Transport Bombers

A Conceptual Shift in Precision-Guided Munitions Delivery

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Abstract

The US Department of Defense has identified a shortfall in bomber and transport capabilities necessary to execute the two nearly simultaneous major regional contingencies called for in the president's national security strategy. One option to fill the bomber and transport shortfall, though one not discussed in current studies, is to develop transport bombers.

This study addresses three main questions to determine the transport bomber's usefulness. The first is whether commanders can use such an aircraft in ways that truly enhance force application and mobility operations without unduly undermining one in favor of the other? The answer, because of technology enhancements and budget constraints, is definitely yes. The second question targets technology, specifically, by asking whether engineers could place some elements of both missions on a single aircraft? Again, the answer appears to be positive. This study analyzes budgetary and operational constraints in an attempt to answer the question of the appropriate force mix. In the end, either three squadrons of C-17s or two squadrons of B-747-400s provide the necessary capability. The C-17 is a more versatile and flexible mobility platform than the B-747, and engineers have identified all the technological challenges that will allow it to rapidly convert into a bomber. The B-747, on the other hand, can employ twice as many missiles, carry more than two and one-half times the number of cargo pallets and fly farther than the C-17. However, its ability to "swing" promptly remains unproven, and it requires intratheater airlift support to move its cargo to forward operating bases.

About the Author

Maj Bryan J. Benson (BS, Parks College of St. Louis University; MBA, National University) is a C-141 pilot. A distinguished graduate, he was commissioned through the Reserve Officer Training Corps in 1982 and spent the next year in undergraduate pilot training at Vance Air Force Base (AFB), Oklahoma. His first operational flying tour was in the C-141 at Charleston AFB, South Carolina. In addition to upgrading to Special Operations Low Level II instructor pilot, he served as the squadron tactics officer and combat aircrew training manager. Major Benson was reassigned to the Military Airlift Command (MAC) Combat Aircrew Training School at Nellis AFB, Nevada, where he taught combat tactics courses to MAC, Strategic Airlift Command, Air Force Special Operations Command, and sister service personnel. He later served in the Directorate of Operations and Transportation, Headquarters MAC (later Air Mobility Command), Scott AFB, Illinois, as the chief of Strategic Special Operations Programs, Special Operations Branch, and then executive officer to the director. As a senior pilot with more than 2,600 hours, he is a graduate of Squadron Officer School, the US Army Command and General Staff College and completed Air Command and Staff College. In June 1996, Major Benson returned to the cockpit as a KC-135 pilot at Robins AFB, Georgia. Major Benson is married to the former Sherrie Crews and has two sons, Christopher and Matthew.

Chapter 1

Introduction

It was not appreciated, and has scarcely been appreciated today, that the fighting power of an army is the product and not the sum of the arms composing it.

—J. F. C. Fuller
Foundations of the Science of War

The United States (US) Department of Defense (DOD) has identified a shortfall in bomber and transport capabilities. The Bottom-Up Review (BUR) and the Mobility Requirements Study (MRS) outlined the bomber and airlift assets (respectively) necessary to execute the two nearly simultaneous major regional contingencies (MRC) called for in the president's national security strategy (NSS).[1] The BUR called for a conventional bomber force structure in 1999 of 184 precision-guided munitions (PGM) capable bombers, 100 of which would be necessary to fight the first MRC.[2] Today, the US Air Force (USAF) has 168 bombers of which only 67 are PGM capable.[3] Furthermore, the Nuclear Posture Review (NPR) recommended a nuclear capable force structure of 86 aircraft (66 B-52s, 20 B-2s).[4] The BUR includes these aircraft, and they are available for conventional use unless the commander in chief (CINC), US Strategic Command, needs to withhold them for the nuclear (deterrence) mission. Similarly, the MRS highlighted a five-million-ton mile per day (MTM/D) airlift shortfall by 2003.[5] An increase of pre-positioned stocks has eliminated most of the airlift shortfall. The remainder of the shortfall will persist throughout the Future Years Defense Plan.

The National Command Authorities responded to the shortfall of bombers and transports by increasing the level of risk that it would accept (from no risk to moderate) in the two MRC scenarios rather than by increasing force structure. This decision reflected President William J. Clinton's continued desire to cut federal budget deficits, as well as the realization of a more-or-less natural tendency of requirements to exceed force structure in high-cost bomber and transport programs. Real DOD budget authority (after inflation) has decreased by 30 percent since 1990.[6] Likewise, military procurement decreased 59 percent and research, development, test, and evaluation (RDT&E) decreased by 20 percent.[7] Original acquisition plans for the B-2 and C-17 called for 132 and 210 aircraft respectively, but the Clinton administration's drawdown curtailed production at 20 B-2s and 120 C-17s.

One option to fill the bomber and transport shortfall, though one not discussed in current studies, is to develop transport bombers. Multimission aircraft are operationally useful and practical in today's budget environment, as exemplified by the Pentagon's decision to add a surface attack mission to the F-22 air superiority fighter. The transport bomber, if operationally and technologically feasible, could enhance flexibility and provide a greater return on a costly investment. There are many examples of transports being used in force application roles. The German air force flew Ar 232s and Ju 52/89/188/290s as transport bombers during World War II.[8] The French used C-119s to drop napalm on targets around Dien Bien Phu in 1954.[9] C-130s, in different variants, lay claim to dropping the US's largest bomb in combat, shooting the largest aerial gun, as well as air transporting cargo continuously for nearly 40 years.[10] Today, the practicality of employing transport-type aircraft in combat roles is evident in the P-3, a converted Lockheed Electra, and the Air Force's use of the B-747 as the platform for the new airborne laser.

It is important to understand that such multirole aircraft are not likely to replace all specialized aircraft. Some mission requirements will always require maximized capabilities. For example, the B-2 bomber can penetrate almost any high threat environment and drop eight or more F-117 equivalent payloads (depending on the type of PGM). Likewise, it would not be financially prudent to integrate a bombing capability on every transport aircraft. The real question, therefore, is not whether the transport bombers should comprise the entire fleet, but whether such dual role aircraft should perform some part of the bomber and transport missions.

Even at the qualitative level of this analysis, determining the usefulness of bomber transports is a complex challenge. There are essentially three main questions to address. The first explores the idea's operational utility. That is, can commanders use such dual capable aircraft in ways that truly enhance force application and mobility operations without unduly undermining one in favor of the other? The second question focuses on the idea's technological viability. Can the capabilities required for at least some elements of both missions be placed on a single aircraft? The third question, and the hardest to quantify, addresses the idea's practicality. Given the realities of budgetary and operational constraints, what are the appropriate force mixes? This thesis addresses these and a number of corollary questions.

This thesis first examines the operational parameters of the transport-bomber concept. This examination includes a review of bomber and transport requirements, suggestions on how to make each mission more efficient, and methods of reducing transportation requirements while increasing available firepower. Next will be a discussion of the technological problems and possibilities of marrying desired bomber and transport capabilities into a single airframe. For this, it is important to understand the targeting and employment methodology necessary to employ ordnance. These requirements dictate the aircraft and weapons technology necessary to employ such ordnance from transport aircraft. Last, we address whether transport-type aircraft can accept this technology (including weapons) without degrading either the transport or bomber missions. The third main area is the operational and budgetary cost and benefit analysis of transport bombers. This discussion also provides alternative uses for transport-bomber aircraft to satisfy other requirements. It concludes with a discussion of doctrinal and policy implications of the concept.

