Intelligence, Surveillance and Reconnaissance

during Operation Iraqi Freedom

Dr Carlo Kopp

T he large scale use and integration of Intelligence, Surveillance and Reconnaissance (ISR) capabilities during last year's Operation Iraqi Freedom air/land campaign remains the case study in the ISR game.

While most observers focused on the impact of large scale precision guided munitions use in effecting a defacto 'three week duration war', these precision weapons relied largely on targeting data generated by the US 'ISR Constellation'.

What is of no less concern is that in Australia few of the key lessons of OIF have been properly understood, let alone applied to ADF force structure planning. As with other current issues in RAAF force structure, rhetoric supplants analysis.

Smart air war using ISR

The decisive role of Intelligence, Surveillance and Reconnaissance (ISR) during Operation Iraqi Freedom represents as much an evolutionary development as it is a revolutionary development. Past air campaigns are illustrative and clearly expose this evolution in strike 'targeting cycles'. The 'targeting cycle' is the cyclic activity of 'detection-identification-tracking-engagement-assessment' - this loop encompasses the activity pattern of an air force in a bombing campaign. Potential targets are found, their identity determined so as to decide whether they should be hit, if hostile they are followed and hit, and finally the effect of the strike is evaluated to determine whether a repeat strike is needed. The key measure of effectiveness is the duration of the 'targeting cycle', since most targets in the modern world refuse to stay put and usually will not oblige an attacking air force by staying still.

During the Vietnam Rolling Thunder and Linebacker I/II campaigns targeting cycles of days were not uncommon – as photographic imagery on wet film had to be processed, interpreters had to assess it, high ranking bureaucrats and politicians had to be consulted, and finally the briefing for the strike had to be telexed to the unit involved. By Desert Storm in 1991 the game had changed significantly. While many ISR systems still used wet film techniques many were already digitised, permitting much faster transmission and processing. Internet technology and electronic mail permitted very rapid transmission of digitised data. A pair of the new E-8 JSTARS, in prototype form and largely crewed by contractor engineers, were available for trials. The result of these developments was a reasonably consistent 24-hour targeting cycle, with a full Air Tasking Order produced daily. The effects of this targeting cycle compression were evident to all - an unprecedented six-week campaign during which vast attrition was inflicted, especially against dug-in static battlefield targets.

Technology evolved further over the decade and by the 1999 Allied Force campaign the US Air Force fielded a large fraction of its E-8 JSTARS fleet and deployed the new RQ-1A Predator A UAV to gather battlefield intelligence. The scene was set for another contraction of the targeting cycle. As history demonstrated, this was not to be, as the French and other NATO council members insisted on reviewing all targeting orders in minute detail, resulting in targeting cycle durations claimed to be as great as two weeks, and repeating the Rolling Thunder experience. The technological gains of the decade did not have the opportunity to produce the expected effect.

