# The USAF Heavy Bomber Fleet- Flexible Platform, Flexible Future

By Thomas Withington

Primarily relics from the Cold War, the United States Air Force (USAF) heavy bomber fleet of B-52H 'Stratofortress', B-1B 'Lancer' and B-2A 'Spirit' heavy, long-range bombers have proved indispensable to US military operations since the end of the Cold War. This paper will consider the key attributes of these aircraft and examine why they been so important in recent military operations, then discuss some of the future options being mooted for the USAF heavy bomber fleet as the aircraft reach obsolescence.

## The key attributes of the heavy, long-range bomber

The USAF's present fleet of heavy, long-range bombers such as the massive B-52 Stratofortress were designed primarily to carry large, thermonuclear gravity bombs over an unrefuelled range of 8,800 miles (14,162 km) to targets deep in the Soviet Union. Later configurations of the aircraft such as the B-52G and B-52H retained this capability, but could also carry either nuclear AGM-69 Short-Range Attack Missiles (SRAMs), AGM-28B 'Hound Dog' missiles or AGM-86B air-launched cruise missiles.

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**B-1B Lancer**

In addition, the aircraft was able to carry a significant load of conventional 'dumb' weapons.[1] B-52s have since been configured to carry conventional precision weapons such as the Joint Direct Attack Munition (JDAM), the Wind-Corrected Munitions Dispenser (WCMD), the AGM-84 Harpoon Anti-Shipping Missile (AShM), the AGM-142 'Have Nap' glide bomb; the AGM-86C Conventional Air-launched Cruise Missile (CALCM), and the AGM-154A Joint Stand-Off Weapon (JSOW).

The JSOW will be carried by all three USAF heavy bombers. This contains 145 BLU-97A/B submunitions and is primarily designed to hit soft targets such as trucks, armoured personnel carriers, parked aircraft and surface-to-air missile (SAM) installations. The missile can also carry BLU-108 sensor fused anti-armour submunitions allowing the B-52 to hit tanks and infantry fighting vehicles as well as SAM sites and mobile 'Scud'-style ballistic missiles.

This has allowed an aircraft, designed as a strategic Cold War nuclear bomber, to retain a 'tactical' ability to devastate frontline forces. In 2001, the aircraft was certified to carry the AGM-86D. This weapon, a variant of the AGM-86C, is designed to hit hardened and deeply buried targets; it also retains a standoff range of 600 miles (966 km). The importance of a 'bunker-busting' capability was

B-2 Spirit

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illustrated when underground Al-Qaeda complexes were attacked during Operation 'Enduring Freedom' in Afghanistan.

The B-1B Lancer, which entered service in 1986, had an equally large payload, which was able to carry nuclear weapons such as SRAM and Hound Dog as well as B-28, B-43, B-61 and B-83 gravity bombs. Following the end of the Cold War, the B-1B fleet began the Conventional Munitions Upgrade Program (CMUP), with the first part of the programme being completed in 1997. This was designed to re-orientate the aircraft away from its nuclear mission into more conventional roles.

The aircraft was removed from nuclear Single Integrated Operational Plan (SIOP) on 1 October 1997, following the second Strategic Arms Reduction Treaty (START-II) signed between Russia and the United States in January 1993. Following their removal from the SIOP, the B-1B was first configured to deploy CBU-87/89/97 cluster bombs (CBUs) and their accompanying Wind-Corrected Munitions Dispenser (WCMD). The aircraft can also act as a standoff missile platform, deploying JSOW. It retains low-observable characteristics, and a radar signature one percent of that of a B-52. This gives it greatly enhanced protection against radar, compared to the much more visible B-52.

The trend towards low-observability and a high payload continued with the B-2A Spirit. Incorporating revolutionary stealth technology, this aircraft was designed to hit mobile Soviet intercontinental ballistic missile launchers such as the RT-2PM/SS-25 (NATO codename 'Sickle') with nuclear weapons such as the B-61 and B-83 bombs; AGM-129 Advanced Cruise Missiles and AGM-131 SRAM-II. The aircraft entered service as the Cold War was coming to an end.