Several assumptions underpin this study. First, the baseline time frame used for the operational concepts and technology outlined in this study is fiscal year (FY) 2005. Second, the American aversion to friendly, and even enemy, casualties and collateral damage drives an increasing reliance on precision-guided, all-weather munitions and delivery platforms. Third, continental United States (CONUS)-based military forces will have limited en route facilities available to support their overseas employment. Fourth, Air Force weapons and aircraft will become more dependent on off-board, space-based sensors and systems for navigation and target guidance. Fifth, scenarios and hypothetical concepts of operations take into account BUR assumptions, facts, and figures.

Any evaluation of the viability of such dual capable aircraft, of course, rests on their merits, with a mixed fleet of specialized bomber and transport aircraft doing the same job. Ultimately, the purpose of this paper is to present the war-fighting CINCs with a potential solution to shortfalls of bomber and transport force structure and capabilities by exploring new alternatives, one of which could ultimately change the character of war.

Notes

1. William J. Clinton, *National Security Strategy of Engagement and Enlargement,* February 1995, 9.

2. *An Assessment of the Bottom-Up Review*: *Hearings before the Military Forces and Personnel Subcommittee of the Committee on Armed Services House of Representatives*, 1 and 22 March 1994.

3. Gen John M. Loh, USAF, *Testimony before House Armed Services Committee*, 20 April 1994, 700–710. PGM and accurate weapons capability includes conventionally air launched cruise missiles (CALCM), joint direct attack munitions (JDAM), joint standoff weapons (JSOW), AGM-142 Have Nap, and global positioning system (GPS) aided munitions. Currently, only 67 B-2Hs and one B-2 block 20 can carry precision or accurate weapons.

4. Theodor W. Galdi, *Bomber Non-Nuclear Roles: Background to the Heavy Bomber Debate*, Congressional Research Service Report for Congress, 8 June 1995, 22.

5. Joint Chiefs of Staff, J-8, *Mobility Requirements Study*, vol. 1 (Secret), 23 January 1992, VIII-4. Information extracted is unclassified.

6. Loren B. Thompson, *A Revolution in Organizational Behavior*, prepared for the Quadrennial Review of Military Compensation by the Alexis de Tocqueville Institution, 16 February 1996.

7. Ibid.

8. Kenneth Munson, *German Aircraft of World War 2* (Poole, England: Blandford Press, 1978), 120–55.

9. Bernard B. Fall, *Hell in a Very Small Place*: *The Siege of Dien Bien Phu* (J. B. Lippincott Co., 1967), 130.

10. Jack S. Ballard, *The Development and Employment of Fixed-Wing Gunships, 1962–1972* (Washington, D.C.: Office of Air Force History, 1982), 13–14.

Chapter 2

Operational Utility

In the development of airpower, one has to look ahead and not backward and figure out what is going to happen, not too much what has happened.

—William "Billy" Mitchell
Winged Defense

Any new weapons platform, as a matter of first priority, must be operationally viable. This means it must have the capability to do the job in its required operating environment. In the case of the transport bomber, it must be able to operate in both the force enhancement and force application environments without degrading the capabilities of either role. This chapter seeks commonalities in the operational characteristics and operating environments of the bomber and transport missions that suggest the ability of a single aircraft type to do some part of them. First, this analysis begins by examining bomber and transport requirements in the context of the BUR. Second, it examines ways to increase the efficiency of the existing fleet of US bomber aircraft, and it recommends solutions to any operational deficiencies identified. Third, it analyzes whether the transport bomber can accomplish any of the less demanding but still required bomber missions. Fourth, this chapter demonstrates how the transport-bomber concept, if employed, might increase the war-fighting capability of the combatant commanders. The MRS, BUR, NPR, and the Mobility Requirements Study Bottom-Up Review Update (MRS BURU) provide a useful point of departure for evaluating bomber and transport requirements.

Requirements

Recently, four major studies have shaped strategic bomber and mobility requirements: the MRS in 1992, the BUR in 1993, the NPR in 1994, and the MRS BURU in 1995. "The MRS provided the basis for current strategic mobility forces and a comprehensive review of US strategic mobility for the 1999 period. The Bottom Up Review resulted in changes to the defense strategy and overall force structure, modernization, and infrastructure."[1] The NPR recommended strategic nuclear forces sufficient to deter political and military leaders with access to nuclear forces from acting against our vital interests.[2] The recommended strategic force of 20 B-2s and 66 B-52Hs is significant because it allows the remaining bombers to focus strictly on conventional operations. The MRS BURU analyzed the strategic mobility mix to ensure the nation could successfully execute the two strategies.[3] The total future force structure necessary to execute the two MRC strategies is a function of the amount of assumed risk.

The three conventional studies set out to identify force structure necessary for conducting three war-fighting phases with a moderate level of risk. The BUR defined risk as “the likelihood of an undesirable outcome.”[4] The BUR called for a three-phased strategy to stop the aggressor (Phase I), build up US and coalition counterattack forces (Phase II), and, subsequently, counterattack and defeat the fielded forces (Phase III). The MRS BURU concludes that the sooner halting forces are in-theater, the lower the risk. Thus, the present strategy attempts to rapidly deploy US land- and sea-based air and heavy ground forces in time to save essential ports, infrastructure, and other critical facilities.[5] Current scenarios rely on airpower to provide the bulk of the combat power in Phase I. Figure 1 is a notional depiction of the geographic lines associated with risk. Consequently, airlift, bombers, and some fighters are the priority assets in this period. Surface-based forces (and their requisite sea lift minus pre-positioned assets) do not play a large role in the halting phase because they cannot arrive in time to affect its outcome. Phase I defines halting risk in terms of forces and not time.[6]

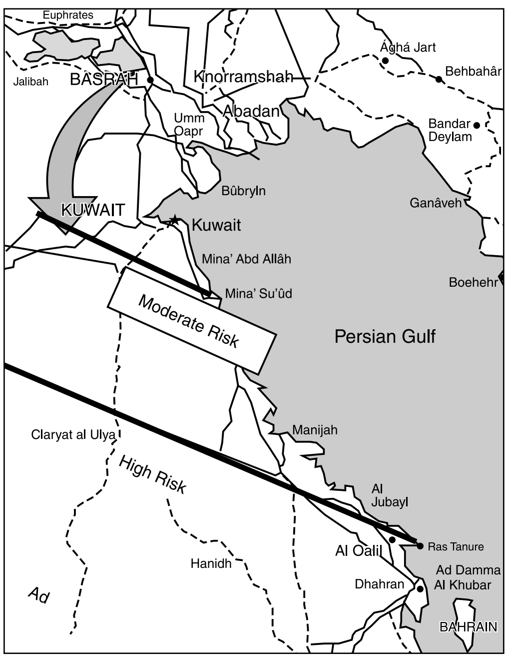

Figure 1. Halting Risk Strategy

The objective in Phase II, the build-up phase, is to provide the combat and logistic force support necessary for the counterattack phase. Phase II forces arrive by a combination of sea lift, airlift, and pre-positioned assets (in priority). Planners define Phase II build-up risk by time and not forces.[7]

In Phase III, US and coalition forces carry out a large-scale air and surface counteroffensive to decisively defeat the enemy. Combat air forces provide firepower against the entire spectrum of targets, while surface forces attack tactical and operational level targets. Sea lift is the primary mode of transportation for the material of heavy ground units and force sustainment during the counterattack phase, while airlift provides the movement of time critical equipment and personnel. Planners also define Phase III risk by time and not forces.[8]

The MRS, BUR, and MRS BURU all concluded that a single MRC required 100 PGM capable bombers (184 bombers total aircraft inventory [TAI]). Twenty percent (37) of the bombers would be unavailable (depot, training, test, etc.), while the remainder (47) serve in attrition reserve or in a nuclear deterrent role. If fewer than 100 deployable bombers are available, theater commanders must either assume additional risk or include additional assets to make up for the bomber shortage. There is clearly a bomber deficiency in the event of a second MRC since there are only 147 bombers (after the 20 percent degradation, but before attrition) to serve both theaters.

