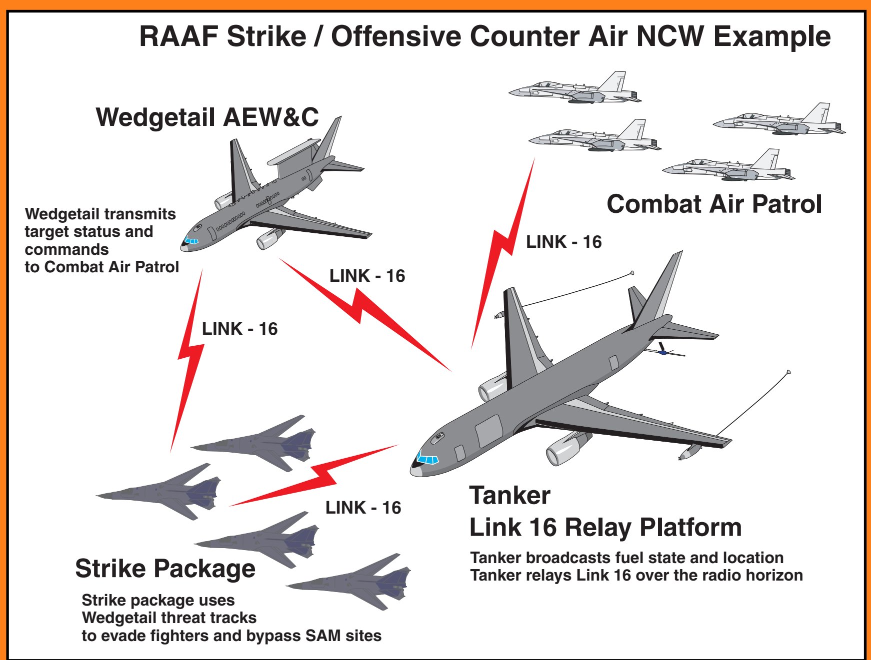
NCW

buzzwords, bytes and the battlespace

Dr Carlo Kopp



A 'Wedgetail' AEW&C aircraft relays ISR data and commands to a tanker and multiple fighter CAPs. The RAF first introduced the use of JTIDS on tankers, providing both a relay capability to extend the coverage footprint, but also permitting tankers to advertise their fuel status information to fighters. The model has now been adopted by the US Air Force in the 'SMART tanker' scheme where KC-135R and KC-767 tankers will be equipped with palletised JTIDS and other communications relay nodes. Benefits seen in Defensive Counter Air translate directly into Offensive Counter Air and Strike operations. Strike aircraft equipped with JTIDS/Link-16 can be provided with a continuously updated wide area picture of air defence threats, particularly fighters and hostile radar emitters. This facilitates evasion of these threats, improving survivability.

"NCW provides a mechanism to accelerate targeting and engagement cycles, but without the Intelligence Surveillance and Reconnaissance assets plus persistent firepower delivery assets to exploit the engagement cycle improvements its utility is of dubious value in itself."

Dr Carlo Kopp

NCW in Air Defence Operations

Air warfare is the first area in which we have seen the widespread use of early NCW techniques, both in air defence roles and in strike warfare. The results achieved to date, even with relatively rudimentary capabilities, have been the impetus behind the drive to introduce NCW capabilities on more platforms and also to develop more advanced technology for this role.

Air defence operations were the first to see broader introduction of networked data capabilities, when the Joint Tactical Information Distribution System (JTIDS)/Link-16 time division multiplex system was adopted. Until then interceptors were mostly controlled by voice, but by the 1970s this became unusable for the expected air battles over the NATO-WarPac FEBA in Central Europe due to the intense jamming environment and sheer density of traffic. With the expectation that both sides would put hundreds of fighters up concurrently, voice control of interceptors would be untenable.

The jam resistant JTIDS and its Link 16 messaging format thus became the first 'networking' scheme adopted for air defence operations, as earlier systems were essentially point-to-point uplinks allowing ground control to vector interceptors. JTIDS entered development in the early 1980s.

