by Carlo Kopp

A Heavy Bomber Rennaissance?

The Enduring Freedom air campaign against the Taliban and their al-Qaeda allies was won largely through the firepower delivered by a mere 10 or so daily sorties flown by USAF B-52H and B-1B bombers operating from Diego Garcia in the Indian Ocean.

Dropping 2000lb GPS/inertially guided GBU-31 JDAMs, the "heavies" delivered around 75% of the total tonnage of bombs used to break the Taliban regime and inflict decisive attrition upon their ground forces.The dominance of the heavy bomber in this air campaign reflects the enduring value of this class of combat aircraft. Despite empirically observable reality, dedicated bombers continue to come under incessant criticism (true in this country as in the US), another enduring feature of the bomber.

Historically the heavy bomber emerged to fill the need for strategic bombardment of an opponent's heartland – destroying the industrial base which is the pivotal element of an industrial nation states ability to wage war. The bombardment of Germany and Japan, and industries in occupied territories, will remain the most controversial but also strategically decisive campaigns of WW2.

During this period the heavy bomber found another important role, one in which it has been used ever more frequently over the last half century – Battlefield Air Interdiction (BAI) and Close Air Support (CAS). It would not be an overstatement to observe that BAI/CAS now rivals in importance the strategic roles of the heavy bomber – the pivotal blow in the Kosovo campaign involved a pair of B-52s obliterating Serbian trenches along the southern border.

The advent of the near precision/precision JDAM on the US heavy bomber fleet opened up a new chapter in the saga of the heavy bomber – with the ability to deliver guided bombs the vast endurance and tonnage capabilities of these aircraft saw the remarkable paradigm shift of the Afghan campaign. Buffs (B-52s) and Bones (B-1Bs) orbiting target areas using persistent (loitering) bombardment tactics, awaiting ground and aerial FAC directives to drop individual JDAMs on Taliban positions.

Another critical strategic role first flown by Curtis LeMays B-29 force was aerial delivery of naval mines. To this very day the B-52 and B-1B remain tasked with this role, and both can deliver a range of naval mine types.

The US and Russian heavy bomber fleets retain their strategic nuclear roles, even though both nations now employ ballistic missiles as the primary pillars of their respective nuclear strike triads.

Wherein lies the future of the US heavy bomber fleet? The place to look is the 'US Air Force White Paper on Long Range Bombers', published in March 1999, and better known as the 'Bomber Roadmap'.