Notwithstanding the speed or stealth characteristics of the B-1B and B-2A, all three heavy bombers in current USAF service share one major characteristic, which is the ability to carry a large payload in a single platform, giving much more 'bang for the buck' compared with several smaller aircraft carrying a similar quantity of ordnance. Moreover, their capacious bomb bays, combined with underwing hardpoints, allows for an impressively varied range of ordnance.

As noted by Air Vice-Marshal Tony Mason, the bomber's range combined with its impressive and varied payload allows the aircraft to perform several varied missions from the outset of a conflict. For example: 'they can neutralise theatre air defences in preparation for the arrival of a follow-up task force. Such tasks will be within the capacity of the B-2, threatening distant political, industrial or military installations or hostile forces close to a frontier. That versatility confers a wide range of responsive options on the government.'[4]

*The US attack on Libya in 1986, ELDORADO CANYON, required over 100 combat and support aircraft. The tasks could have been carried out by six B-2s and six tankers*

For example, the conventional Cold War munitions listed above have since been either combined or replaced with newer weapons such as the JSOW, EGBU-28 glide bomb units and the GBU-30/32 JDAMs. All three aircraft will also carry the AGM-158 Joint Air-to-Surface Standoff Missile (JASSM). This air-launched cruise missile will equip the heavy bomber fleet by mid-2003.[2] An extended range variant will also be available. This will augment the standoff capabilities of the bomber fleet with a range of 575 miles (925 km), further reducing the risks to aircrew from anti-aircraft artillery and missiles by eliminating the need to enter hostile airspace.

All three aircraft in the US arsenal have an impressive range. Unrefuelled, the B-52H can travel 8,800 miles (14,162 km); the B-1B has a range of 3,444 miles (5,542 km) with a normal weapons load; and a 'high intercontinental' range is stipulated for the B-2A. Once in-flight refuelling is factored into the aircrafts' range, their ability to fly from the Continental United States (CONUS) and then to return without requiring a forward base allows them to strike almost anywhere.[3] This was seen with the B-2A strikes in Kosovo and Afghanistan. The range allows the US bomber fleet to strike an enemy suddenly at the outset of a rapidly emerging crisis.

The low level of US casualties in military operations following the end of the Cold War gives a 'value added' attraction to the heavy bomber fleet. Western populations now expect military campaigns involving their armed forces to feature very low casualty figures. Since Vietnam, only two USAF heavy bombers have been lost during hostilities. The first aircraft, a B-52G, crashed on 7th February 1991 in the Indian Ocean with the deaths of three aircrew.[5] The second, a B-1B, was also lost in the Indian Ocean on 12 December 2002; however all of the aircrew survived. On both occasions, neither aircraft was lost through hostile action. Crewing levels of five for the B-52H; four for the B-1B and two for the B-2A mean that comparatively fewer US personnel are placed at risk compared to several smaller aircraft carrying a similar payload.

According to Tony Mason, the USAF heavy bomber fleet is a highly economical weapons platform: 'The expansion of the original nuclear weapon deliverer to a multi-role offensive weapons platform over such an extended life cycle makes the (B-52) one of the most cost-effective twentieth century military systems.'[6] Mason argues that this cost-effectiveness extends to the B-2A.

Boeing B-52H

*The US Nuclear Posture Review, which was submitted before Congress on 31 December 2001, stipulated that 97 nuclear-armed bombers should be retained by the USAF*

Although the most expensive combat aircraft yet to enter service, costing on average $2.1 billion (£1.3 billion) per plane, the use of a stealthy B-2A compared to a large force of non-stealth aircraft requiring fighter escorts, Suppression-of-Enemy-Air-Defence (SEAD) platforms and accompanying Electronic Counter Measures (ECM) planes saves money and aircrew: 'The US attack on Libya in 1986, ELDORADO CANYON, required over 100 combat and support aircraft. The tasks could have been carried out by six B-2s and six tankers.'[7]

However, despite its cost-effectiveness, the B-2A has still not totally replaced the large strike packages more routinely used during air strikes. For example, an attack on a military facility in western Iraq during 2002 saw almost 100 combat aircraft participating.[8] This was also the case during Operation Desert Storm, when strike missions involving F/A-18 Hornets could sometimes include 30 or more aircraft.