An AWACS would typically control a Link 16 network, with time slots in the messaging scheme allocated to flights or individual aircraft equipped with onboard terminals. A first generation Link-16 installation would use a dedicated cockpit display which would graphically present the message broadcast by either the AWACS or a ground station. Messages could vary from text strings to Plan Position Indicator (PPI) diagrams showing the locations and states of friendly and hostile fighter aircraft. Many JTIDS terminals fitted to fighters are 'receive only', enabling fighters to listen passively for messages but not send any.

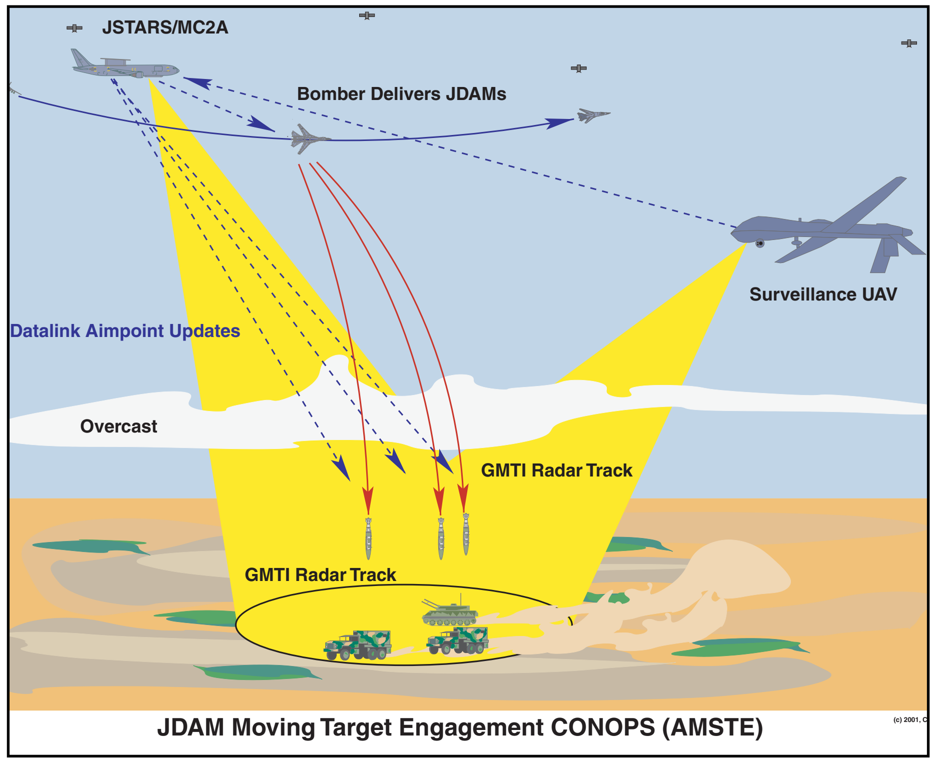
The transition from voice control to JTIDS has produced notable advances in tactics: fighters can operate in radio and radar silence listening for AWACS commands via JTIDS or monitoring the tactical situation via JTIDS. Radars light up only once the fighter is ready to shoot to provide a missile solution and midcourse guidance updates to the missile once it is launched. Many anecdotal tales exist describing exercises in which fighters and AWACS equipped with JTIDS wiped out their exercise opponents using fighters and AWACS not yet fitted with JTIDS.

First generation JTIDS systems present an important advance over voice based communications in terms of jam resistance, unambiguous and complete message transmission, and speed of transmission.

Above: Artist impression of a RAAF AEW&C 'Wedgetail' aircraft destined to play a pivotal role in any future ADF networked force.

Right: Naval ships would not only receive situational awareness information and tactical data from other sources but could also collect, process and disseminate such data across the battlespace. Ships could also provide command & control and other higher level battlespace management functions.

Below: The US Air Force envisages ultimately an NCW environment with digital connectivity through the whole ISR and striking chain, down to the smart weapon. The recent AMSTE trials saw an F-16C drop modified JDAM bombs fitted with JTIDS receivers, against moving ground vehicles. The bombs were guided to impact using JTIDS target position updates transmitted by a remote JSTARS, in effect relegating the F-16 to a UCAV-like 'dumb' delivery role.



