnel and equipment at a squadron level, so that modified software can be loaded at any major operational site during the conduct of combat operations.

At a squadron or operational level there will be a need for an on site automated mission planning system and tactical database which can integrate data from the central source and from immediate reconnaissance in the area of operations. The information thus produced can be used not only by units directly involved in the Electronic Combat campaign, but also by units involved in the OCA and Air Strike campaigns.

25. Personnel

All units with a combat function should have a specialised Electronic Combat Officer (ECO), in addition to any operations planning staff. The role of this officer should be to ensure that aircrew and maintenance personnel are provided with expert advice and assistance in operational planning, the use and support of equipment, and that relevant Electronic Combat related intelligence is both gathered and also as required distributed. ECOs should have a tertiary degree in electronic engineering or physics, in addition to specialist training, to ensure that their standard of technical judgement is high, and depth of knowledge in the discipline sufficient to the task.

In addition, those units tasked with Electronic Combat operations should have appropriately qualified aircrew to operate specialist equipment. All combat aircrew should be provided with basic training in Electronic Combat principles and tactics, with all operational commanders receiving training in the principles of Electronic Combat operations and warfighting strategy. This is necessary to ensure that aircrew and operations staff involved in all air campaigns appreciate the requirement for mutual support of the campaigns, and understand how it will assist in the pursuit of the objectives of their campaign.

26. Summary:

This paper has argued the case for an Electronic Combat Campaign and has proposed a structure for an Electronic Combat doctrine for the RAAF. This structure has been developed in more detail than the existing doctrinal elements in the AAP 1000 manual, primarily to clarify the reasoning behind specific items. Further study is needed to more closely define the required command and control structures, and the relationships between the proposed specialised entities and the existing structure of the RAAF.

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APPENDIX A:

Definitions

Electronic Warfare is the use of electromagnetic energy to determine, exploit, reduce or prevent hostile use of the electromagnetic spectrum and to retain friendly use of that spectrum. Electronic Warfare (EW) is a soft kill means of commanding the electromagnetic spectrum, in that the hostile systems remain physically intact and capable of function upon cessation of the application of Electronic Warfare means.

Direct Attack with lethal weapons is a hard kill means of commanding the electromagnetic spectrum, in that the hostile systems will sustain physical damage or be destroyed by direct attack.

Electronic Combat (EC) is the use of soft and hard kill means to determine, exploit, reduce or prevent hostile use of the electromagnetic spectrum and to retain friendly use of that spectrum.

Anti Radiation Missiles (ARM) are high speed precision guided munitions which home in on specific sources of electromagnetic energy to destroy them.

An **Emitter** is any source of electromagnetic energy. A Threat Emitter is any emitter associated with a weapon system with the capability and intent to destroy a friendly platform.

A **Modulation** is a specific and controlled change in the electromagnetic or spatial parameters of an emission, imposed to perform a specific function such as angle tracking or range tracking.

Electronic CounterMeasures (ECM) are electronic means via which the operation of a sensor system dependent upon electromagnetic energy can be disrupted, degraded or prevented.

Electronic Counter Counter Measures (ECCM) are electronic means via which the effect of hostile ECM can be reduced or eliminated.

OptoElectronic CounterMeasures (OECM) are optical, optoelectronic means via which the operation of a sensor system dependent upon electromagnetic energy n the optical bands can be disrupted, degraded or prevented.

OptoElectronic Counter Counter Measures (OECCM) are optical, optoelectronic or electronic means via which the effect of hostile OECM can be reduced or eliminated.

ElectroMagnetic Pulse (EMP) is a physical effect which can cause irreversible damage to electronic equipment, particularly computers and receivers used in radar and communications equipment. EMP can be produced by nuclear or non-nuclear means.

APPENDIX B:

Electronic Combat and Alternative Doctrinal Classifications

The preceding discussion has argued the case for an Electronic Combat Campaign, based upon both historical evidence and fundamental principles of air war strategy. It has shown that the evolution of air defence technology has altered one of the fundamental assumptions underpinning the established Western strategy for conducting an air war, and how the introduction of an Electronic Combat Campaign into the established model can yield a decisive advantage in the prosecution of the established air war campaigns.