The MRS BURU, after extensive war gaming, modeling, and simulation, established a cargo airlift requirement of 49.4 to 51.8 MTM/D. Figure 2 illustrates this requirement.

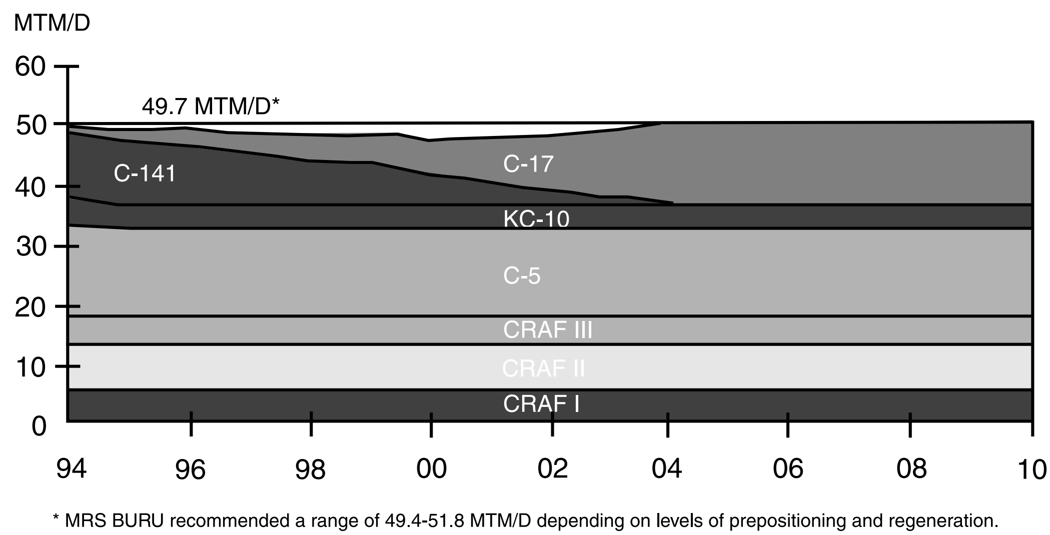

Figure 2. Strategic Airlift Capacity

> The analysis models aircraft loading, movements and cargo delivery on a Time-Phased Force Deployment Data (TPFDD) timeline established by the JCS to meet the needs of supported CINCs. The models compute timelines for delivery and then wargames assess the resultant impact to combat effectiveness. This analysis, conducted as an iterative process, determined that airlift is most significant early in the scenario, during the halting phase, before sealift arrives. The Air Mobility Command (AMC) uses 49.4 MTM/D for broad force structure planning assuming sufficient levels of prepositioning and regeneration of war-fighting materials from the first to the second MRC.[9]

Another measurement of airlift capability and requirements is “closure,” or cumulative daily, “tons delivered” to a theater. Closure requirements match how much the CINC needs (expressed in short tons [s/t]), and when he needs it (measured in days), against the fleet capability. The “delta” between the two is the risk. It is limited to that one scenario, fleet, and point in time but is illustrative of a particular airlift fleet’s capability to support that war-fighting commander.[10] Figure 3 illustrates the relationship between lift requirements and total lift available.

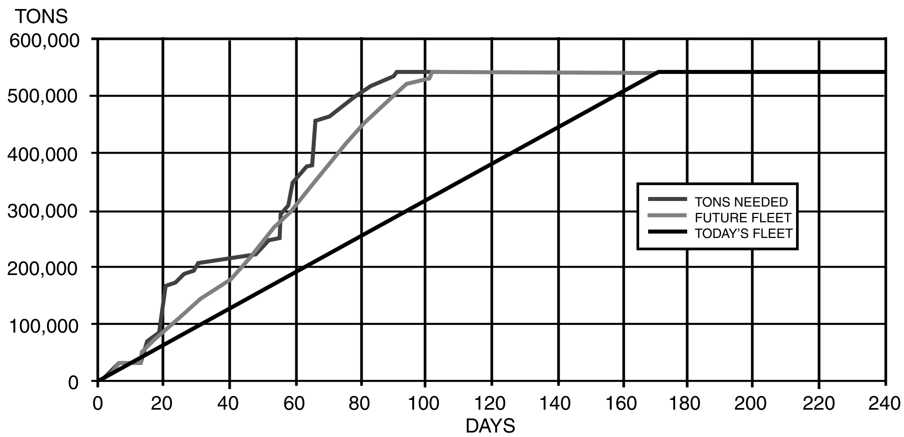

Figure 3. Notional Closure Requirement

The most demanding MRC centers on Southwest Asia. The low number of deployed forces, coupled with the long distance to the theater, present a number of challenges to planners. Phase I deployment forces include substantial air forces, light infantry and Marines, and a number of heavy brigades and naval carrier battle groups. Coalition forces provide additional ground, air, and naval firepower. In Phase I, the CINC does not want to mass troops—he wants to mass fires. Long-range aircraft with PGM increase his ability to do this. After all, stopping the force early is a critical part of the strategy.

There is a potential trade-off. It may be possible to exchange some transport capability early in the MRC scenario for use in a force application role. By stopping the invading force earlier than planned (between the border and the moderate risk line in fig. 1), the CINC incurs a lower level of risk. Further, by reducing this risk, he ostensibly reduces overall counterattack force and transportation requirements. Converting some transport sorties into transport-bomber missions provides a greater opportunity to mass fires on the invading army, thus increasing the likelihood of halting the enemy forces early. On the other hand, if the invading force proceeds beyond the moderate risk line, exchanging transport for bomber missions may stop the invading force from damaging/destroying ports and airfields, thus keeping them open and thereby reducing the amount of required lift.

Bomber Analysis

The fundamental characteristics that distinguish heavy bombers from other weapons are their long range and their substantial payload capability. They can deliver large, diverse payloads virtually anywhere in the world in a matter of hours. That means they have inherent advantages in situations where massive and/or sustained firepower matter, particularly if the attacks must occur at long range from relatively safe bases.[11] The US political establishment has limited options for bringing force to bear in the early period of an emerging conflict as force structure recedes from overseas bases and shrinks in size. The bomber fleet of B-52s, B-1s, and B-2s may be the only practical option where commanders need massive or sustained firepower (more so if naval force is not available).[12] Each bomber brings unique war-fighting capabilities to the scene.

The characteristics and capabilities of USAF heavy bombers have evolved along with changes in national policy, the threat, and technology. The cold war's creation of the B-52, B-1, B-2, and their requisite weapons are testimony of this fact. The B-52 remains the most versatile bomber in the fleet. It can carry the full complement of conventional and nuclear weapons and can operate in low threat environments autonomously, medium threat environments with some tactical support, and alone against targets in high threat environments with its long-range cruise missile (LRCM) capability. In terms of diversity of mission capabilities and weapons mixes, it is the most capable conventional bombing platform in the world today. In the Persian Gulf War, 68 B-52s flew more than 1,600 sorties and dropped 72,000 weapons, representing over 27,000 tons of munitions (42 percent of the USAF and 30 percent of all US bomb tonnage).[13] It is also the only US bomber currently capable in the antishipping operations. A major weakness is its large radar cross section (RCS) that makes it vulnerable to radar guided surface-to-air (SAM) missiles. As a result, it will most likely operate in a standoff mode to remain survivable until the radar and enemy air threats are reduced/suppressed to the point that aircraft can safely penetrate hostile airspace.