One of the current roles envisaged for the F/A-22A is the use of its low probability of intercept (LPI) APG-77 radar and ESM receiver package as a 'horizon extender' for the AWACS, relaying the gathered data over JTIDS. The F/A-22A also carries a covert fighter-to-fighter datalink, but will also now acquire a JTIDS transmit capability to support this role.

NCW

However, many installations are not tightly integrated with the aircraft's weapon system. A pilot or weapons officer must read the JTIDS display, interpret it, and then fly the intercept based on the interpretation of the display. Even if the aircrews are free of error in processing the information, they will have to commit concentration and seconds of time to reading the display.

A second generation JTIDS installation is tightly integrated with the aircraft's mission computers running the navigation and display control software. This permits de facto data fusion by presenting the JTIDS information concurrently with information produced by onboard systems such as radar or radar warning equipment – all on the same display. A tactical situation display layout presented on a cockpit display might overlay a moving map, radar tracks of targets and RWR tracks of hostile emitters, and JTIDS data such as messages and PPI presentations of AWACS tracks with friendly and hostile aircraft positions.

The most recent fighters, such as the US Air Force F/A-22A and F-35 Joint Strike Fighter (JSF) will have such capabilities embedded.

While passive 'receive only' JTIDS terminals provide valuable capabilities in permitting rapid and wide area distribution of tactical situation data to fighters they are limited in terms of exploiting data gathered by fighters. JTIDS terminals with an active transmit capability provide the ability to relay target tracks produced by the fighter back to the AWACS.

One of the current roles envisaged for the F/A-22A is the use of its low probability of intercept (LPI) APG-77 radar and ESM receiver package as a 'horizon extender' for the AWACS, relaying the gathered data over JTIDS. With a 250+ NMI ESM horizon and 200 NMI radar detection range against larger targets, a small number of F/A-22A Combat Air Patrols can largely expand the footprint surveilled by an AWACS. The JSF has nominally such a capability, but is much less effective due to less capable sensors compared to the F/A-22A.

Left: Cockpit multi-function displays in the Gripen fighter cockpit display real-time targeting and situational awareness information to the pilot from which to make decisions about offensive and defensive counter air tactics and weapons employment, or the conduct of attacks against ground targets.

Once fighters are equipped with active transmit capability in JTIDS, the terminal can then double up as a jam resistant and hard-to-intercept supplement or replacement for military secondary radar or IFF equipment. While an IFF code could be spoofed by an opponent, the encryption facilities in JTIDS make it much harder to break into.

In practical terms, widespread introduction of integrated and active transmit capable JTIDS/Link-16 terminal capabilities in fighter fleets will produce a major improvement in air defence capabilities, as the wide area situation picture can be distributed accurately and quickly to all aircraft in an operating area. This will permit significantly greater autonomy by flight commanders or individual Combat Air Patrols.

Other capabilities also accrue. One is that air refueling tankers can be equipped with active transmit capable JTIDS terminals and can broadcast securely their orbit locations and available fuel state. A fighter CAP can quickly determine which tanker in its neighbourhood is the best prospect for a top up. The RAF were the first to introduce this model.

Although a scarce commodity in Australia, tankers are ubiquitous in the real world and this led to RAF proposals during the 1990s to use them as JTIDS relays – effectively 'horizon extenders' for the JTIDS footprint of the nearest AWACS. More recently, the US Air Force has opted to emulate this model with the 'Smart Tanker' scheme using the ROBE equipment package, which is more ambitious in its aims compared to the RAF scheme.

The paradigm produced by a JTIDS net is also valuable for strike aircraft. If equipped even with a basic 'receive only' JTIDS terminal, they can use the situational picture to evade opposing fighters.

With a 'Gods eye' view of friendly and enemy fighter positions, the safest ingress and egress routes can be rapidly chosen.