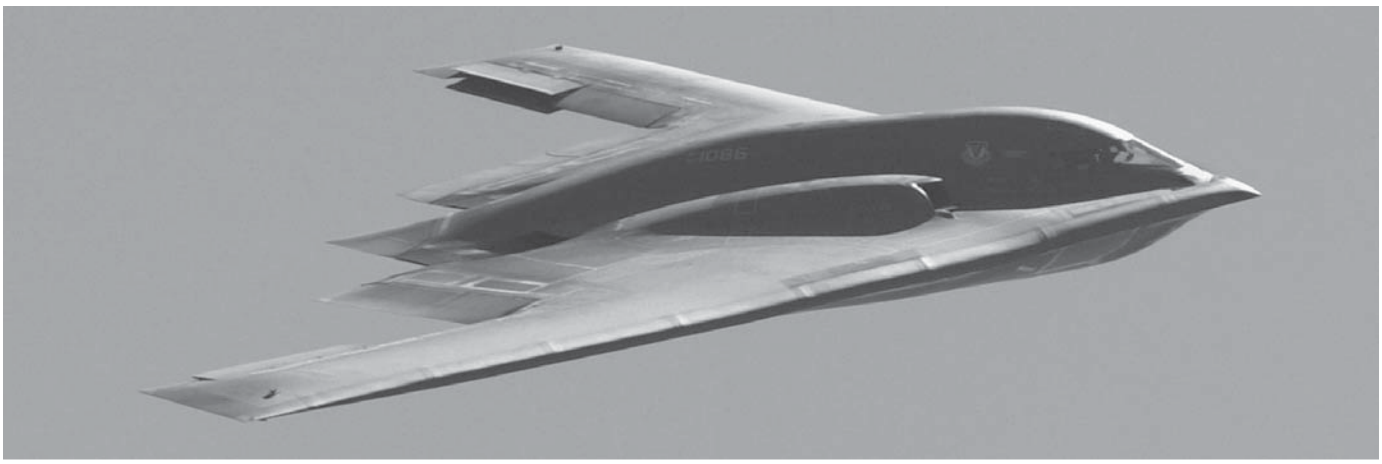
US Air Force Bomber White Paper

The 'Bomber Roadmap' is a long term policy document outlining the US Air Force's thinking about its heavy bomber fleet, and mapping out near term upgrades and long term planning and management strategies. The document provides a framework for planning funding allocation, airframe structural rebuilds to manage fatigue, and weapons, systems and avionics upgrades. The roadmap implicitly assumes some flexibility in how systems, avionics, weapons and tactics evolve and recognises that available alternatives may change over time, as new weapons and sensors are devised.

When published in 1999, the strength of bomber fleet was sized around the ability to successfully wage and win two 'nearly simultaneous major theatre wars' or contigencies like Iraq or North Korea. The aim was to sustain over coming decades a force of 130 'combat coded' bombers, ie 70 x B-1B, 44 x B-52H and 16 x B-2A, with additional airframes to cover training, depot overhauls and attrition reserves, making for a total fleet of 190 bombers.

Planning in 1999 envisaged Ellsworth AFB hosting 24 x B-1B, Mountain Home AFB 6 x B-1Bs, McConnell AFB 8 x B-1Bs, Robins AFB 8 x B-1B and Dyess AFB 18 x B-1B. The B-52H force was concentrated largely at Barksdale AFB, with 24 x B-52H, and 12 x B-52H at Minot AFB. Barksdale remains the primary training base for the B-52H fleet. The

The tip of the US Air Force spear is the stealthy NorthropGrumman B-2A Spirit, of which 132 were originally intended to replace the B-52G/H. With a fleet of only 21 aircraft the batwing is a low density asset and used only for very high value targets in heavily defended airspace. The aircraft is expected to be armed with the 500lb GBU-38 JDAM and later adapted to carry up to 320 Small Diameter Bombs, providing a fearsome conventional first strike capability. (Paul Sadler)



The backbone of the ACC bomber fleet and workhorse of the Afghan battlefield interdiction effort is the Boeing (Rockwell) B-1B Lancer (pictured with an F-15E), of which 100 were built during the Reagan presidency. Evolved around the same penetration model as the older F-111/FB-111, the B-1B carries the largest internal payload of any US bomber. Plagued by ongoing difficulties with its complex electronic warfare package, the B-1B has never been far from controversy. The fleet is currently being downsized with 30 aircraft being mothballed or retired. (US Air Force)

16 'combat coded' B-2A Spirits are based at Whiteman AFB.

The most significant change in force structuring since 1999 was the Bush administration's recent decision to downsize the B-1B fleet – this is intended to free up funding to perform upgrades on the remainder of the B-1B fleet. Of the total of 90 existing B-1B airframes, 30 will be mothballed at AMARC as structural and system spares. The future B-1B fleet will be concentrated at Ellsworth AFB (South Dakota) and Dyess AFB (Texas), where fleet training will be concentrated. The B-1Bs sent to storage will be mostly airframes built in 1983 and 1984.

This decision produced much argument in the US, and was actively opposed in the legislature. The B-1B continues to attract controversy, its supporters arguing its superior performance and capability over the B-52H, its opponents arguing that it is costly and ineffective. Nevertheless, it outperformed the B-52H in Afghanistan and can be expected to play a pivotal role in Iraq if/when combat begins.

The B-2A remains the most controversial of the US bomber fleet, and is often labelled the billion dollar bomber. This label is unfair, since the program carried development costs originally for a build of 132 aircraft, amortised over a mere 21 airframes.

Repeatedly proposals have surfaced for a large build of second generation B-2Cs, structurally identical but with newer generation avionics and systems, and production engineered for a lower unit build cost. Funding constraints have prevented this from happening.

It is worth noting that even a new build B-52 clone would cost around $US 250m to 300m apiece, without the complex avionics and systems. A more refined airframe with a higher fraction of exotic structural and radar absorbent materials would drive that cost up further.