The B-1B is ready to take over the core bomber role from the B-52. Rockwell designed the B-1 to penetrate Soviet airspace below the defensive radar detection threshold at subsonic speed and deliver strategic nuclear weapons on selected targets with a high degree of accuracy. The B-1 has less than a third the RCS of the B-52 and is, therefore, less detectable in the radar environment.[14] The US government's recent decision under the Strategic Arms Reduction Treaty (START) II to restrict the aircraft to a conventional-only mission has given new direction to the employment of the B-1. The aircraft's speed, agility, and weapons carriage capability make it nearly four times more effective per sortie than a comparably equipped F-15E (or F-111) on certain critical air-to-surface missions.[15] START I and START II limitations, however, prohibit the B-1 from employing the current family of long-range conventional cruise missiles. This limits the B-1s to freefall and short-range standoff weapons.

Engineers designed the B-2 to penetrate enemy defenses, search, acquire, and destroy fixed and mobile targets, and coordinate the actions of other, less capable aircraft. The combination of stealth, information processing, and large carriage capability make it the centerpiece of any halting force. America's "flagship" bomber is also the most complicated. It is a highly integrated, software-intensive system, containing 226 computers, 69 software programs, 14 mil-standard-1553B data buses, and 113 processor-to-processor interfaces.[16] Unfortunately, despite the proven bomber shortfall, the DOD, with USAF agreement, has chosen not to purchase additional B-2s because of their high unit cost.[17] Table 1 contains a summary of US heavy bomber characteristics.[18]

Table 1

Characteristics of Heavy Bombers Fiscal Year 2001

Characteristics	**B-52H**	**B-1B**	**B-2A**
RCS	Very High	Moderate	Very Low
Speed	Slow	Fast	Moderate
Versatility	Widely Tested	Conventional Only	Untested
Combat Experience	Vietnam, Gulf War	None	None
Defensive Suite	Outdated	Some EW Deficiencies	Stealth is best defense
Combat Radius*	3,000 nautical miles	2,625 nautical miles	2,500 nautical miles
Crew Ratio**	1.40	1.50	1.31
Payload	64,000 lbs	64,000 lbs	40,000 lbs

*Provided by Headquarters Air Combat Command/XPF.
**Defined as the number of funded aircrews per primary aircraft assigned.

Source: Provided by Headquarters Air Combat Command/DOSB

Since the Gulf War, more than 11 major studies have attempted to identify the roles and missions of heavy bombers as a prerequisite to addressing bomber force structure requirements.[19] The fact that there have been so many formal studies in such a short period is testimony to the military and political interest in the subject. These studies, however, have highlighted four missions that cover much of the range of bomber operations. The missions are (1) suppression of infrastructure, (2) halting of invading armies, (3) defeat of enemy air defenses, and (4) attacks on critical mobile targets.[20]

The dynamics of the modern conventional battlefield demand more flexibility than that of the nuclear battlefield. Bomber missions, scheduled against relatively immobile targets, traditionally required long planning times. One way of achieving the desired flexibility is by providing bombers more robust communications, onboard (or off-board) sensing, and computing capabilities.

> The characteristics of such (dynamic) missions are penetration into an integrated air defense system (IADS) consisting of area and terminal defenses, target acquisition and identification, and the ability to retarget based on late-arriving intelligence data. Missions to halt invading armies involve only limited penetration of national IADS. The tactical defenses of the maneuver forces, as well as fighter forces tasked for peripheral and point defenses, form the basic defense environment. Missions to defeat enemy air defenses involve simultane-

> ous attack of enemy airfields and fixed/mobile long-range surface-to-air missiles (SAMs). Finally, missions to attack critical mobile targets such as theater ballistic missile launchers and high-value command assets stress target search, acquisition, identification, and interpretability capabilities.[21]

Said another way, penetrating platforms need defensive systems, sensors, offensive avionics systems, weapons, and command and control systems capable of operating above the modern battlefield. Table 2 illustrates each bomber's capability to conduct the four mission areas in FY 2001, as well as the baseline threat in a typical Southwest Asia scenario MRC.

Table 2

Bomber Mission Areas

	B-52H	B-1B	B-2A	Target Quantity	Number of Aimpoints
Suppress Infrastructure**	X	X	X	193	3,705
Halt Invading Armies*	X	X	X	10,650	10,650
Defeat Enemy Air Defenses**			X	42	252
Attack Critical Mobile Targets*			X	1,000	1,000
Total				11,887	15,607

*Targets from Bottom-Up Review analysis of threats for a major regional contingency
**Fixed Infrastructure/suppression of enemy air defenses (SEAD) target list from Iranian scenario

Sources: The numbers depicted are taken from a range, neither at the low nor high end, from those used in the BUR. They are presented in finished form in the Boeing Defense & Space Group Briefing titled, *Evaluation of Alternative Combined Arms Study Forces Structures,* February 1995, OA951561. The primary source for these numbers, however, is *An Assessment of the Bottom-Up Review: Hearings Before the Military Forces and Personnel Subcommittee of the Committee on the Armed Services,* House of Representatives, 103d Cong., 2d sess., 1 and 22 March 1944, 28.

Scenarios, weapons carriage capabilities, and crew ratios prevent existing bombers from capitalizing on their substantial payload capabilities. The four mission areas outlined in table 2 produced in excess of 15,000 aimpoints for a single MRC in Phase I. Infrastructure and invasion forces account for nearly 92 percent of the target set. The number of aimpoints nearly triples during the build-up and counterattack phases. In comparison, US and coalition forces attacked approximately 40,000 aimpoints (of all types) during the Gulf War.[22] US planners generally believe the enemy must be attrited by 30 percent before the invading forces reach their culminating point. Applied to the target set in table 2, this represents nearly 4,700 aimpoints, of which 3,200 are combat vehicles.[23]

On D day, air commanders will most likely restrict B-52s to employing LRCMs only until they can sufficiently reduce the air and SAM threats. In the absence of radar threats, the B-52 has a plethora of munitions combinations it can employ. As table 2 shows, there are more than 1,200 aimpoints associated with enemy air defense threats, and it would take 10 days to attack all of these targets with B-2s alone (longer if planners use less than all 16 operational B-2s). The B-52s can assist other forces in halting the invading enemy or continue to strike infrastructure targets once these targets are negated.

B-1s will be the primary bomber employed against invading forces. These aircraft would use weapons such as Joint Standoff Weapons (JSOW) or Wind Corrected Munitions Dispensers (WCMD) with sensor fused weapons (SFW) smart antiarmor submunitions. In a detailed computer simulation sponsored by RAND for the USAF, three B-2s destroyed 350 out of 750 (40 percent attrition) combat vehicles within an Iraqi armored division in road march formation.[24] The B-2s used weapons similar to WCMD. The WCMDs destroyed nearly 200 combat vehicles (26 percent attrition) when the Iraqis spread out into an attack formation. While B-2s will not be configured to carry WCMDs, the B-1 will. The B-1 achieves practically the same weapons effects as the B-2 in this scenario. Each B-1 can cover a target area with over 1,200 submunitions, effectively destroying an Iraqi armored brigade in road march or a battalion in attack formation.[25] In other words, four B-1s can cause an invading armored division to stop offensive operations. Table 3 illustrates the carriage capability of the various bombers.[26]

Having capable bomber platforms is not enough, however, if there are not sufficient crews to generate all of the sorties possible. Bomber crew ratios are insufficient to fly the quantity and types of sorties that may be required in an MRC. During the Gulf War, B-52s flew sorties from Diego Garcia, Saudi Arabia, Spain, and the CONUS. Because of the sortie distances involved, planners flew the Saudi Arabian bombers at nearly twice the normal rate, the Diego Garcia and Spanish-based aircraft at the normal rate, and the Barksdale AFB, Louisiana, aircraft at a less than normal rate. Postwar analysis proved that in-theater and CONUS-based bombers needed at least 2.0 crew ratios to be effective.[27] However, table 1 illustrates that crew ratios are well short of the requirement and may be a limiting factor in long-term bomber sortie generation. Thus, options in future MRCs include (1) crews fly more sorties than currently programmed, (2) crews fly longer duration sorties, or (3) aircraft are tasked at less than maximum surge or sustainment capabilities. In scenarios like an MRC Phase I, option 3 is unacceptable unless other assets are found to replace the lost combat power.