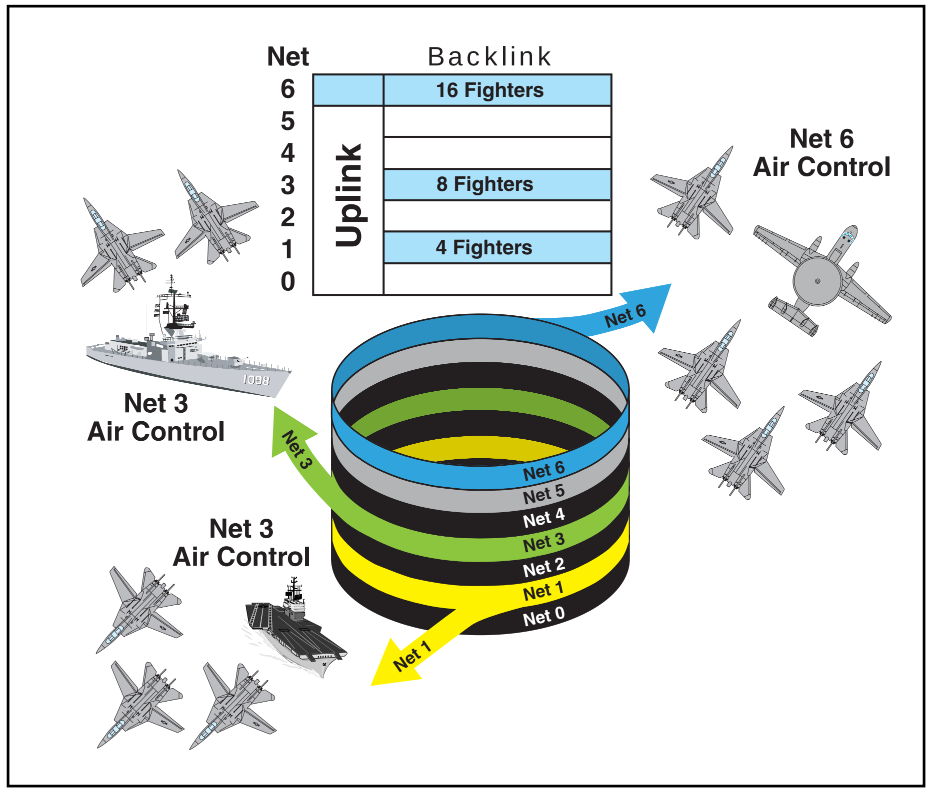
The downside of JTIDS operations has proven to be a propensity to saturate individual JTIDS nets with traffic. While this is often a result of poor planning, it also reflects the reality that a significant depth of training is required to support JTIDS operations.

The success of JTIDS has also motivated the adoption of dedicated fighter-to-fighter datalinks - also termed "inter-flight" and "intra-flight" datalinks. While this was first used on the F-14A based on a TADIL C UHF link, the most recent incarnations are much more sophisticated. The F/A-22A uses a Low Probability of Intercept digital datalink to permit F/A-22As to share situation data; target and threat emitter tracks from one aircraft can be relayed to others. A similar capability is now also planned for the JSF.

JTIDS was designed for distributing a situation picture, and coordinating the deployment of assets, especially in complex air defence environments. It is a product of the high-density air land sea battle environment of the Cold War era where 'friendlies' and hostiles were often easy to distinguish, and hundreds of aerial and surface based assets needed to be coordinated. Its limitations in this role lie in throughput and total capacity, as it is designed to best operate with large numbers of short compact messages.

In naval Anti Air Warfare (AAW) or naval air defence JTIDS is no less valuable as it provides a shared channel through which the aerial situation picture can be relayed between missile armed surface warships, effectively permitting all combatants in a Surface Action Group (SAG) to share a common view of the surrounding environment.

Above: An F-111 releases flares as a countermeasure against surface-to-air missile attack. During the 1980s the RAAF's 82 Wing trialled the 'Precision Air Support' model in which F-111s would orbit at higher altitudes over an area of interest and pick off targets using laser guided bombs, directed by a ground observer. This tactic was embryonic to the 'Persistent Strike' techniques used so successfully in Iraq.



Left: A powerful facility in the JTIDS protocol is the capacity to electronically multiplex more than one JTIDS net in a given area. This diagram illustrates the allocation of seven separate JTIDS nets within one operational area.

Ship-launched Harpoon Block II missile from the USS Decatur of the type Boeing will supply to Australia. Networking of warships with airborne ISR assets offers important gains in situational awareness and survivability.
(US Navy image)

NCW

As with the previous environment in air defence, combatants can passively receive a situation picture from other warships and thus remain radar and radio silent if need be to delay detection.