The planned service life for the current US fleet is to 2040. The numerically most important type, the B-1B, will require a lower wing skin replacement program at 15,200 flight hours, and Wing Carry Through Box rebuild at 18,600 flight hours. However, the consolidation of the fleet is likely to see B-1B wing shipsets removed from AMARC, thus effectively pushing the calendar date for structural work to the right. Attrition over time would be covered by AMARC spares.

The oldest of the US bombers, the B-52H, was built during the early 1960s and was the last of the B-52s built. Serving with Strategic Air Command until 1991, these bombers were largely dedicated to strategic nuclear strike through their early lives. The critical structural fatigue item is the upper wing skin, requiring a rebuild at 32,500 to 37,500 flight hours. Planning in 1999 envisaged that accident related attrition and wearout would see B-52H inventory numbers drop below the total fleet requirement of 62 aircraft in 2044. At that date, many of the B-52H fleet will be octogenarians at an incredible 84 years of age.

The B-2A is expected to provide a service life close to 40,000 flight hours. Planning in 1999 envisaged accident related attrition of two aircraft by 2027.

Of these three types, the B-52H is considered the cheapest to maintain. This is due to its simplicity, easy internal access, but also due to its maturity. With a long running ageing aircraft program, sources of downtime and corroded/fatigued components are simply engineered out of the aircraft over time.

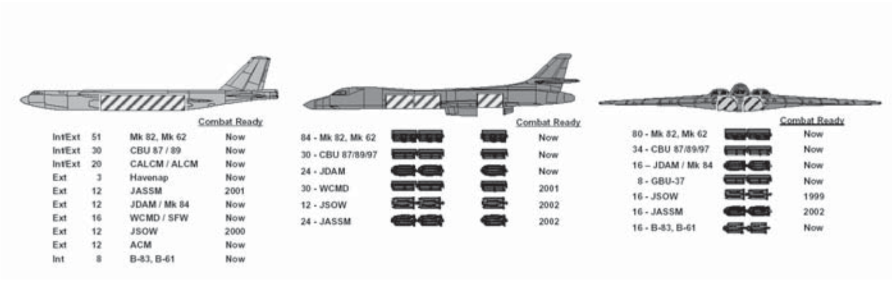
The B-2A is also relatively cheap to maintain as a basic airframe, and is a frugal consumer of kerosene due its unusually efficient design. However, it incurs a hefty overhead in support costs due to the need to apply radar absorbent seals to a range of access panels. A significant manhour cost is incurred when particular panels must be removed for maintenance, and an environmentally controlled hangar is required for such maintenance, adding a further overhead.

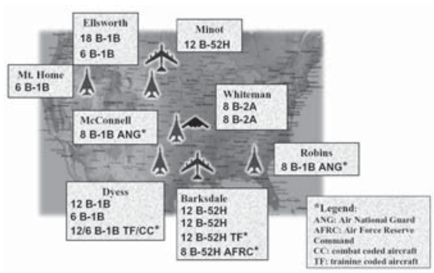
The B-1B is the most expensive to maintain as it is the mechanically most complex type in the fleet, and has afterburning engines and a variable geometry wing. With the most complex avionics suite of the bomber triad, it demands a lot of support time per flight hour.

In an ideal world a build of around 100 new B-2C bombers to replace the B-1B and B-52H would provide the most economical solution in ongoing support costs and capability, however the cost of buying these aircraft would be of the order of $US 35bn, nullifying any near term economic gains. Therefore the most likely outcome will be continuing exploitation of the AMARC boneyard to operate the B-1B and B-52H until 2040.

The bomber roadmap envisages the introduction of a new bomber type to replace the existing types in the 2037 timescale – with development over the preceding two decades. At this time no specific proposals exist, although the most likely design approach would be centred on a supersonic cruise airframe as this would permit a significant increase in long range sortie rates, and when combined with stealth provide F-22-like survivability and penetration capability.

The 'bomber roadmap' envisages four primary roles for the US Air Force fleet. 'Strategic Attack' is intended to destroy assets such as command centres, production facilities





(left) Representative heavy bomber payloads. (right) Deployment plans in 1999 envisaged this disposition of units. Since then B-52 and B-1 operations have been consolidated into a smaller number of bases. (US Air Force)

and infrastructure – it is the 'classical' Douhetian strategic role. 'Offensive Counter-Air' envisages the destruction of an opponents Intergrated Air Defence System (IADS) elements and airfields. 'Counter Land' encompasses both Battlefield Air Interactions (BAI) and Close Air Support (CAS) and covers all forms of battlefield strike. 'Counter Sea' is a combination of maritime reconnaissance/surveillance and strike, the latter performed with guided weapons or naval mines.