Transport Analysis

Nearly every facet of national security and national military strategy execution requires military transport. Nowhere is this better illustrated than in the current national military strategy where airlift leads or assists in 19 of the 22 specific military tasks.[28] America's post-cold-war rebasing of forces from forward locations to the CONUS resulted in a decrease in routine sustainment airlift requirements but an increase in contingency lift requirements. The US military uses airlift continually in training, exercises, and contingencies; and numerous US governmental and nongovernmental agencies procure military airlift when commercial airlift is either not available, not appropriate, or counter to national interests. Furthermore, because the

Table 3

Heavy Bomber Conventional Carriage Capabilities Fiscal Year 2003

		B-52H	B-1B	B-2A
Weapon Type	**Weapon Name**		**Number of Weapons**	
Direct Attack				
-- Freefall	Mk-82/M117GP Bombs	51	84	80/36
	Mk-84 GP Bombs	18	---	16
	Mk-20 Rockeye	24	---	---
	CBU-87/89/97 (SFW)	24	30	34
	Mk-55 Mines	20	---	---
	Mk-62 Mines	---	84	80
-- Accurate				
	JDAM -- GBU-31	12	24	16
	WCMD -- CBU-103/105	16	30	---
	GAM -- GBU-36	---	---	16
	GAT	---	---	16
-- Precision				
	None	---	---	---
Stand-Off				
-- Accurate	CALCM -- AGM-86	20	---	---
	JSOW -- AGM-154	12	12	---
-- Precision	Harpoon -- AGM-84	8	---	---
	RAPTOR -- AGM-142	3	---	---
	JASSM -- AGM-XXX	12	12	8

United States has the world's only robust strategic mobility system—and, more specifically, its only strategic airlift system—it provides lift for numerous countries and organizations for peacekeeping, humanitarian assistance, administrative unit deployments/redeployments, etc.

The increasing demand of the US government to use US military air transport as a sign of American presence translates into an air transportation requirement that often exceeds capacity. Table 4 illustrates the actual commitment rates of the five major mobility weapon systems within the AMC for the last three and one-half years. Upon reviewing the commitment rates, it appears that substantial excess capacity exists. However, when compared against the mission capable (MC) rates, it is evident that little or no excess exists. The KC-135s are flying some airlift missions now; however, their primary task in an MRC will continue to be air refueling. The table also omits the substantial amount of contract airlift that AMC hires from the Civil Reserve Air Fleet participants. In the event of an MRC, the greater part of lift (exact number classified) is dedicated to the war effort. Planners, however, reserve 50 percent of the fielded forces for the second MRC, and most of these forces will lose some of their lift. This will have a negative impact on readiness rates. Purchasing additional transport aircraft above the programmed ceiling of 120 C-17s could alleviate some of the identified shortfalls. It would provide additional lift to the war-fighting CINC as well as continued support to the other airlift customers not actively participating in the MRC.

Table 4

Air Mobility Command Aircraft Commitment Rates

Aircraft	MC Rates Actual/Standard		% of Fleet Committed FY 93	FY 94	FY 95	FY 96*
C-5	68.45%	75%	67.51	68.57	62.72	63%
C-141	71.90%	80%	70.57	81.28	71.10	71%
C-17	82.07%	82.5%	N/A	71.67	66.50	84%
KC-10	93.8%	85%	69.48	69.21	56.71	66%
KC-135	84.3%	85%	33.20	34.85	37.83	36%

*Through February 1996

Sources: Headquarters AMC/LGQA defines MC rates as the percentage of aircraft hours that were fully and partially MC for a unit over a specified period. AMC Pamphlet 21102, atch 1, OPR/LGQA, 18 December 1995, 13 and 16. Commitment rates are defined as the percentage of aircraft scheduled and designated for Headquarters TACC/XOO/XOC tasked missions, spares, and alerts, and local missions (not local spares), operations and maintenance ground trainers, field training detachment trainers, and static displays.

The operating characteristics of bombers and strategic transports are similar. First, "bombers and strategic transports are different from other aircraft in terms of their long range and substantial payload capabilities. They can deliver large, diverse payloads virtually anywhere in the world in a matter of hours. That means they have inherent advantages in situations where massive and/or sustained firepower matter, particularly if the attacks need to be made at long range from relatively safe bases."[29] Second, they are both transport aircraft in the sense that they have internal "boxes" in which they can carry "cargo." Third, the basic operational characteristics and requirements for successfully aerially delivering the "cargoes" of both types of aircraft are much the same. Bomber and transport pilots making airdrops must maneuver their aircraft into a position from which the sensor can acquire the target. Each crew must place the aerially delivered cargo within acceptable launch/drop parameters. Each crew must maneuver the aircraft to a precise release point where the aerially delivered items, accounting for ballistic properties, travel to the desired impact point. Thus, airdrop qualified transport personnel appear to provide a pool from which to draw crew members for the potential transport-bomber mission, much like they do today for the C-141 special operations missions. Using the transport aircraft in the bomber role allows planners to capitalize on the high crew ratios of the transport fleet.

High crew ratios allow transport forces to conduct continuous worldwide operations, allowing planners to maximize aircraft utilization. As table 5 illustrates, active duty crew ratios range from 1.8 to 3.0, but when the secretary of defense (SECDEF) mobilizes the air reserve component (ARC), these expand from 3.5 to 5.0.[30] These crew ratios, coupled with high aircraft utilization rates, permit sustained operations from the CONUS and/or allow multiple sorties from a forward operating base (FOB).[31] Transport shortages appear to be a peacetime and contingency reality, although changes in operational concepts may bring some relief. Operational characteristics, payload, range, and crew ratios appear favorable. The question that remains is, "Why take the operational risk?"

Table 5

Characteristics of Transports Fiscal Year 2002

Characteristics	C-5B	C-17A	KC-10A
Max payload/Range	291K/1,530 NM	160K/2,400 NM	170K/?
Payload/3,200 NM	180K lbs	110K lbs	170K lbs
# of 463L Pallets	36	18	27/23 w pax
Airdrop Capable	Yes	Yes	No
SATCOM Capable	Military	Military	Commercial
RTIC Capable	POM Initiative	POM Initiative	POM Initiative
GPS Capable	Yes	Yes	Yes
Mil Std Data Bus	Yes	Yes	No
Crew Ratio (Active/ARC)	1.8/1.8	3.0/2.0	2.0/1.5

GPS—Global Positioning System
NM—nautical mile
RTIC—real time into the cockpit
SATCOM—satellite communications

Transport Bombers

Given that the bomber fleet falls short of requirements, and that the transport fleet has the latent capability to augment the bomber fleet, the question remains, "in what way and to what extent?" The probable best answer to this question begins by remembering that the goal in Phase I is to halt an invading force and that nearly 75 percent of the targets are mobile. Thus, the best use of available assets might be to focus heavy bombers on mobile targets while attacking the fixed targets with other assets, including transport bombers. While transport aircraft will not be survivable over enemy territory, they do offer promise in the nonpenetrating, standoff mission areas. The only weapons that currently fill that need are ALCMs.