However, during both of these attacks, the USAF already had a significant number of combat aircraft close to the theatre of operations.[9] Secondly, whilst operational specifics are sketchy regarding the deployment of the B-2A in recent operations, rumours have circulated that the B-2A still flies on combat missions with an impressive array of escorting aircraft, notwithstanding tankers. The high cost of the aircraft, coupled with its ultra-secret technology may mean that the USAF is reluctant to put such an aircraft at additional risk by flying it into theatre without an escort.

The nuclear role of the USAF bomber fleet has not been neglected in the post-Cold War world. However, as with conventional munitions, the trend for the heavy-bomber's nuclear ordnance has been to miniaturise weaponry and give it a more focused effect.

For instance, the B-2A has been cleared to deliver the B61-11 nuclear gravity bomb. This is a modification of the B61-7 nuclear bomb, which was originally designed for low-level retarded parachute delivery. For the B61-11 modification, the parachute assembly was removed and replaced with an aerodynamic fin. A reinforced steel nose was also added. The yield of the weapon is unknown.[10]

Plans are afoot to develop a new, bunker-busting nuclear device. It is thought that the B61-II is the only earth-penetrating nuclear weapon in the USAF arsenal. In March 2001, the Defense Authorization Bill earmarked funds for the US Department of Energy to develop a new bunker-busting nuclear weapon in response to concern about Weapons of Mass Destruction (WMD) being stored in deep underground facilities rendering them invulnerable to existing conventional or nuclear munitions.[11] The existing warhead design for the B-61 and B-83 weapons may be under consideration, and that this maybe fitted into a 5,000-lb (2,268-kg) ground-penetrating body.

The study is to be undertaken by the Los Alamos, Sandia and Lawrence Livermore National Laboratories in New Mexico and California. The study phase will produce several prototypes, one of which be chosen for deployment.[12] In terms of numbers deployed. The US Nuclear Posture Review, which was submitted before Congress on 31 December 2001, stipulated that 97 nuclear-armed bombers should be retained by the USAF. This is to include 76 B-52H and 21 B-2 aircraft.[13]

The USAF heavy bomber fleet has brought the attributes of payload, flexibility, range and casualty reduction to recent conflicts involving the US armed forces. The force has demonstrated itself to be an essential platform for the post-Cold-War era. Most importantly, the introduction of hi-tech precision weapons into the fleet has 'merged precision, stealth, and stand-off with the payload, range and responsiveness of the bomber arsenal. Bombers are now a critical element of a joint conventional aerospace team with unique capabilities to fulfil Commander-in-Chief requirements across the full spectrum of conflict.'[14]

### Post-Cold War military operations involving the USAF heavy bomber fleet

Operation Desert Storm was initiated on 17th January 1991 in response to the Iraqi invasion of Kuwait during August 1990. The air component of the campaign was designed to:

- Attack 'centres of gravity' in Iraq, such as political leadership and military command sites, communications facilities, weapons of mass destruction infrastructure, power stations and industrial facilities
- Suppress enemy air defences
- Prepare the battlefield. Destroy armour, artillery, troop concentrations and ammunition/fuel dumps in the Kuwaiti Theatre of Operations
- Support the ground war to liberate Kuwait

While the B-1B and the B-2A aircraft did not participate in the air campaign, the B-52G played two important roles. Firstly, seven aircraft were charged with launching cruise missiles at military communications and power generation/transmission facilities during 'Operation Secret Squirrel' at the beginning of the conflict on 16 January 1991.