Nuclear strike roles fall under the control of the Strategic Command, and are intended to support either the Single Integrated Operational Plan (SIOP) or Limited Nuclear Options (LNO) plans. A typical SIOP sortie involves the destruction of a high value fixed strategic target, whereas LNO sorties are typically aimed at opposing nuclear delivery systems, and battlefield targets in theatre.

The last decade has also seen a shift in deployment patterns for heavy bombers. With the absorption of former Strategic Air Command (SAC) and Tactical Air Command (TAC) formations into the Air Combat Command (ACC), heavy bombers are now most often deployed as components of composite Air Expeditionary Forces (AEF).

The most recent development in the AEF deployment model is the Global Strike Task Force (GSTF), a 'silver bullet' AEF comprising 48 x F/A-22A and 12 x B-2A, planned for later this decade. The GSTF is intended to break an opponent's defences, permitting conventional AEFs to prosecute the latter portions of an air campaign (the GSTF will be covered in more detail at a later date).

The coming decade will see a number of upgrades applied to all three bombers, in parallel with the integration of a range of newer weapons.

Heavy Bomber Weapons

The most important change to the US heavy bomber fleets capabilities has been the integration of a wide range of conventional weapons over the last decade.

During the SAC era, the B-52H carried the 170 kT nuclear AGM-69 SRAM, free fall nuclear bombs such as the B28 (70 kT – 1.45 MT), the 1 MT B43, the massive 3995kg (8800lb) 9 MT yield B53, the 0.5 MT B61, and the 1 MT class groundburst B83. The 200 kT AGM-86B Air Launched Cruise Missile (ALCM) was the principal nuclear weapon in the latter period of the Cold War, designed to defeat Soviet defences.

The B-1B entered service toward the end of the Cold War, armed with the AGM-69 SRAM and later free fall bombs. The stealthy AGM-129 Advanced Cruise Missile (ACM) was carried only by the B-52.

During this period the heavy bomber fleet carried only dumb bombs (eg Mk.82 and M117 on the B-52H) and naval mines in the conventional roles. The end of the Cold War saw the rapid adoption of other conventional weapons to broaden the roles which could be performed by the fleet. The B-52H and B-2A retain the capability to deliver the B61 and B83 nuclear bombs, and the B-52H the AGM-86B and AGM-129 nuclear armed cruise missiles – the SRAM was retired at the end of the Cold War.

The earliest adoptions were the Israeli built AGM-142 Popeye (Have Nap) standoff weapon on the B-52, and the AGM-86C Conventional ALCM (CALCM) rebuilt from surplus nuclear AGM-86B airframes. The AGM-84 Harpoon was integrated to support the sea control role. All of these weapons qualified as precision guided, but were expensive specialised tools for surgical strike on high value targets.

Unguided cluster munitions were an early addition to the fleet, specifically the CBU-87, CBU-89 and CBU-97 on the B-1/B-2. The need to deliver these from low altitudes produced the impetus for the development of the Wind Corrected Munitions Dispenser (WCMD), an upgrade kit to the standard SUU-64/65 cluster munition dispenser. The WCMD provides inertial heading stabilisation permitting drops from more than 30,000ft. By the late 1990s the whole fleet acquired a devastating capability against massed battlefield targets, using cluster weapons with conventional submunitions and the smart Sensor Fused Weapon (SFW – aka Skeet Bomb). An operational scenario would see heavy bombers carpet bombing opposing armoured units in staging areas or on the move with up to 30 cluster weapons, each delivering 200 bomblets or 40 anti-armour Skeet submunitions.