Operation Enduring Freedom (OEF) was the first opportunity to apply the new generation of ISR systems without bureaucratic hindrance. Afghanistan was swept by JSTARS, Predator, U-2s, Global Hawk, TARPS pod equipped F-14s gathering radar/electro-optical imagery and RC-135V/W Rivet Joint, EP-3E Aries and EA-6B Prowlers gathering electronic, especially communications intelligence. With wideband satellite networking available, and high capacity optical fibre links between the CONUS and Mid-East operations centres, the ISR constellation finally had the opportunity to perform. And perform it did, seeing to the rapid destruction of the Taliban and Al Qaeda forces in situ and in transit across the theatre.
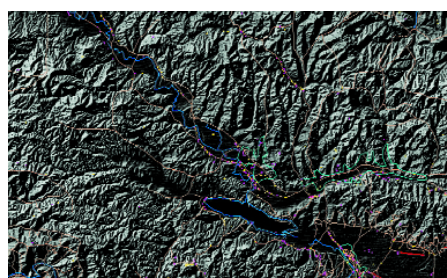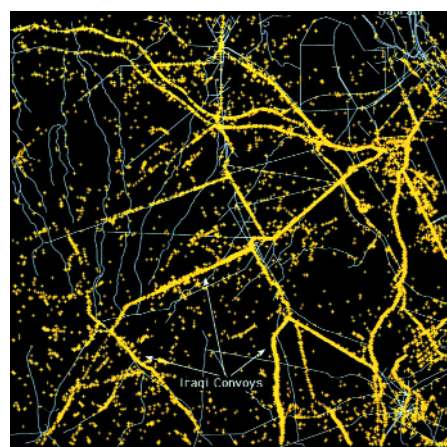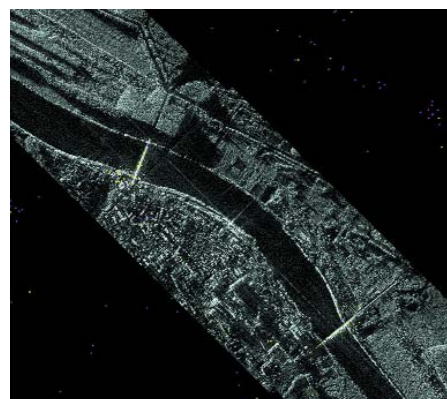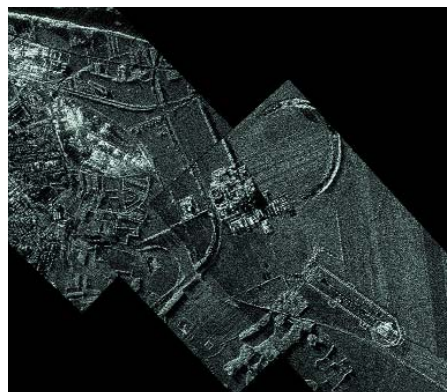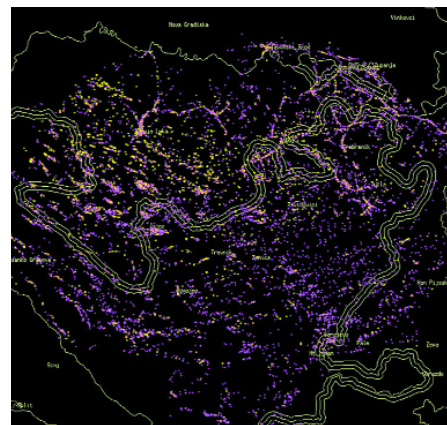
So effective was the ISR constellation that the strike fleet could not keep up using conventional striking tactics - the transit time from Diego Garcia or a CBVG in the Indian Ocean was many times longer than the time window in which many targets could be engaged. The traditional model of briefing a crew for a strike, loading with target specific munitions, and flying out to drop bombs, was largely abandoned in favour of launching aircraft without pre-briefed targets and loaded with 'swiss army knife' weapons mixes to kill yet-to-be-detected targets. Persistent bombardment techniques were coupled with ISR to achieve on some occasions, targeting cycles as short as three minutes between detection and the bomber arriving overhead.

Afghanistan became the proving ground for a new type of ISR-driven air campaign in which persistent bombers waited in orbits to pounce on 'emerging' targets as soon as the ISR constellation could unambiguously determine their identity and then proceed to strike. The B-52H's circular orbit contrails will remain the enduring image of Enduring Freedom.

Much was learned during OEF, especially in terms of demands in communications capacity, the need for reliable target coordinate transmission, and the need for more automation in transferring targeting data between platforms. What followed 18 months later over Iraq was a full scale application of this warfighting philosophy, with many of the early bottlenecks seen during OEF removed.

The US Air Force leadership today talk in terms of 'compressing the kill chain' or aiming to contract the targeting cycle as much as possible. Analysis of OIF shows that much remains to be done before the theoretical bounds on targeting cycle times can be reached robustly.

'Shooting fish in a barrel' was a description applied to the battlefield bombardment of Iraqi ground forces. This imagery, fusing E-8C JSTARS synthetic aperture radar, GMTI radar and GIS databases graphically illustrates how naked the Iraqi ground force actually was.
Imagery - Bosnia in WAS mode,
Modrica in SAR mode, time lapse of 1991 retreat from Kuwait,
Sava River in overlayed MTI/SAR modes,
UK countryside in overlayed MTI/SAR modes with GIS, dtto (US Air Force).

OIF and the ISR constellation

The sole RQ-4A Global Hawk flown in the OIF campaign, although carrying a smaller payload than the U-2S (below), had much greater persistence and performed above expectations.