There are two alternative models for the doctrinal integration of Electronic Combat which will be discussed here. The question is, whether the highest payoff is achieved by treating Electronic Combat as a campaign, or integrating it into existing or alternate new campaigns.

The established strategy involves treating Electronic Combat as supporting operations to the classical campaigns, and RAAF doctrine classifies elements of Electronic Combat as a role supporting the three principal campaigns. The central argument underpinning this approach is that much of the final objective of Electronic Combat operations is a situation which furthers the objectives of the Air Control, Air Strike and Combat Air Support Campaigns. Superficially, this is the case, but a more careful examination of the scope of EC, as defined in this paper, indicates that the end result of a successful Electronic Combat Campaign spans a much wider area than that covered by the classical campaigns. By classifying Electronic Combat as a role supporting the three campaigns, it is very likely that the objectives of Electronic Combat will be subjugated to the purpose of other campaigns and this could prevent the central objective from being achieved by diverting assets before command of the electromagnetic spectrum is achieved.

Another alternative classification for Electronic Combat is as a component of a C3I Campaign. A C3I Campaign pursues the objective of crippling an opponent's Command-Control-Communications and Intelligence structures. While a C3I campaign has only ever been postulated, and at this time does not exist as a structural element of any established doctrine, it is a concept with some merit. The objective of a C3I Campaign is a situation where the opponent is substantially paralysed due to the destruction of command posts and severing of communications channels between command elements, intelligence and surveillance elements and operational fighting units.

It is clear that the objectives of a possible C3I campaign overlap with many of those pursued in an Electronic Combat Campaign. However, the same counterargument as applied to the case of Air Control Campaign applies also in this instance. The C3I campaign is by its nature narrower in scope than the Electronic Combat Campaign proposed herein, and the application of Electronic Combat assets to such a campaign would most likely lead to an analogous result, that is of a situation where an opponent has suffered major damage to his warfighting capability but still retains command of portions of the electromagnetic spectrum, thus allowing him to conduct operations, albeit with substantially degraded capability.

There can be no doubt that the C3I campaign can be a most effective strategy for dealing with an opponent who employs a highly centralised C3I system, an instance being the former Warsaw Pact and any parties who have adopted its doctrine. However, the payoff in effort expended versus results achieved will decline rapidly when the opponent has a more decentralised C3I structure. An opponent who has substantially decentralised his C3I and built in much redundancy in communications channels, both up and down and across chains of command, will be far less susceptible to a systematic C3I Campaign. However, once such an opponent loses command of the electromagnetic spectrum, any residual capability in his C3I system may be of limited use once warfighting elements lose much of their functional capability.

Vincent [4] applies a useful biological analogy to describe the C3I campaign, that being the model of severing nerves in a body thereby paralysing the victim. Applying this model to the Electronic Combat Campaign proposed here produces the effect, whereby Electronic Combat in effect emulates a nerve agent which inhibits the function of all nervous tissue including sensory organs. In doing so, the option of bypassing severed junctions to restore communications is no longer possible, as no alternate real time paths are available, while sources of real time information at all levels are inhibited in function.

Ultimately it is an argument of granularity. Is it better to isolate larger components or smaller components to achieve paralysis ? The case for isolating larger components is that of economy of effort. However, with increasing decentralisation of the opponent's C3I system this argument will progressively weaken.

The argument for isolation at an elemental level is therefore stronger, as it encompasses a wider range of situations. Ultimately, a successful Electronic Combat Campaign will create a situation where a platform and its guided weapons are mutually isolated thereby rendering them totally ineffective. It follows therefore that an Electronic Combat Campaign is a more effective strategy than a C3I Campaign, as its effects are more general and less sensitive to the idiosyncrasies of the opponent's C3I structures.