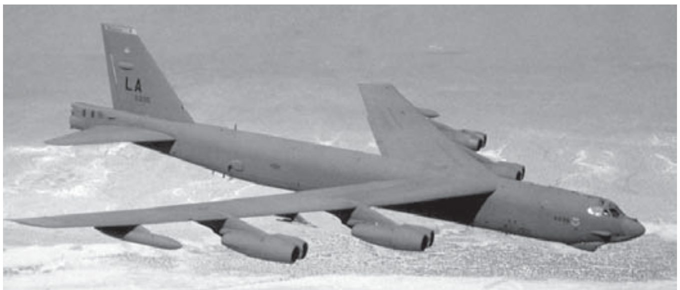
A pivotal development was the adoption of the 2000lb GBU-36 GAM (GPS Aided Munition) on the B-2A. This was the template for the later mass production JDAM and only small numbers were built to support the B-2A fleet, otherwise limited to the Mk.84 and Mk.82 dumb bombs. The GBU-36 was later adapted to the BLU-113 4500lb bunker buster, to create the GBU-37, which was subsequently replaced by the GPS aided EGBU-28 bunker buster common to the F-15E.

The JDAM was the first mass production conventional weapon using the Mil-Std-1760 smart interface, and the 2000lb GBU-31 was soon integrated on all three bombers, with the B-2A expending much of the accumulated JDAM stocks during the 1999 bombardment of Serbia. The 2001 Enduring Freedom campaign saw all three types deliver 2000lb JDAMs against strategic and battlefield targets.

The advent of the 500lb GBU-38/Mk.82 JDAM has seen a drive to integrate smart bomb racks on the fleet, as existing internal bomb bay racks support only the dumb Mk.82. A 500lb smart bomb provides for a massive bombardment capability – the B-52H carrying up to 51 rounds, the B-1B 84 rounds and the B-2A 80 rounds. Saturation near precision attacks on clusters of 50 to 80 aimpoints change the whole bombing equation.

Late generation standoff weapons are planned for all three bombers. The AGM-154 JSOW gliding dispenser was recently integrated, providing cca 30nm (55km) of range. It is available with CEB, SFW and unitary warhead payloads, although heavy bombers are likely to carry only the submunition armed variants.

The Northrop AGM-137 TSSAM was originally intended to arm all types with a 200nm (370km) range class stealthy weapon, combining GPS/inertial guidance with an autonomous thermal imaging terminal seeker. TSSAM is



Arc Light, Arc Light! Octogenarian Boeing B-52H bombers may become a feature of the strategic landscape in the 2040s, if current bomber funding priorities remain. The cheapest to operate of the three US Air Force bombers, the B-52H carries the widest range of weapons in the fleet. The aircraft played a key role over Afghanistan performing persistent bombbardment and would also make important contributions to any campaign in Iraq. (US Air Force)

still regarded to be the stealthiest vehicle ever built, but cost overruns led to its cancellation during the mid 1990s.

The LockheedMartin AGM-158 JASSM was adopted to fill this niche, after a hotly contested flyoff against a competing Boeing bid. While JASSM remains to enter full scale production, its low US$400k unit cost will see it widely adopted. It would provide all bombers with standoff range to strike from outside the typical perimeter of an opposing IADS, making it a useful 'first day of the war' capability.

It is likely that an extended range derivative of the JASSM will replace the AGM-86C CALCM, powered by a turbofan rather than a thirstier but cheaper turbojet. Ongoing use of the CALCM has consumed the stockpile of missile airframes – although new production of the AGM-86C has been proposed as an alternative.

The advent of glide wing kits, such as the HdH (Boeing) JDAM-ER or GEC offering would provide a cheap enhancement to the JDAM on all types. The value of such weapons should not be underestimated, since they provide a very cheap means of placing the bomber outside the reach of terminal defences.

The Small Diameter Bomb (SDB) is likely to be adopted across the fleet later in the decade, further enhancing massed strike capabilities.

Boeing B-52H Stratofortress Upgrades

To exhaustively discuss the vast range of progressive upgrades applied to the B-52H since its introduction in the 1960s would make for a treatise in its own right. As a legacy platform and 'ageing aircraft', the B-52H is in a continuous upgrade process, comprising replacement of unsupportable or obsolete components, in parallel with the integration of new weapons and avionics to enhance capabilities.