The OIF campaign saw the use of a vast array of ISR assets, so broad that many observers still fail to properly understand the relative importance of these assets. The most important and least understood division between categories of ISR asset is not the medium in which they operate, radar, passive electronic or optical, but rather the footprint of the sensor system. At the top tier of this information 'food chain' sit the E-8C JSTARS, RC-135V/W Rivet Joint, E-3C AWACS, U-2S, E-2C, EP-3E Aries and Low Earth Orbit satellites such as the KH series thermal and visible band imaging vehicles, the Lacrosse radar imaging vehicle and the various electronic and signals intelligence gathering vehicles. These large systems typically surveil footprints hundreds of nautical miles in extent, and tens of thousands of square nautical miles in area. In this game, typically, the orbital systems are 'transient' observers, while the airborne systems are 'persistent' observers of the area of interest. This wide area coverage provides a continuous and often very detailed picture of the battlespace, in realtime or near realtime. Movements of large ground formations can be tracked continuously, and the enemy's intent inferred often very exactly.

The next tier down the information 'food chain' are the focal area surveillance assets, the best examples of which are the RQ-1A Predator and RQ-4A Global Hawk, which can orbit often for tens of hours surveilling targets in a specific area of interest. With lower power radars and optical systems designed to dwell rather than strip map vast areas, these systems provide a closer and more detailed picture of a small portion of the battlespace. Wide area footprint is traded away for a more precise and finer picture of a smaller footprint.

Finally, at the lowest tier of the information 'food chain' are the fighters tasked as 'Fast FACs' and their siblings fitted with reconnaissance pods. Highly survivable, but limited in persistence and often sensor coverage, their task remains in investigating potential contacts of interest found by systems further up the chain, and in the case of the FACs guiding 'shooters' to engagements. The importance of the lowest tier assets should not be denigrated as these have some valuable and unique capabilities, such as being able to gather Imagery Intelligence (IMINT) from below a cloud base, where slow moving UAVs cannot survive, and being able to respond extremely quickly due to the sheer performance differences between supersonic fighters and slow moving UAVs. The traditional division between surveillance and reconnaissance lies in the former being 'persistent' and the latter 'transient' – divisions that are now blurred with platform tasking. A fighter with a recce pod and fast digital datalink, refuelling from a tanker can become a defacto persistent surveillance system, while an RQ-4 Global Hawk flying a single pass past a target area becomes a defacto transient reconnaissance system. Both capabilities are mutually complementary and valuable operationally.

The OIF campaign was characterised by the continuous surveillance of key areas of interest across Iraq, especially using the E-8C JSTARS and RC-135V/W Rivet Joint to collect complementary high resolution radar images, ground moving target tracks and electronic and signals intelligence. This information was 'fused' to aid with identification but also to analyse the opponent's intentions on the ground. The Global Hawk was used more flexibly, both

The U-2S cockpit.

as a complementary imaging surveillance system and for reconnaissance. The single Global Hawk used was claimed to have accounted for 55% of time critical IADS targets, including 13 SAM batteries, 50 SAM TELs, 300 missile storage canisters, and 70 missile transloader vehicles. It was also credited with 300 armoured vehicle detections.

The broader system architecture used included CONUS based teams of intelligence analysts who worked through near real time or real time intelligence transmitted from the theatre to the US. This reduced deployment problems and permitted a larger number of analysts to be employed.

The US is reported to have used several new techniques in the campaign. One was 'predictive battlespace awareness' in which a historical database of several years worth of data gathered over Iraq was mined for specific patterns of behaviour, such as positioning of mobile IADS elements or other assets. If a potential target was known to have relocated into a general area, the historical database more than often provided an exact cue to the location at which the system was later found and engaged. One of the wonders of the digital age is that such patterns of behaviour can be quickly discerned by dredging through archives of previous intelligence.

The RC-135V/W Rivet Joint fleet is a pivotal element of the US ISR constellation, and can surveil and analyse radar and communications emissions produced by airborne and surface targets. It played a vital role in ferreting out Taliban targets in 2001, and more recently IADS, RG and Baath party militia targets in Iraq. While long term planning envisages the replacement of the RC-135V/W Rivet Joint with a 767 based MC2A variant, the aircraft continue to receive ongoing and extensive sensor, and systems upgrades. The most important recent upgrade is the recently initiated retrofit with CFM-56 engines (USAF).

Coherent Change Detection (CCD), a technique pioneered in the Predator ground station, was also widely used. CCD involves taking imagery of specific areas of terrain from exactly the same point in space, at different times, and then digitally comparing the images pixel by pixel. The differences are then highlighted in colour as an overlay over the newer image to aid an analyst in quickly finding changes.