Secondly, once the preparation of the battlefield had got underway, B-52s were tasked with dropping M-117, Mk. 82 and Mk. 84 bombs to devastate Iraqi positions before the Allied ground offensive to liberate Kuwait began. Flying from King Abdul Aziz Airport in Jeddah, Saudi Arabia; Moron, Spain and Fairford, England, they attacked airfields, factories, oil refineries, ammunition dumps and railheads. Throughout the conflict, B-52s dropped 25,700 tons of bombs – 29 percent of the total ordnance delivered during the war.[15]

The effect of the area bombing by the B-52G aircraft not only degraded the Tawakalna, Hammurabi and Al-Madinah Republican Guard

## *The ordnance would arrive without warning; terrorising those who witnessed the attacks*

divisions; it also had a powerful psychological effect. The B-52 attacks badly demoralised Iraqi soldiers who were suffering round-the-clock bombardment prior to the start of the ground war. The attacks were conducted using a three-aircraft formation, which would undertake a co-ordinated strike dropping 153 bombs. The result on the ground would be a 1.5 square mile swathe of destruction. As the bombs were released from high altitude, the Iraqi troops would often not hear or see the bombers as they approached.

The ordnance would arrive without warning; terrorising those who witnessed the attacks. Whilst it is impossible to analyse all of the factors which influenced so many Iraqi troops to surrender prior to the start of the ground war on the 24th February, the B-52 attacks undoubtedly had a major effect.[16] The actions of the B-52G aircraft in undertaking both missile and bombing missions illustrated the all-important flexibility of the aircraft. Secondly, as one study commented, the use of the B-52 also demonstrated its considerable cost-effectiveness. Their impressive contribution to the air offensive: 'was reached with little cost in terms of men and aircraft.'[17]

On 24 March 1999, NATO began airstrikes against the Serbian political and military targets following Belgrade's refusal to halt attacks against ethnic Albanians in Kosovo. The B-52 would participate in the conflict as a missile carrier, firing CALCMs against targets in Serbia.[18] It was joined in the conflict by the B-1B and the B-2A. The B-1B had made its combat debut less than four months before, when it participated in Operation Desert Strike against Saddam Hussein's regime for the former's refusal to co-operate with United Nations weapons inspectors.

During the conflict in Kosovo, it assumed a different role, striking Serbian military targets with CBU-87, CBU-89 and CBU-97 cluster munitions to destroy tanks, artillery pieces and ground forces.[19] The B-2A also played an important role during the conflict. On 24 March, the opening night of the air offensive, two B2-As dropped 32 2,000-lb (907-kg) JDAMs against Serbian military sites protected by heavy air defences.[20]

Some experts had claimed that Operation Desert Storm and Operation Allied Force represented the last missions for the USAF's heavy bombers. David Wragg commented 'One feature that the Gulf War and the Kosovo crisis had in common was what effectively amounted to the final operation of the traditional bomber, with a large aircraft carrying substantial munitions in a bomb bay … Increasingly, bombing raids became the preserve of the interdictor or strike aircraft, carrying their warload on underwing and under-fuselage strongpoint, as with the Panavia Tornados of the RAF, with increasing use as 'bombers' of fighter, strike and ground attack aircraft, including the British Aerospace Harrier GR7, Lockheed F-16 Falcon and Boeing (formerly McDonnell Douglas) F/A-18 Hornet.'[21] However, Wragg could not have foreseen Operation Enduring Freedom over Afghanistan, which, as Operation Allied Force, saw all three USAF heavy bombers being deployed.

Operation Enduring Freedom began on 7th October 2001, against Al-Qaeda and Taliban targets in Afghanistan, in retaliation for the former's attacks on the United States on 11th September 2001, and the latter's harbouring of the terrorist organisation. Once again, the venerable B-52 illustrated its considerable flexibility. As in Operation Desert Storm, the aircraft dropped unguided gravity bombs against Taliban troop concentrations, enabling the Northern Alliance to break out from their Panjshir Valley redoubt in North Eastern Afghanistan.