Upgrades recently completed, in progress, proposed or planned include the replacement of the GPS receiver, the TACAN, addition of the Integrated Conventional Stores Management System (ICSMS) to replace the myriad of incrementally added systems, ARC-210/DAMA Secure Voice radio, KY-58 VINSON Secure Voice crypto, improvement of the AGM-142 installation and installation on all fleet aircraft, AGM-84 Harpoon integration across the fleet, replacement of the legacy batteries, ECM improvements and replacement of the ALR-20 Radar Warning Receiver, an Off-Aircraft Pylon Tester (OAPT), adoption of the standard Air Force Mission Support System (AFMSS) for planning, enhancement of the Electro Viewing System (TV/FLIR), NVG compatible cockpit and ejection seats, panoramic NVGs, a Standard Flight Loads Data Recorder (SFLDR), Fuel Temperature Monitoring System Avionics Midlife Improvement (AMI) including INS refit, a Real Time Engine Health Monitoring system, a modern attack radar retrofit, and ongoing improvements to the Heavy Stores Adaptor Beam (HSAB – wing pylon).

Replacement of the obsolescent TF33 turbo fans has been proposed repeatedly, including a lease arrangement, but has yet to materialise.

As the integration of current generation mil-Std-1760 based weapons is completed, it is likely that most of the upgrade effort will be concentrated on replacement of unsupportable hardware, and avionics enhancements to support Network Centric Warfare. Should current US Air Force planning be followed, the octogenarian B-52, which retires in 2040, is likely to bear little resemblance under the skin to the current configuration of the aircraft.

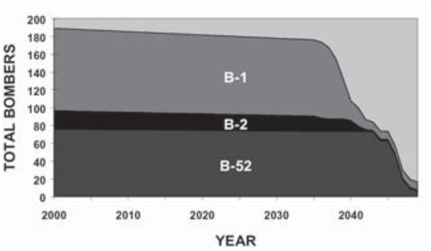
Boeing B-1B Lancer Upgrades

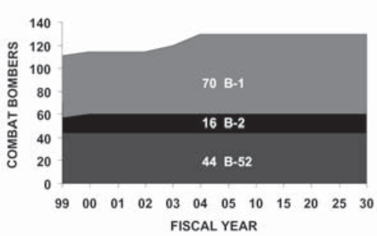
Like the B-52H, the B-1B is now an ageing aircraft, and is now in its second cycle of upgrades. Like the B-52H it will also spend its future in a continuous upgrade cycle. Since its introduction in the late 1980s, the B-1B fleet has undergone numerous upgrades under the Conventional Mission Upgrade Program (CMUP).

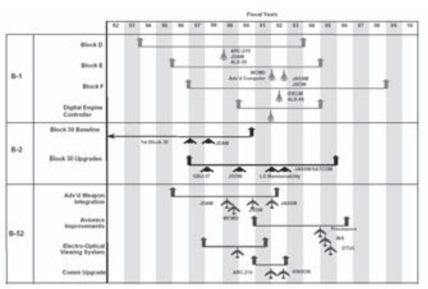
The Block A configuration introduced the Mk.82/Mk.84, Block B added incremental improvements to the APQ-164 synthetic aperture radar and the ALQ-161 jamming system, Block C introduced support for CBUs in 1997 covering half of the fleet, Block D added the GBU-31 JDAM, the ALE-50 towed decoy, jam resistant radios and KY-58 crypto, and is ongoing. Block E, in progress, adds the WCMD, JSOW and JASSM, and improves the mission computers. Block F was to comprise mostly the Defensive System Upgrade Program (DSUP) incorporating the ALR-56M, the US Navy ALQ-214 IDECM jamming suite and the ALE-55 Fibre Optic Towed Decoy. The DSUP was recently cancelled leaving the aircraft with a largely obsolescent EW suite.

A likely upgrade in time will see the APQ-164 phased array incrementally upgraded using components from the APQ-80 (F-16/B60), including the AESA, to provide high resolution SAR and GMTI capabilities. At the time of writing this remained a wishlist item.

(left) Current fleet life cycle planning envisages retirement of all three types around 2040, although the consolidation of the B-1B fleet might extend its life through reuse of mothballed wings. (centre) The US Air Force originally planned to operate over 90 B-1Bs to provide for 70 'combat coded' aircraft. Recent funding cuts have seen that number adjusted down to around 50 aircraft, with 30 aircraft mothballed. (right) This chart shows timelines for key fleet upgrades. The large size of the fleet results in some overlap between upgrades, as only a small number of aircraft are in depots at any given time. (US Air Force)







NorthropGrumman B-2A Spirit Upgrades

Despite its relative youth, the B-2A has been subjected to ongoing upgrades since its introduction. The Block 10 configuration introduced the Mk.84 dumb bomb, Block 20 introduced the GPS Aided Targeting System (GATS) and GBU-36 GAM, the CBU-87/B, and Terrain Avoidance/Terrain Following (TA/TF) on the APQ-181 phased array to permit low level penetration. Block 30 entered service in 1997, and incorporates JDAM/JSOW, Milstar UHF satcom, additional radar modes, improved defensive avionics, major radar cross section performance improvements incorporating MagRam laminates, and a LIDAR based system for monitoring contrail formation at altitude.