The cruise missile carrier concept is not a new idea for transport aircraft use. Secretary of Defense Harold Brown seriously considered it in the late 1970s as a replacement for the canceled B-1A.[32] The idea of a single aircraft carrying up to 72 cruise missiles interested the secretary, but he decided to modify the B-52 instead of procuring a wide-body cruise missile carrier because the bombers were already "hardened" for the nuclear mission. That concern is not as relevant today.

Transport bombers can substantially increase an air commander's targeting capability. A squadron of transports carrying 20 conventionally air launched cruise missiles (CALCMs) each (same capacity as existing B-52s) could target 240 aimpoints or 6 percent of the fixed targets (previously identified in table 4) on one strike. Further, because a transport aircraft on the ramp does not have the political "baggage" that a bomber does, host nations may allow discreet basing for transport-bomber operations. This would allow planners to capitalize on the robust crew ratios and high aircraft utilization rates, thus generating more sorties per aircraft per day. Aircraft such as the C-5 could deliver 60 or more weapons per aircraft, 720 per squadron on each strike. By using the transport aircraft to augment existing bomber capability, air commanders could exhaust the infrastructure and fixed air defense targets list sooner, allowing the bombers and other tactical assets to penetrate and strike at the fielded forces or other target sets.

In contrast, by using the transport aircraft to strike the fixed targets alone, bombers and other tactical assets can attack fielded forces earlier and, ostensibly, force them to halt sooner than they otherwise would have if allowed to go unimpeded. Bombers can attack more aimpoints against combat vehicles than fixed infrastructure by using weapons with smart submunitions. LRCMs with high explosive warheads can only strike one aimpoint. Consequently, a B-52 with 20 CALCMs strikes, at most, 20 aimpoints. In contrast, a B-52 or B-1 can carry 16 or 30 WCMD weapons respectively. WCMDs with 40 SFW submunitions averaged over three combat vehicle kills per weapon in RAND's wargaming models. That equates to as many as 90 vehicles per bomber sortie.[33] In other words, freeing up bombers to strike fielded forces produces a greater than four-to-one kill ratio advantage over bombers striking fixed targets with cruise missiles.

Transport bombers can use existing airlift platforms, communications and computer processing equipment, and operating concepts to reduce costs and allow the aircraft to "swing" from one role to the other. Since AMC equips transports (or will by FY 2005) with satellite communications (SATCOM), GPS, and possibly real time in the cockpit (RTIC), they can ostensibly operate and communicate with any commander, anywhere in the world, at anytime. Current technology is sufficient to employ LRCMs without the aid of expensive onboard sensors. Planners can load weapons with targeting information before flight, and the capability exists to retarget the weapons in flight if necessary. Engineers should design the system so that qualified crews can employ the weapons using RTIC outside the range of threats. The goal is not only to make as few modifications to the transport airframe as possible, so as not to adversely affect either mission, but to improve both missions with the improvements that are made. This translates into more—and more responsive—capability for the war-fighting commander.

Conclusion

The limited number of both bombers and transports requires employment concepts that capitalize on the strengths and minimize the weaknesses of both. The bomber concept should be one that masses the most fires on the invading force so as to halt it prior to the loss of territory or critical facilities. This destruction occurs quickest when the B-52s and B-1s employ WCMD weapons against armored forces. Transport bombers can support them in this endeavor by either augmenting the B-52 in the nonpenetrating standoff role against fixed infrastructure targets or by attacking these targets alone.

Clearly there is a shortage of peacetime airlift, and the transport concept should provide more lift capability or reduce the lift requirement. In an MRC scenario, transport bombers could be used against an invading force any time its value as a force application platform is higher than its value as a transport vehicle. One example where the concept may be helpful is when the invading force is threatening to overrun vital airfields and/or ports. By using the aircraft in the bomber transport role and stopping the invading force short of the facilities, commanders effectively reduce overall airlift requirements by keeping the ports open. The corollary here is if AMC had additional airlift assets to use as bomber transports, then they would be available to augment the transports during peacetime operations or augment the bombers during Phase I and swing to the transport mission during Phases II and III. The idea appears to be operationally sound, and the current transport infrastructure, crew training, and manning appear capable of supporting the concept. The next issue to address is whether the idea is technologically feasible.

Notes

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3. MRS BURU, ES-1.
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21. Ibid.

22. Jasper Welch, "Bomber Forces for 'Cold Start' Conflict," *Air Force Magazine*, December 1994, 33.

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24. Buchan and Frelinger, 4.

25. Ibid.

26. Headquarters ACC Briefing, Plans Directorate, Forces Division, 21 March 1996, 9–17.

27. General Loh, 707.

28. Gen John M. Shalikashvili, *National Military Strategy of the United States of America*, 1995, 4–16.

29. Buchan and Frelinger, 2.

30. Headquarters AMC/XP, *AMP*, 19, atchs 2, 3, 4.

31. Objective utilization rate (UTE) is defined as the average number of hours per day the primary aircraft inventory (PAI) fly and is measured over two periods: "surge" and "sustained." During the surge period, every effort is made to maximize aircraft utilization and deliver the maximum cargo and troops during the critical early days. After 45 days at the surge rate, the flying rate decreases to a sustained rate. The objective surge UTE rates are used for MTM/D calculations. Headquarters AMC/XP, *AMP*, 19, atchs 2, 3, 4.

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Chapter 3

Technological Assessment

New arms give ever new forms to combat. To foresee this technical evolution before it occurs, to judge well the influence of these new arms on battle, to employ them before others, is an essential condition for success.

—Excerpt from *Die Truppenführung*

History has often overlooked theorists, inventors, and visionaries because their operational concepts were not technologically feasible. Just as chapter 2 evaluated the operational requirements and concepts of the transport bomber, chapter 3 will evaluate the technical aspects. There are three components of the transport-bomber technical feasibility question that this study addresses to support concept viability. What are the aircraft targeting and weapons system requirements necessary to employ weapons? What are the specific weapons types best suited for transport-bomber employment? Can the necessary employment systems and weapons be adapted to transports without disproportionately degrading either the transport or bomber missions? Any serious analysis on transport-bomber requirements and feasibility must spring from an understanding of the basic system requirements of weapons employment.

Bomber Systems Requirements

To understand the transport-bomber targeting and employment requirements, it is important to understand the concept of putting "iron on target." The system requirements include the weapons platform, sensor(s), fire control computer, weapons guidance, and munitions.

Airmen operate their weapons platforms, the vehicles that carry crews and munitions into battle, in one or more of three threat environments: low, medium, and high.[1] The DOD has equipped its aircraft to operate in three possible settings relative to the target environment: (1) stand off beyond the threat range and employ its weapons, (2) penetrate the threat environment and employ its weapons, or (3) both.