Interestingly, the aircraft demonstrated additional flexibility, by operating closely with Special Forces on the ground that fed targeting co-ordinates to the bombers. This enabled the aircraft to act as de facto tactical support platforms, striking targets of opportunities as they emerged.[22] As well as dropping dumb ordnance such as Mk. 82 bombs in saturation attacks on Taliban frontlines, the aircraft also deployed precision-guided JDAMs.[23]

Whilst B-52s acted as proxy tactical air support platforms, B-1B and B-2A heavy bombers also struck targets. Both of these bombers were important in SEAD missions and destroying Taliban

Rockwell B-1B launching a JDAM (Joint Direct Attack Munition) bomb

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aircraft on the ground. They also played a vital role in degrading the Taliban's limited command and control structure and assisted the B-52s in destroying targets in the rear.[24]

Whilst the details regarding the participation of the USAF heavy bomber fleet in Operation Enduring Freedom are still sketchy, it is clear that their contribution in terms of payload, flexibility and range were vital to the operation. All three aircraft participated in the action, deploying both smart and dumb munitions. This enabled the aircraft to devastate troop concentrations as tactical platforms, as well as devastating other targets with more pinpoint bomb and missile attacks.[25]

During 'Operation Iraqi Freedom' against the regime of Saddam Hussein, commencing on 20th March 2003, all three heavy bombers in the US arsenal were in action. As with the previous campaigns in Afghanistan and Kosovo, the aircraft demonstrated their considerable flexibility. On 8th April, a B-1B struck a target in the Mansour area of western Baghdad where Saddam Hussein and his two sons Uday and Qusay were believed to have been meeting.

The aircraft had been loitering over Baghdad and destroyed the target 12 minutes after receiving the order to strike.[26] The B-1B and its JDAM payload was referred to as the 'weapon of choice' for the

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Precision attacks on Saddam Hussein's Republican Palace on the Tigris River

air campaign planners during hostilities. Particularly attractive was the aircraft's ability to carry 50 per cent more JDAMs than any other platform.[27] However, reports from Central Command in Qatar confirmed that on one occasion, all three heavy bombers were used in a single strike package to attack leadership and command and control targets in Baghdad.[28]

Much as they did during operations Desert Storm and Enduring Freedom, B-52s again attacked frontline troop concentrations. As well as dropping dumb bombs and JDAMs, the aircraft have deployed CBU-105 WCMDs. Inside each bomb are 10 submunitions. These contain an imaging radar, which homes in on large military vehicles, but also has an inbuilt recognition memory to avoid large civilian vehicles such as buses. They were used to breach the Republican Guard defences around Baghdad.

The munitions were also used against an Iraqi armoured column.[29] Furthermore, B-52s were used to hit rear areas of the Republican Guard divisions guarding the southern approaches to the Iraqi capital.[30] B-52s were also involved in the initial attacks of the campaign. The 'shock and awe' attacks which the USAF executed from 21st March 2003, were trumpeted as the first ever 'precision only' strikes by the force as B-52s armed with around 100 CALCMs attacked several targets in Baghdad.[31]

Interestingly, for the first time since it entered service, the B-2A was based beyond CONUS for the campaign. Special climate-controlled facilities are available to the USAF at their bases on Diego Garcia in the Indian Ocean, and RAF Fairford, UK, and two of the planes were thought to have been deployed to the former. The aircraft were primarily used to hit leadership and command and

*The B-2A is literally worth its weight in gold! Northrop Grumman have estimated that it could cost US$1 billion ($636 million) to restart the production line for additional B-2s*

control targets. On 27th March, one aircraft dropped two bombs onto a communications tower in central Baghdad. The attack was part of the coalition strategy to: 'degrade the ability of the Saddam Hussein regime to control the actions of Iraq's military forces.'[32]

**Future options for the USAF heavy, long-range bomber force**

The versatility of America's heavy bomber fleet as underlined by military operations since the end of the Cold War has led to a rethink of the heavy bomber's role in US defence planning. The combination of payload, flexibility, range, casualty limitation and cost-effectiveness has led strategists to consider how these important characteristics could be harnessed in future platforms. In 1999, the USAF released its 'White Paper on Long Range Bombers'. The study stressed the modernisation of the bomber fleet, and introduced new technologies and weaponry.