A major advantage does accrue when JTIDS is used to connect an AWACS and fighter package with a naval SAG. Surface warships suffer an inevitable and basic handicap as a result of a limited radar horizon. Depending on the radar antenna elevation above sea level, and the sea state, this can be between 15 and 25 NMI typically. Low-flying strike aircraft and cruise missiles are effectively invisible to warships until they 'pop-up' over the horizon.

Crossing the 'joint' boundary, an AWACS orbiting overhead with a JTIDS capability permits its 'Gods eye' view to be relayed down to the warship, giving the ship evasive manoeuvre options (circumstances permitting) but also early raid warning of an impending attack. In practical terms a single AWACS can provide a surveillance footprint, especially against low flying threats, vastly superior to even the largest shipboard radars. Physics cannot be beaten here.

The advantages seen in naval AAW resulting from the use of JTIDS are also repeated in land based air defence operations. Radars, missile and anti-aircraft artillery batteries or fire units can be netted together. Again, crossing the 'joint' boundary and netting into a situation picture feed from an AWACS provides like advantages to land based air defenders.

JTIDS is 1970s technology and as such has implicit limitations, especially in flexibility and throughput. Nevertheless, it has proven to be a very effective first generation technology for network centric air warfare, be it in single service or joint service operations. Future technologies such as the US Joint Tactical Radio System (JTRS) are expected to be far more flexible.

NCW in Strike Warfare

NCW technology and technique is much less evolved in strike warfare, compared with air defence environments. This reflects both technological pressures and historical operational pressures.

The digital datalink channel of choice today for NCW oriented strike operations is the Improved Data Modem (IDM) modulation and protocol, running over the Have Quick II jam resistant HF/UHF radio channel modulation. The nearest analogy to the IDM is the conventional voice-band modem running over a telephone line.

The IDM lacks much of the sophistication of the JTIDS scheme and was adopted as a quick gap-filling measure after experience in early Balkans conflicts demonstrated a need to rapidly deliver targeting coordinates from Intelligence, Surveillance and Reconnaissance (ISR) systems such as the E-8 JSTARS and RC-135V/W Rivet Joint to F-16C fighters tasked with interdiction and defence suppression tasks.

In air defence operations only targeting coordinates and target attributes need to be distributed, and in a timely and repetitive manner. In strike warfare the nature of the targets is quite different, be they emitting radars and SAM/AAA systems, or hostile ground forces. Frequently, much more information needs to be distributed to the aircraft tasked with killing the target. For instance, a hostile radar needs to be identified by type and, frequently, qualified with other information on specific operating frequencies and search patterns being emitted, to permit the attacking aircraft to acquire it faster. No differently, an enemy ground unit or camouflaged site/vehicle/position may require a bitmap image (eg JPEG) to permit the striker to unambiguously separate the target from civilian facilities nearby.

A key challenge in strike warfare is thus transmitting what might be a complex package of information required to identify a target without ambiguity. Collateral damage is used by opponents as a weapon in Information Warfare operations; therefore, precision and unambiguous targeting is essential, and not respecting this reality provides an enemy with ammunition.

The earliest implementations of the IDM model were based on the same 'centralised ISR platform plus distributed shooter' scheme seen in air defence operations using JTIDS based technology. As the technology has become more widely used and mature, we have seen other sources of targeting information such as UAVs and distant ground based analysis centres introduced into the system.

This reflects the changing nature of strike warfare. A decade ago most targets attacked by strike aircraft were static or 'semi mobile', regardless of whether they were strategic or battlefield targets. Aircraft would be launched with crews prebriefed on what they were to kill and where it was situated.

Since the 2001 Enduring Freedom air campaign in Afghanistan this has all changed. Evolution in action has seen opponents of the West rapidly shift to mobility to protect their ground force assets. The time it takes to prepare a sortie and fly a strike aircraft into position to prosecute an attack is typically much greater than the time it takes to rapidly relocate a smaller ground force element and conceal it. The result has been a revolution in strike warfare over the last three years as targeting models built around predominantly static and semi-mobile targets are replaced with one assuming targets to be highly mobile.