This technique is exceptionally powerful and amenable to use with both synthetic aperture radar imagery and optical or thermal imagery. Sample imagery made available in Predator brochures shows vehicle tracks in sand and grass being highlighted instantly. Like 'predictive battlespace awareness' the CCD technique is one that is a byproduct of the digital age and is extremely difficult to beat. A camouflage net, which might deceive a human observer, is apt to produce enough shadowing or contrast difference for the software to detect it as pixel level changes in a scene.

Another new technique was the real time integration of ground based cryptological and language experts with ISR aircraft over the battlefield to rapidly analyse enemy activity based on wireless communications intercepts. US sources suggest that many IADS elements and ballistic missile launchers were hunted down using pairs of RC-135V/W Rivet Joint aircraft, working closely with analyst teams. The earlier damage inflicted on the Iraqi cable communications infrastructure yielded the important dividend of forcing radio communications use instead. Used in pairs, the Rivet Joints could very quickly and accurately triangulate the location of enemy transmitters.

Not all of Iraq's forces were foolish enough to transmit arbitrarily, especially operators of SAM systems who learned over the previous decade the risks in doing so. To elicit SAM radar activity to aid targeting, the US Air Force fired a number of expired BQM-34 Firebee drones into the Baghdad area, equipped with chaff dispensers to lay down 'chaff corridors'. This emulated traditional 'chaff corridor' laying before strikes to entice SAM operators to light up their radars. A more devious play was the use of two sacrificial fatigue life expired RQ-1 Predators, stripped of their sensor payloads. These were flown into Baghdad airspace to draw Iraqi fire so as to expose the SAM systems. Six Predators were prepared for this role but the air defence collapsed so rapidly that four lived to see another campaign. US sources report the Predator seen on Baghdad TV being pulled out of a lake was one of the two aircraft used after it ran out of fuel and crashed.

A central issue for the US falling out of OIF is the ability to rapidly transmit ISR information and targeting coordinates between platforms. A good number of F-16Cs and F-15Es are now equipped with the Improved Data Modem (IDM), which is a multiport voiceband modem (not unlike conventional home computer modems in technology) which transmits a digitally modulated modem carrier over the voice channel available in the Have Quick II jam resistant radio, widely used on combat aircraft. The IDM is a very basic and slow link but in the absence of alternatives it has proven itself to be a very useful point-to-point transmission tool, later variants permitting the transmission of single frame JPEG target imagery in addition to coordinate and text messages.

What the IDM does permit, with good software integration, is for one platform to feed aimpoint GPS coordinates into the fire control system of another platform with, for all practical purposes, error free transmission. Coordinate errors resulting from human error have been a major factor in known blue-on-blue and collateral damage incidents. A particularly unfortunate effect seems to be the very common problem of digit or whole coordinate transposition during transmission or garbled voice reception. At this time voice-only platforms have to adopt tedious procedures such as two or more crew members writing down the received voice message for comparison, and readback to the remote end to verify correct reception. This is time consuming, and current thinking in the US is to aim for full automation in the channel between the information source and ultimately the weapon.

The JTIDS/Link-16 datalink has proven to be another important capability, but in its basic configuration it is used primarily for air interception operations, air traffic management, Identification Friend Foe and situational awareness. The JTIDS system is much more complex and expensive, and is a true dedicated time division multiplex digital channel designed for text and digital coordinate data, using spread spectrum jam resistant signal modulations. It is not well suited to the transmission of bulk digital data such as target imagery.

Longer term US thinking is to use the Joint Tactical Radio System (JTRS - 'jitters') as a general purpose datalink channel, using 'smart tankers' as platforms to deploy datalink relay equipment. The ROBE 'SMART tanker' concept is a US Air Force evolution of an idea first used in Vietnam with dedicated KC-135A and EC-135L Combat Lightning airborne communications relay platforms and more recently revived with the RAF's JTIDS relay equipped tankers. The 'smart tanker' concept essentially fuses the Combat Lightning paradigm of a persistent platform with a package of diverse communications relays with the RAF model of a 'multirole' tanker acting as a digital datalink relay.

Other than basic connectivity the remaining issues in ISR are centred on sensor systems, processing and means of deployment. At this time the three pillars of the US ISR constellation are the E-3C AWACS, E-8C JSTARS and RC-135V/W Rivet Joint, as these provide wide area sensor coverage, high volume track analysis and processing, and management of target engagements as required.