The paper stipulated that, for the short term, the USAF does not expect to procure any new bombers of either existing or new designs. Instead, the fleet will undergo successive upgrades. The near-term upgrade began in 2000 will conclude in 2010. This is intended to equip the existing fleet with the capability to delivery PGMs. Improvements will also be made to the aircraft's command, control, communications and intelligence (C4I) systems. This will consist of installing systems to enable one aircraft to transmit data to another, in addition to aircraft-to-command-and-control and aircraft-to-sensor connectivity through installation of Link 16 data links. Furthermore, the B-2A will be integrated with Extremely High Frequency (EHF) satellite links, whilst the B-52 will receive an improved ECM suite.[33]

The mid-term upgrade for the fleet will begin in 2006 and will conclude in 2015. This will see the B-1B outfitted with a new cockpit and will further improve the conventional capabilities installed on the aircraft during the CMUP. According to the document: 'This programme increases B-1 survivability by providing critical situational awareness displays needed for conventional operations, keeping pace with current and future guided munitions integration, enhancing situational awareness and improving tactical employment.' Other plans for the mid-term phase including fitting the B-52 with Link 16, and the replacement of the B-2A's analogue engine controllers with a digital equivalent. The B-52 will also receive a new databus in its bomb bay to improve its carriage of JDAM, JSOW and JASSM.[34]

The long-term upgrade project will run from 2015 and beyond. A number of options have been mooted. These include a radar upgrade for the B-1B. The B-2A may also receive new computers, processors and additional improvements designed to further reduce the radar signature of the B2A. The B-52 may receive an Enhanced Bomber Mission Management (EBMM) system, which would enable the aircraft to update and replan its mission whilst in-flight.[35]

One of the major pillars of the paper has been to stress the need to improve the flexibility of the bomber force in terms of munitions, which will increase the flexibility of the missions which the aircraft can undertake. When commenting on the White Paper, Under Secretary for Defence Acquisition Dr. Jacques Gansler commented that: 'These new capabilities will open a wide array of new bomber roles and missions that capitalise on the bomber's unique attributes and permit the bomber force to actively participate in tomorrow's full-spectrum battlespace.'[36]

One idea which has been mooted by the USAF is the 'Global Strike Task Force'. This would see B-2A and F-22 'Raptor' aircraft being integrated into a single force which would be able to provide a stealthy, round the clock precision-bombing capability. Playing to the bomber's key strengths of sudden attack, the Global Strike Task Force would be able to destroy critical targets at the beginning of hostilities and to achieve air superiority in the opening days of a conflict. The force will 'kick the

*when you see something you have to attack, you've got to do it immediately. A 16-hour bombing mission by a B-2 may be too late*

door down for the entry of follow-on forces.'[37] One other option which has been mooted for the B-2A includes upgrading the aircraft to engage moving targets.

Paul Marchisotto, Joint Strike Fighter Program Manager at Northrop Grumman, speaking in 2002, commented that: 'We could wind up using the radar to define moving targets – like an armoured column and apply those precision munitions on those vehicles independently. Our current capability against those types of targets is to cut the road. We lay a carpet of weapons out there and we don't actually destroy the vehicles.'[38]

Despite the talk of the Global Strike Task Force, there are few plans to purchase additional B2As. Although the Department of Defense had originally planned to purchase 132 aircraft, the number of planes was capped at 21 in 1992, because of concerns over the aircraft's exorbitant cost. The B-2A is literally worth its weight in gold! Northrop Grumman have estimated that it could cost US$1 billion ($636 million) to restart the production line for additional B-2s.[39]

While deliberations continue as to whether additional B-2s will be purchased, the thoughts of the USAF are now turning to both aircraft and technologies, which could complement and replace the existing USAF long-range, heavy bomber fleet. It is expected that by the middle of 2003 a clear picture will emerge from the USAF as to what this will be, provided that the funding, the military requirement and the political will to embark on such a project are present.[40] Three factors are likely to affect what type of system the USAF opts for.