Sensors are devices that search, acquire, and track targets. They range in technical complexity from the human eye to phased-array, synthetic aperture radars, to multispectral satellite imaging systems. As a result, they may be off or on board the aircraft. Off-board sensors feed targeting data to the weapons platforms either directly to the aircraft's fire control computer via improved data modems, or to crew members via data or voice transmission. Because this mode depends on a data link, it is theoretically vulnerable to jamming. In that case, crew members must hand enter data into their fire control computers. Likewise, onboard sensors such as the aircraft's radar, forward-looking infrared (FLIR), or electro-optical (EO) systems send targeting data either to the crew or directly to the fire control computer.[2]

The fire control computer receives, interprets, and processes various inputs including targeting information, aircraft performance information (present location, altitude, airspeed, winds, etc.), and weapons specific characteristics (launch parameters, ballistics information, weapons status, etc.), to generate weapons release at the correct place and time.[3] On the B-52, it encompasses three central computers tied together by a mil-std-1553B data bus. They are the brains of the offensive avionics system.

Weapons guidance occurs from a variety of internal, external, or combinations of internal and external sources, or does not occur at all ("dumb" munitions). Internal sources include inertial navigation systems (INS) and digital scene matching area correlation programs.[4] These systems are autonomous after they leave the host aircraft. External systems include radio controlled, EO (sometimes), and laser-guided systems. These systems require an aircraft (may or may not be the host) to give either steering commands or a guidance source to the weapon until weapon impact and, consequently, require the aircraft remain within line of sight (LOS) of the weapon and target. Other guidance methods, such as infrared (IR) and antiradiation, use a combination of internal and external sources for weapons guidance. These systems require the target to provide an energy source that the weapon, in turn, translates into steering commands. Like the internally guided weapons, they are launch-and-leave. Finally, some weapons use a combination of guidance methods to improve their probability of kill. For instance, a weapon may use INS until the terminal phase then use IR or radiation energy to guide to the target. This allows the host aircraft to employ the weapon farther from the target. For obvious reasons, planners and crews prefer launch-and-leave weapons to those requiring LOS with the target. They tend, however, to be much more expensive and fewer in number than other weapons.

Weapons can be either direct attack (freefall, accurate, or precision) or standoff. Direct attack weapons require an aircraft to maneuver to a release point that allows the weapon(s) to travel by their own kinetic and potential energy to the target.[5] Standoff weapons use the kinetic and potential energy imparted by both their delivery aircraft's speed and altitude, as well as their motors, to propel them to their targets—or sometimes by gliding, as with the cruciform airfoils on the guided bomb unit (GBU)-15 or the low-level laser-guided bomb. Standoff weapons enhance an aircraft's survivability by allowing it to deliver ordnance at increased distance from the enemy's defenses.

Some modern, long-range standoff weapons allow for simpler, less integrated avionics (offensive/defensive) systems on their delivery aircraft compared to other weapons types. This is a function of a number of characteristics. First, nonpenetrating platforms require fewer and less complicated defensive system components. Electronic and IR jammers are not as necessary, and better situational awareness tools such as RTIC can replace radar warning receivers, thus reducing defensive systems requirements, increasing situational awareness and mitigating the need for electronic warfare officers aboard transports.

A second characteristic is that preprogrammed or "flexible targeting" weapons eliminate onboard sensor requirements and reduce the complexity of the offensive avionics system. Direct attack and some standoff weapons like JSOWs require onboard sensors to search, acquire, and track mobile targets and to feed this information to the fire control computer. This requires an enormous computer processing capability because increased accuracy of the fire control solution is a function of the fidelity of the sensor, the amount and speed of hardware processing, and the quality and speed of its software. By using preprogrammed cruise missiles, planners can reduce some sensor requirements. They can further reduce them by storing a targeting database on board the aircraft, or alternatively, by providing a digital data link capability to the aircraft offensive avionics system to receive weapon specific mission profiles en route.

The third characteristic that allows standoff weapons to have simpler, less integrated avionics is that they usually have a launch-and-leave capability. Since cruise missiles are autonomous, they do not require the aircraft remain within LOS of the weapon and target as EO and radio controlled weapons do.

Transport aircraft are best suited for nonpenetrating, standoff force application missions, given the lack of an integrated self-protection capability in the medium-to-high threat environment. Cruise missiles have the longest range among conventional air launched weapons, thus permitting the weapon instead of the crew to bear the risk of penetration. The air launched cruise missiles (ALCM) assumed the penetration role for the aging B-52 in 1981 and thus kept the aircraft viable. The B-52 is testimony that not all weapons delivery platforms require state-of-the-art or redundant systems to accomplish their missions.[6] Table 6 summarizes the components of a force application system as it compares conventional to transport bombers.

Table 6

Force Application System Components

	Bombers	**Transport Bombers**
Threat Environments	High	Medium
Sensors	Onboard/Off-Board	Off-Board*
Fire Control Computer	Integrated	Strap-on
Weapons Types	Direct Attack/ Standoff	Standoff
Munitions	Freefall/Accurate/ Precision	Precision

*Some transports have with radar and FLIR; however, the sensors usually lack the fidelity required to locate, identify, and track targets.

ALCM Requirements

The B-52, currently the United States's only cruise missile carrier aircraft, is useful as a point of comparison in determining host aircraft requirements for ALCMs from transport aircraft. It can carry up to 20 AGM-86B/C or AGM-129A/B missiles—eight internally on the common strategic rotary launcher and six on each wing pylon. In contrast, the C-5, C-17, KC-10, and B-747-400 could carry as many as 48, 30, 30, and 72 respectively.[7] ALCMs require four things from the host aircraft: electrical power, pneumatic cooling air, aircraft flight information (known as velocities), and mission profile data. The bomber satisfies these requirements through two "umbilical cords" to the weapons—one electrical and one pneumatic.

The electrical umbilical is the weapons lifeline to the aircraft. Through it, ALCMs receive power, velocities, and mission profile information, both on the ground and in flight. On the ground, crews perform a complete weapons power-up and offensive avionics system check that all weapons are MC. In flight, the weapons require power to accomplish another health check and to align their INS. The central air data computer provides information such as present position, aircraft heading, and altitude, through the offensive avionics system to the weapons ejector racks. Mission profile and GPS information also travel through the connection. The mission information updates either a preloaded flight profile or installs a new profile, as required. The information comes from the aircraft's mission planning computer (MPC) and enters the weapon the same way as the velocities.[8]

The offensive avionics system and MPC are the brains of the weapons system. The offensive avionics system serves as the fire control computer. The MPC should be a stand alone component because of the complex algorithms needed to process the mission profiles. The computer may contain the entire theater fixed-target library, and it must have a data link feed to provide in-flight flexible targeting capability. It prevents "out-of-the-envelope" weapons release through software mechanisms, as well as inadvertent weapons release through mechanical or electrical connections.

In summary, to be effective, an ALCM needs a power source, cooling air, an MPC, an offensive avionics system and a data bus interface. Transport aircraft have adequate power and pneumatic generation capability but lack adequate MPCs and offensive avionics systems to accomplish the bomber mission. However, "strap on" components could provide these capabilities.

Strap-On Systems

Strap-on configurations offer several benefits. One is that they provide more aircraft with the desired capability for less cost.[9] Another is that these systems are often replaced easier, faster, and cheaper than their integrated counterparts. This is especially true regarding computer processing capability, a factor critical to the concept of modifying transport aircraft to perform bombing missions. Today, computers double their operating speeds every 18 months with a nearly corresponding decrease in price.[10] Consequently, given current DOD acquisition timelines, the systems being installed are slower and more expensive by a factor of three than those currently available. The main problem, however, comes when newer components (weapons, ejector racks, computers, etc.) are added to older and slower hardware/software. As a result, engineers must design expensive bridges and workarounds to allow interoperability, or else replace the entire system. The B-52H offensive avionics system illustrates this point.