While the Hellfire armed MQ-1A Predators attracted the most media attention, they played a much less important role than the much larger U-2S and sole RQ-4A Global Hawk flown in the OIF campaign.

Northrop Grumman Boeing E-8 JSTARS

The E-8C JSTARS was the pivotal ground surveillance asset used in OIF, accounting for the largest number of ground targets. Flying sorties of up to 17 hours duration with aerial refuelling, the JSTARS stripped away the cover of darkness, cloud, fog and sandstorms to expose Iraqi land force assets to withering aerial firepower (USAF).

Often colloquially labelled the 'Ground AWACS' the JSTARS is the most potent asset of its kind in existence and until replaced by the new Multi Mission Command and Control Aircraft (MC2A) will remain so.

The origins of the JSTARS lie in the late 1970s when DARPA and the USAF launched the Assault Breaker program, intended to trial a radical new paradigm for breaking massed Soviet armoured assaults in the Fulda Gap. Assault Breaker was ambitious and far reaching, and merged radically new ISR concepts with radically new mass attack munition concepts - such as the SFW/Skeet.

The most dramatic breakthroughs in Assault Breaker came from its ISR segment, which saw the development of two competing 'Pave Mover' X-band radars designed specifically to track slow moving ground vehicles. The Pave Movers incorporated then new developments in Ground Moving Target Indicator (GMTI) radar techniques, such as Displaced Phase Center Antenna (DPCA), and rapidly evolving digitally processed Synthetic Aperture Radar (SAR) techniques to provide a comprehensive image of the battlefield in real time. While the SAR techniques had modest demands in transmitter X-band microwave power, this was not true of the GMTI function which like air-air radar acquisition of low flying targets, had to sort faint returns from clutter and cover a large footprint as well. The demand for high power output in GMTI surveillance radars remains an ongoing issue and presents genuine issues especially for UAVs in this role. Global Hawk and JSTARS are to soon acquire new MT-RTIP active phased array X-band radars for this reason.

The two Pave Movers were trialled as sidelooking radars in the weapon bay of an F-111E, and a Low Probability of Intercept

(LPI) variant was to have been carried in the fuselage radar bay of the stealthy Tacit Blue (aka 'Whale') demonstrator. The Pave Mover on the F-111E would look into hostile territory to surveil the zone just past the FEBA, while the Tacit Blue would go deep and surveil 'follow-on forces'. The radar imagery was to be relayed to ground based or airborne processing and analysis stations. From these, commands would be issued to strike aircraft, or batteries launching ballistic missiles armed with Sensor Fused Weapon or other smart submunitions. The waves of Soviet armour were to have been stopped in the tracks, and then annihilated by waves of air power.

The Assault Breaker program evolved into the Joint Surveillance Targeting Attack Radar System (JSTARS) and ended up on the Boeing 707-320/C-137 series airframe, under the label E-8. While the US Air Force wanted new build C-137 (military 707) airframes, Congress forced the closure of the 707 line and used aircraft had to be rebuilt for this purpose - often at greater cost than new build C-137s.

The heart of the JSTARS is the massive APY-3 X-band radar, one of the most powerful radars ever built in this band,

carried in the canoe radome under the forward fuselage. The 24ft roll-stabilised antenna subsystem, designed by former Norden Systems (now NG), uses a very large three segment passive phased array and implements DPCA techniques to accurately locate slow moving ground targets. The beam is electronically steered in azimuth and manually steered in elevation.

No less important is the APY-3's data processing subsystem, originally built around militarised DEC VAX processors in a distributed architecture, with a processor in each of the 17 operator stations. Processed data can be used to manage engagements from the aircraft, or can be sent via a high speed datalink to mobile ground stations. This highly capable system can overlay GMTI track data over SAR maps and stored digital terrain maps, but it also has the capability to overlay historical track data many hours old, permitting specific patterns of enemy movement to be discerned. Even hidden sites visited by vehicles at random time intervals will be detected by the APY-3 system.

The system has three basic operating modes: Wide Area Surveillance (WAS/MTI), Sector Search, a sector limited GMTI mode, and Synthetic Aperture (SAR) with ancillary beacon tracking and datalink modes. The signal processing is reported to be capable of resolving wheeled and tracked vehicles, and given the presence of modes to detecting rotating radar antennas in the Norden APG-76, is likely to have a similar capability. The three surveillance modes can be interleaved.