These include the remaining airframe life of the existing fleet; the proliferation of advanced surface-to-air missiles such as the Russian S-400/SA-20, and finally whether the money for what will undoubtedly be an expensive venture is available. It is thought that the USAF will go for one of three options: a new, manned aircraft, an Unmanned Combat Aerial Vehicle (UCAV), or a 'system of systems' – a mix of UCAVs and conventional aircraft. According to one USAF official: 'We don't want to limit our horizons. It could involve a totally different type of platform or a totally different type of weapon.'[41]

Cost is a major issue regarding a replacement aircraft. Both the B-1B and the B-2A were hugely expensive programmes; add to this the USAF's modernisation of its fighter force with the F-22 Raptor and the F-35 Joint Strike Fighter. Money has also been paid out for the expensive C-17 Globemaster freighter. The air force's current shopping list is both extensive *and* expensive; the question remains as to whether it can accommodate a brand new bomber?

In addition to airframe life and the proliferation of surface-to-air threats and budgetary questions, tactical considerations may also affect what kind of platform is procured. Although the bomber brings unprecedented reach in air-to-ground operations, there is a perception that the present fleet may simply not be fast enough. According James Roche, Secretary for the Air Force in the US Department of Defense (DoD): 'The attacks of 11 September brought home that we've got to have information, surveillance and reconnaissance systems … It also told us that when you see something you have to attack, you've got to do it immediately. A 16-hour bombing mission by a B-2 may be too late.'[42]

One option being discussed is the construction of a hypersonic aircraft. The US Air Force Research Laboratory (AFRL) is investigating aircraft capable of travelling at speeds over Mach 5. One earlier incarnation of this was the X-30, although this experimental craft was cancelled in 1995. However, the Bush administration has revived interest in hypersonic travel, which may yield technologies which could be used on a future bomber.[43]

Another option could be to construct a slightly slower platform; one example of this is the 'Quiet

*Another manned bomber concept called 'HyperSoar' would undertake both reconnaissance and strike missions. It is an ambitious project which would see an aircraft of a similar size to the B-52 travelling at speeds of Mach 10 and carrying double the payload. It is thought that HyperSoar would use the earth's surface as a trampoline from which to bounce off in a similar way to a pebble bouncing off the surface of a pond*

Supersonic Platform', which would travel at speeds of Mach 2.4 whilst producing a low sonic boom. The AFRL has reportedly been working on a project with the Defence Advanced Research Projects Agency (DARPA). The AFRL has also been investigating a concept platform called the Supersonic Global Attack Demonstrator Concept. This will demonstrate the concept of developing either a crewed or uninhabited aircraft, which would have a supersonic cruise speed of around Mach 2. Its weapons load would comparable to the B-2A's 40,000-lb (18,143-kg) warload.[44]

Research being undertaken by Northrop Grumman – the makers of the B-2A – chimes with this emphasis on speed. This is important, as the B-1B is the only USAF heavy bomber with a supersonic capability. A USAF-sponsored study called the 'Future Strike Aircraft' has commissioned Boeing, Lockheed Martin and Northrop Grumman to examine concepts for a new, crewed bomber.

Northrop Grumman is exploring the possibility of constructing an aircraft, which could operate in the supercruise and hypersonic range, with the aim of halving the time it takes for a B-2A to conduct a long-range mission, such as the return trips to Afghanistan during Operation Enduring Freedom. It is thought that Northrop Grumman is considering an aircraft similar to the B-2A, which will use a 'flying wing' design. Dubbed the 'B-3', this aircraft would travel at high subsonic speeds similar to the B2-A, but would have a larger payload.[45]

One option for a replacement aircraft could be to use 'off-the-shelf' components for its construction. New technologies, such as those being utilised in the F-22 and F-35 designs, could be used to equip a new bomber and would help to reduce costs. This was recommended by the RAND Corporation in 1999. A study undertaken by the organisation stated that the aircraft should have a Mach 2 capability and an un-refuelled range of 4,091 miles (6,588 km). It was stipulated that the aircraft should weigh 290,000-350,000lb (131,543-158,759 kg) and have a maximum payload of 15,000-20,000lb (6,804–9,072 kg).[46]