This has been reflected in a shift to 'persistent strike' techniques: ISR platforms maintain 24/7 continuous surveillance of areas of interest, with Combat Air Patrols flying 'killbox interdiction' sorties (loaded with smart bombs) maintained on station continuously, waiting to pounce on targets as soon as the ISR machinery can unambiguously identify a target to be killed.

The earliest attempts at 'persistent strike' involved mostly US Air Force B-52H and B-1B bombers, supplemented by US Navy F/A-18Cs and F-14B/Ds over Afghanistan, with targeting data transmitted by voice over radio channels and crews punching the GPS coordinates into the mission management system using the cockpit keypad. Despite this slow and error prone technological limitation, the technique often resulted in targets being killed within minutes of the striker being tasked to attack.

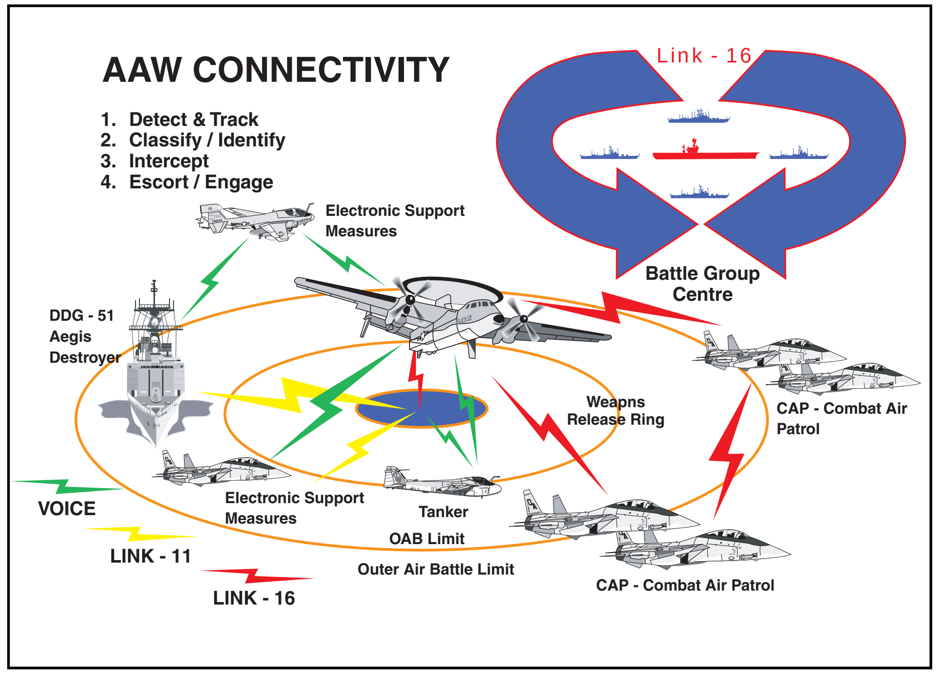
What digital links like the IDM provide is a mechanism to avoid the double handling of targeting coordinates as is the case with voice channels. Targeting data generated typically by a complex and often distant ISR system is transmitted directly into the mission management computer system of the striking aircraft.

Current US Air Force thinking, articulated recently in public by Chief of Air Staff John P. Jumper is 'compressing the kill chain' with the ultimate aim of providing unbroken digital connectivity between the ISR system which finds the targets, through to the strike aircraft which delivers the weapon, even down to the weapon that kills the target.

Adoption of this model will provide a mechanism to minimise the time between a target being detected and killed, with an error free transmission path between the ISR system and the weapon itself.

This model not only reflects the changing nature of opposing target sets but also the deep changes in targeting philosophy. The Cold War era involved opponents on known geographical boundaries, with much known fixed infrastructure and enormous land armies. The military paradigm was one of breaking the opponent's warfighting capability by large-scale attrition using air attack.