As the APY-3 can look through cloud, rain, fog, dust storms and other impediments to electro-optical ISR sensors, it provides a genuine all-weather 24/7 capability to look deep into the battlespace and track thousands of surface targets.

Of all the ISR systems used in OIF, the JSTARS of the US Air Force 93rd Air Control Wing produced by far the greatest impact and proved to be the backbone of the effort to attrit Republican Guard armoured formations.

The RC-135V and RC-135W Rivet Joint

Electronic reconnaissance and surveillance played a no less critical role in OIF. The most prominent asset used for this task was the detachment of US Air Force 55th Wing RC-135V/W Rivet Joint aircraft.

The Rivet Joint fleet has had a long and colourful history, since the first of these aircraft were rebuilt from reconnaissance role modified RC-135C/U aircraft during the Vietnam conflict. These aircraft are easily distinguished by their unique thimble shaped 'hognose' radomes and large cheek bays for mission avionic antennas. During the latter part of the Cold War the Rivet Joint fleet was largely occupied with monitoring Soviet radar and communications activity along the USSR's vast borders. Since 1991 these aircraft have become used as much for in theatre tactical operations as for strategic reconnaissance work. The former is much more demanding as it is 'real time' work and has often seen specialist linguists carried aboard to interpret data as it is gathered.

The heart of the Rivet Joint is the massive and complex signals and electronic intelligence gathering system, comprising the Raytheon 55000 Electronic Support Measures (ESM) and 85000 signals intelligence (SIGINT) receiver systems, widely regarded to be the most capable such system in existence. It can passively monitor and record signals across a very wide spectrum, geolocate them, and analyse their modulations with very high accuracy for onboard or ground analysis - encompassing both radar and communications signals.

While long term US planning envisages the Rivet Joint mission package eventually migrating to the MC2A, numerous upgrades remain in progress for this unique platform. These include a major upgrade of the cheek antenna arrays to provide a larger number of steerable high band beams (SHF High Gain Steerable Beam Antenna Upgrades I/II), a ten element HF band direction finding receiver, an additional circular antenna array for continuous 360 degree coverage, and a range of datalink upgrades to improve digital connectivity. A vital upgrade now in progress is retrofitting CFM-56 engines, to improve fuel burn, performance, endurance and range.

The Rivet Joint receives little media attention, yet it is one of the most important systems the US deploys in any air campaign. Its capacity to 'vacuum up' and rapidly analyse all electronic signals within a 250 nautical mile circle is invaluable as few opponents are capable of functioning without electronic wireless communications.

Conclusions

If any single capability could be labelled as 'decisive' in OIF it was the US ISR constellation. There can be no doubt that its capabilities are central to current shift to information driven 'network centric warfare'. Whether it hides or moves on the ground, or emits, one or more platforms will detect the target's signature.

The US Air Force is aggressively pursuing further growth in the ISR domain, with the ambitious MC2A program, active AESA MT-RTIP upgrades for the E-8C JSTARS, U-2S and RQ-4 Global Hawk, and plans to carry ISR payloads on air refuellable and enlarged production X-45C UCAVs. The F/A-22A is expected to relay radar and passive ESM tracks into the ISR constellation using datalinks and thus pushing the 'ISR horizon' up to 500 nautical miles deep into hostile airspace. We should not be surprised if an ISR or recce derivative of the F/A-22A emerges in time as 'deep ISR' is the remaining domain to be conquered by the US Air Force. Smart tankers and universal datalink connectivity between ISR platforms and combat aircraft will further enhance the vast capabilities of this 'warfighting system'.

In Australia the rhetoric has been gushing, especially in terms of the 'future networked air force', with the JSF being presented as 'JSTARS-like' in capability. Global Hawk has been canvassed publicly, despite the likelihood that maritime patrol tasking would devour all hours available in the small numbers proposed.

What is more telling is that recent decisions in a number of areas indicate that the whole paradigm of persistent ISR and persistent firepower - the central backbone of the US paradigm, have not been intellectually grasped. The commitment of $2B into a mere five new build tankers rather than larger numbers of used airframes, the commitment to kill the persistent F-111 off, and a failure to even articulate the need for a JSTARS-like ISR platform are all visible indicators of a force structure paradigm and thought process deeply rooted in Cold War era thinking.

In twenty first century air wars, dominance in the ISR game is a prerequisite for winning.