Another manned bomber concept called 'HyperSoar' has been mooted. This aircraft would undertake both reconnaissance and strike missions. It is an ambitious project which would see an aircraft of a similar size to the B-52 travelling at speeds of Mach 10 and carrying double the payload. It is thought that HyperSoar would use the earth's surface as a trampoline from which to bounce off in a similar way to a pebble bouncing off the surface of a pond. Furthermore, this aircraft would be designed to have a range which would enable it to fly anywhere without refuelling.

HyperSoar was the result of a study by the Physics Directorate and the Laboratory Directed Research and Development Program at the Lawrence Livermore National Laboratory in California and the University of Maryland's Department of Aerospace Engineering. The somewhat optimistic development costs for HyperSoar have been mooted at $10 billion (£6.3 billion), which is approximately the same as the development costs for the 777 airliner. However, many of the technologies for HyperSoar are yet to be developed. For instance, the necessary 'Scramjet' engine, and heat-

resistant surfaces are still in development. Furthermore, even when developed, these technologies would have to undergo an exhaustive test period.[47]

Rather than using crewed aircraft, UCAVs offer another option. They have the advantage of placing no aircrew at risk. One possible platform is 'StrikeStar'. This is a prototype, unmanned aircraft weighing 24,000lb (10,886 kg) with a 4,000lb (1,814kg) payload and a 105-ft (32-m) wingspan. It is thought that StrikeStar could have a range of 19,787 miles (31,842 km), giving it the impressive range already seen in the USAF's present bomber fleet. Furthermore, the aircraft would be designed to cruise at high altitude to shield it from emerging SAM threats.[48] Yet there are concerns whether the payload levels on StrikeStar would be sufficient for long-range strike missions.

## Conclusions

Ostensibly a leftover from the Cold War, the USAF long-range, heavy bomber fleet has shown itself to be a vital component of military operations in the post-Cold War world. All have impressive, flexible payloads. The advent of precision munitions such as the JDAM have increased the mission flexibility of these aircraft. Furthermore, the stealthy characteristics of the B-1B and B-2 greatly increase their survivability. The ranges of the aircraft allows them to strike almost anywhere on earth.

Moreover, the 'trade off' between crew size and payload allows fewer aircrew to be put in harm's way. These factors make the fleet cost-effective. Operations in the Gulf, Kosovo and Afghanistan have illustrated why these attributes are so useful. All three aircraft in the US heavy bomber fleet have undertaken missions as diverse as air-launched cruise missile attacks, battlefield preparation, suppression of enemy air defences and psychological warfare.

The role of the heavy, long-range bomber has refocused the interest of the USAF towards what will replace the present fleet, as the aircraft leave service. In the short term, the present fleet will receive several important modifications, enabling the aircraft to improve their conventional capabilities, their reach and flexibility. However, several factors will influence the kind of system which will replace the aircraft.

Considerations regarding the airframe life of the existing force, combined with future military requirements; the proliferation of SAM threats; the political will to procure a new system and finally available funding will determine whether a high speed manned platform is purchased; or whether an uninhabited system, or a combination of both is procured. Whilst the performance and appearance of a future platform may be vastly different from today's heavy bombers, it is almost certain that the core heavy bomber characteristics of impressive payload, mission flexibility, reach, aircrew risk reduction and cost-effectiveness will be at the heart of the design.

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**Notes**

1 The 'dumb' weapon load of a B-52 can consist of CBU-52, CBU-58, CBU-71, CBU-87, CBU-89 and CBU-97 cluster munitions, together with Mk. 20, Mk 36, Mk. 41, Mk. 52, Mk. 55, Mk. 56, Mk. 59, Mk. 60, Mk. 62, Mk. 64, Mk. 65, Mk. 82 and Mk. 84 'iron' bombs.
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46 Ibid.
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