Other upgrades proposed or in progress include replacement of the analog engine controllers with a digital design, COTS/VME computer upgrades, Link-16/JTIDS/MIDS, and AMLCD cockpit displays.

The recent loss of the Ku band spectrum used by the APQ-181 has forced a major upgrade of the radar, shifting its operation into the X-band. This will involve replacement of the passive phased array with an AESA, most likely based on APG-79 module technology.

In the Enduring Freedom campaign over Afghanistan, B-52s and B-1s operated from Diego Garcia, the British possesion in the Indian Ocean.

Conclusions

The US Air Force heavy bomber fleet will remain the backbone of US conventional strategic power projection capabilities for the next four decades, unless unexpected technological or strategic changes arise.

At the planned 2040 retirement, the B-52H will be over 80 years old, the B-1B over 50 years old, and the B-2A over 45 years old. While proposals for new build B-2Cs have surfaced repeatedly, the funding environment favours incremental upgrades over block replacements and unless compelling strategic changes or funding abundance arise, the current force structure is likely to persist. While long term savings could accrue from a block replacement of the B-52H and B-1B with B-2Cs, annual budgets will remain the ongoing obstacle for new bomber proponents.

Even so, strategic opponents of the United States will have to contend with a highly lethal force capable of projecting state- of- the- art conventional capabilities over global distances, against strategic, maritime and battlefield targets.

What lessons can the ADF/DoD glean from the US Air Force? The first and perhaps most important is that dedicated bombers are expected to remain pivotal components of modern airpower for decades to come. The expectation that the JSF will be capable of robustly replacing the capabilities of the F-111 is dubious, even with sufficient tanker support, tanker fleet size being another unresolved long term force structure issue for the RAAF. Once an opponents air defences are broken, tonnage does matter!

One might wish to ask why Australia sees the future in a single type light strike fighter force structure, while the US plans for a future where dedicated bombers remain a key force structure component until 2040 and beyond. The Asia-Pacific strategic environment is a key factor in US long term force structure planning.

The persistent bombardment techniques against battlefield targets pioneered in Afghanistan are uniquely the province of dedicated high payload bombers. They provide enormous force multiplication for any small land combat force short of heavy firepower. The deafening silence from Australias land warfare community, the principal operational beneficiaries of this capability, suggests that the longer term implications of the RAAF's current force structure thinking have simply not been understood.

The second lesson is that systematic ageing aircraft programs and rolling block upgrades can significantly improve the economic costs of supporting large fleets over very long times. While they do not necessarily match the running costs of brand new aircraft – an advantage which disappears within a decade- the incremental funding model puts much less short term pressure on budgets, unlike large block replacements which can distort the funding environment severely. Unless compelling tactical or technological reasons force a block replacement, stretching assets via incremental upgrades is much less painful in sustained periods of scarce funding.

The third lesson is that broad 'roadmap' documents for capabilities and platforms, integrated with systematic strategic planning, can provide a valuable means of presenting service strategic thinking and planning to service personnel not involved directly in the area, and to competing services, technologically illiterate bureaucrats, legislators and the public at large. Roadmaps for the key RAAF platforms would provide a tool for arguing funding needs, but also force the adoption of coherent and long term planned strategies for managing these platforms.

Expecting third parties to understand in-service thinking on the basis of scattered project definitions in stale Defence Capability Plan documents and press releases is not a recipe for inspiring confidence within the parliament or winning funding arguments Long term 'roadmap' documents provide a basis for the supporting industrial base to plan its future, and permits optimal investment into infrastructure to minimise long term costs.

The US bomber fleet therefore presents a model which is deserving of careful scrutiny in every respect.

Since its introduction in the late 1980s, the B-1B fleet has undergone numerous upgrades under the Conventional Mission Upgrade Program (CMUP). (US Air Force)