The US Navy have a well developed and tightly integrated scheme for Anti Air Warfare (AAW), which uses a combination of JTIDS/Link-16, Link-11 and Voice comms links. F-14D and F/A-18C-F fighters network with the E-2C Hawkeye AEW&C system and shipboard radars to provide a comprehensive layered maritime Integrated Air Defence System. The Outer Air Battle (OAB) zone is primarily covered by fighters and picket warships, the inner zone defences are covered by SAM systems on Aegis cruisers and destroyer escorts. This model evolved from late Cold War pressures to defend against Russian Backfires, Bears and submarines firing supersonic cruise missiles.



Above: A Boeing CH-47F 'Chinook' helicopter, which may be offered to Australia under Air 9000 would be an important troop-lift asset on the networked battlefield. Survivability of helicopters is an ongoing issue, and JTIDS can be used to broadcast threat location data to aid evasion of mobile SAM and AAA systems and hostile helciopters.

Left: Smaller fighters such as the F/A-18A require intensive aerial refuelling support to provide the persistence required for NCW-enabled strike techniques. With only 4 or 5 tankers planned the F/A-18A and JSF will have difficulty exploiting the targeting cycle improvements from networking.

NCW

The DoD's preferred fighter solution is the F-35 Joint Strike Fighter, designed primarily for battlefield air interdiction and close air support. The JSF will carry a comprehensive suite of digital datalinks and software to permit it to accept targeting data from a wide range of ISR assets and other JSFs.

The current model is much more refined, and involves faster and more concentrated attrition of the opposing nation state's apparatus of power: government leadership, military leadership, command and control facilities, propaganda apparatus, internal security forces, and the most loyal and resilient military and paramilitary combat forces. While this target set is geographically distributed across the breadth and depth of the opposing nation state, it is also mobile and concealed, often exceptionally so.

Historical origins of the 'persistent strike' model lie in Australia . During the 1980s the RAAF's Strike Reconnaissance Force through 82 Wing trialled the 'Precision Air Support' model in which F-111s would orbit at higher altitudes over an area of interest and pick off targets using laser guided bombs, directed by a ground observer. It is little known that a video datalink was trialled to downlink imagery from the F-111 to the ground controller on site. While the scheme did not achieve prominence in Australian military thought, it did migrate to the US via exchange officer postings and ultimately evolved over time into the technique we observed in Afghanistan, with B-52H bombers flying circular orbits over Taliban positions.

Afghanistan also demonstrated the inherent joint warfare potential of this targeting model, as a large proportion of targeting information was generated by special forces units on the ground who identified the targets and then assessed the effect of the attack. This was repeated over Iraq last year. To extract the full potential of this model, however, requires that digital connectivity exists to link together ground force elements and airborne ISR and strike elements. This remains a weakness in the US force structure and an even greater one for Australia. For instance, the IDM is an option on US Army AH-64D Apache Longbow reconnaissance/attack helicopters, permitting the helicopter to accept targeting information on 'over the horizon' targets from airborne ISR platforms and fighters, and vice versa. This is the correct model but it needs to be implemented across a much greater range of land force elements such as tanks and armoured recce vehicles – and infantry units will ultimately require such two-way connectivity.

The Future

There are two fundamental issues that define the future in the NCW game. The technological element is straightforward in concept even if complex in implementation. The first concerns universal high speed digital connectivity between platforms, later including weapons. The second relates to high levels of seamless integration of the connectivity paths with the embedded weapon systems software of platforms. In the US we are seeing this reflected in the software and systems architectures of the F/A-22A and JSF aircraft, the MC2A replacement for the E-8 JSTARS, RC-135V/W and E-3 AWACS, as well in increasing levels of digital integration in naval air defence systems and some Army platforms.

The doctrinal and thought element is reflected in a shifting emphasis in targeting philosophies and in personnel training to support this regime of combat. The US experience has shown that most progress has been achieved in single Service environments, with the joint paradigm lagging quite severely. The well developed and growing intra-Service NCW capabilities of the US Air Force and US Navy reflect this fact: cross-Service doctrine and technique, as well as digital connectivity, lag severely.

In Australia, rhetoric is far more potent than implementation. Many recent decisions indicate that there is little understanding of the deeper relationships between NCW and platform/force structure capabilities. There seems to be a deeply entrenched belief that NCW capabilities, especially connectivity, are a replacement for raw firepower, ISR capability and battlespace persistence. This is a dangerous delusion, insofar as NCW provides a mechanism to accelerate targeting and engagement cycles but without the ISR assets and persistent firepower delivery assets to exploit the engagement cycle improvements its utility is of dubious value in itself.

Three examples of such broken thought processes are evident. A belief seems to exist that the provision of a JTIDS capability can wholly reverse the performance and missile engagement range disadvantages of the F/A-18A HUG and JSF operated with Wedgetail AEW&C against Russian Su-30 fighters and A-50 AWACS now being acquired across the region. Were parity to exist between fighter and AWACS capabilities then the NCW capability of the ADF system could indeed be the decider in a confrontation. But in a situation where the fighters are clearly challenged to outperform opposing aircraft it is unclear how the NCW capability would provide this advantage. If the opponent can shoot much earlier and aerodynamically close or open engagement distances more readily, knowing they are doing this will not prevent them from doing so. The potential for developmental Russian counter-ISR weapons such as the 200 NMI range KS-172 missile to be deployed within the region later this decade raises some very good questions about ISR platform survivability. AEW&C platforms are not throwaway assets.

Another prime example of a broken thought process is the drive for early F-111 retirement and the expectation that four or five medium sized tankers and standoff missiles will offset a de facto 50% reduction in force structure firepower. NCW in strike warfare permits rapid engagement cycles against mobile ground targets, but such engagement cycles can only be executed if strike assets can persist over the target area with large precision bomb payloads. In the absence of plans for two dozen tanker aircraft, the F-111 is the only ADF asset with the on-station persistence and smart bomb payload to effectively make use of an advanced NCW capability - yet it is to be killed off in 2010. The much promoted NCW software and datalink capabilities of the JSF will be of no value if the JSFs are not orbiting the target area since they have run out of gas and smart bombs and have to go home. On balance, the extra NCW processing and bandwidth in a JSF against an IDM and JTIDS retrofitted F-111 is of less value than the inherent persistence and bomb load of the F-111, carrying almost twice the internal fuel of the JSF.

The third example of a broken thought process is the budgetary balance between the RAAF operated Wedgetail AEW&C fleet and the RAN's intended Air Warfare Destroyers. Both have long-range radars but the Wedgetail can acquire and track targets at all altitudes while the destroyers are blind to low altitude targets beyond a very short radar horizon. In effect, the destroyer can only defend a large area footprint properly against representative imported regional threats of Russian design if a Wedgetail is orbiting overhead and datalinking coordinates down to permit missile engagements at maximum range - preferably with the warship radar silent to deny targeting data to the opponent. On balance it makes more sense to invest in more Wedgetails rather than large expensive long-range shipboard radars that drive up the size and cost of the warships significantly. The cost of putting a naval SAM seeker compatible X-band illuminator radar on the belly of a Wedgetail to permit it to provide terminal phase SAM guidance over the radar horizon of warships, and buying more Wedgetails, is cheaper than overinvesting in larger and vastly more expensive warships of dubious survivability.

An issue in its own right is supporting the technological capability in Australia. The policy, not always followed, on ADF Electronic Warfare systems being supplied with software source code and development systems should be extended to encompass all NCW systems, such as datalinks and mission computer integration software. The issues behind this are no different for NCW systems as for EW systems.

In summary, NCW offers enormous potential for the ADF, but it is not a substitute for proper force structure planning. Until this is recognised, rhetoric about NCW will achieve nothing of significant value, and often provides excuses for dubious force structure planning.

Above: Australia seems certain to buy the RQ-4A 'Global Hawk' UAV seen here landing at RAAF Base Edinburgh. Long-range UAV platforms such as 'Global Hawk' would be an important Intelligence Surveillance and Reconnaissance asset. A Global Hawk role seldom discussed in Australia is the 'pseudolite' role in which a Global Hawk carries a communications relay and networking payload rather than ISR sensors, providing persistent airborne 'satellite like' wireless network coverage in areas where proper satellite coverage is absent.

Left: The Australian Army is close to making a decision on a replacement Main Battle Tank (MBT) for its 'Leopard' fleet. With its inherent firepower and mobility the MBT would gain great advantage from target and tactical information plus command & control within an NCW environment.