The B-52H has had considerable work done to its integrated offensive avionics systems and MPCs. In the early 1980s, the USAF upgraded the B-52G and H model offensive avionics system with three 16-bit computers that ran approximately 600 thousand operations per second. A mil-std-1553B data bus provided connectivity between the computers.[11] Unfortunately, this capability did not allow the aircraft to communicate with newer and smarter weapons, so in the late 1980s (using mid-1980s' technology), some aircraft were upgraded with the mil-std-1760A data bus at considerable expense.[12] It also meant the aircraft were not available for mission taskings while the upgrades took place. In the lean years ahead, the USAF cannot afford large numbers of any type aircraft to be unproductive in depots. Snap-on systems, by definition, should reduce aircraft downtime. That is, because they are modular or palletized vice permanently installed, the systems can be replaced and/or upgraded between flights or during scheduled maintenance activities. For example, if snap-on programs reduce depot downtimes by 5 percent and there are currently 30 aircraft in depot (20 x C-5, 4 x C-17, and 6 x KC-10), then that would equate to an additional 1.5 aircraft in the fleet, or a capability increase of well over $100 million of lift.[13]

There are, however, dangers associated with snap-on programs. One such danger is that snap-on components, more so than their integrated counterparts, can be easily added without much forethought on how it effects crew workload, integration with other components/systems or maintenance repair cycles. Obviously, there must be a balance between human factors, mission requirements, and cost.

Snap-on systems give transport aircraft a quick fire control and mission planning capability. Adding a module or pallet to the C-5B, C-17A, KC-10, or B-747-400 that contains an MPC, offensive avionics system, data link capability, and operator workstations requires the host aircraft have at least a central air data computer and aircraft mission computer connected via a data bus. The MPC and offensive avionics system depend on accurate and integrated velocities information, and the data bus assures a level of software commonality. Currently, as table 5 illustrates, only the C-5, C-17, and B-747-400 (assumed capability) have at least an integrated 1553B data bus, and thus the requisite technology suitable for the transport-bomber mission. The requirements addressed thus far are mainly associated with the “front end” of the transport bomber. An assessment of the weapons carriage deals with the “business end.” The next section evaluates the technology required for actually ejecting the weapons from the aircraft.

Weapons Carriage Assessment

The challenge in transport bombers is to find the best way of safely placing their weapons into the airstream at the minimum absolute and relative cost, in the shortest time, and requiring the least aircraft reconfiguration and/or modification. There are numerous methods of accomplishing the delivery, as well as a variety of aircraft candidates. Some of the delivery methods include (1) external carriage, (2) conventional bomb bays, (3) manual insertion, (4) conventional airdrop delivery, and (5) missile ejection and translation system (METS) delivery method.[14] The transport-bomber aircraft candidates available in FY 2005 (baseline for this study) include the C-17, C-5B, KC-10, and the B-747-400. The C-130 was purposefully excluded because of its limited weapons capacity and slow operating speed in the long-range intertheater airlift role.

The first method of delivery considered external weapons carriage. Unfortunately, none of the three military transports have external hard points on the wings capable of carrying more than 2,500 pounds. While carrying some weapons on the transports’ fuselage may be possible, there has been no testing of weapons release and flyaway characteristics. Engineers associated with the B-1 will attest that these are not simple problems to solve. Even if it is technologically feasible, it is cost prohibitive (in the absolute sense) to modify all of the transports and, more importantly (in the relative sense), it would add weight to the aircraft. This weight increase would reduce the total payload and/or fuel weight carrying capacity of the aircraft and increase the total life cycle cost of the aircraft.

The second method of weapons delivery is one that places conventional bomb bays on transport aircraft. It is worthy of investigation and the Scientific Advisory Board recommends the concept for further study.[15] While it, too, may be feasible (and even desirable), it is too costly to retrofit existing aircraft with the capability. As a result, neither of the two methods addressed fit the desired criteria of employing weapons at the minimum cost, in the shortest amount of time, and requiring the minimum reconfiguration/modification. Consequently, they are not retained as viable options. The balance of this assessment focuses on the remaining options. In the interest of converting transport aircraft to bomber missions in the shortest period of time, the assessment only considers palletized and/or modular components using the snap-on concept.

Manually deploying the weapons requires a mechanical arm to insert the weapons into the slipstream. There are three modular and/or palletized components in this configuration. The forward section contains the offensive avionics system, mission computer, secure data link facilities, and operator workstations. The midsection contains the weapons "hangar," and the aft section contains a launch mechanism. After the aircrew brings the weapons on-line, the launch mechanism picks them up one at a time, places them in the slipstream and releases them. An advantage to this method is that the cruise missiles are only released after successful deployment of elevons and engine start, thus reducing noncombat weapon losses. The disadvantages include (1) the long time period required to salvo weapons, (2) creating a mechanical link as the critical component, and (3) needing a mechanical arm long and strong enough to penetrate the boundary layer while maintaining weapons stability. McDonnell Douglas has conducted a technical assessment on this option and concluded that it is technically feasible today.[16] Figure 4 illustrates the manual insertion delivery method deploying unmanned aerial vehicles; however, the same concept could be used for cruise missiles.[17]

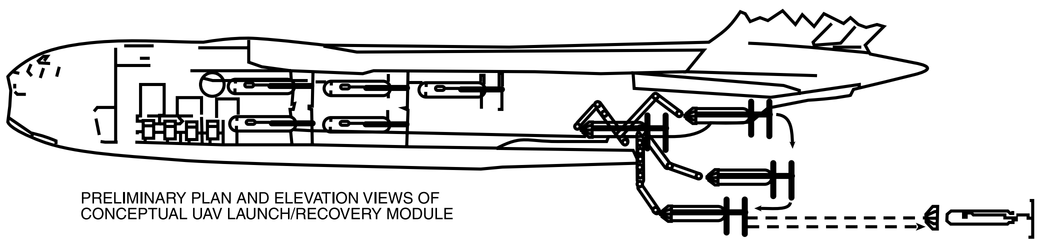

Figure 4. Manual Insertion Delivery Method

Airdropping weapons using conventional cargo air-drop techniques is another delivery option. In this method, the weapons are preloaded into tiered modules on the ground. Again, the forward section of the fuselage contains the MPC, offensive avionics system, and data links. The mid and aft modules contain weapons racks. The advantages of this method include (1) a quicker release of weapons than possible with a mechanical arm, (2) aerial delivery of weapons similar to delivery of air cargo container delivery systems, and (3) the existence of aircrew and cargo handlers already familiar with air-drop missions and procedures. The disadvantages include (1) the requirement for cargo riggers and aerial delivery assets and (2) the slow forward airspeed of the weapon upon parachute release. The latter is especially true concerning employment from the C-5B.[18] The resulting weapons release parameters force minimum release altitudes for these kinds of deliveries above 20,000 feet unless the weapons were equipped with rocket boosters similar to the Tomahawk land attack missile (TLAM). Allowing for operational requirements, Boeing aerospace engineers (the prime contractor for the AGM-86) believe the air-drop concept is technologically viable today.[19]

The last delivery method evaluated here is one that forcibly, yet cleanly, places the missile into the airstream. The two most studied options investigating this method include one using missile tubes and differential pressure and another using mechanical or pneumatic force to place the weapon in the airstream. This first option is similar to launching a torpedo from a submarine; the second is similar to ejecting bombs from conventional weapons racks. The defense aircraft industry proposed these methods in the late 1970s.[20] In the first method, the weapons are loaded into (and possibly stored in) modules for C-17 or C-5B employment. As with other methods, the MPC, offensive avionics system, data links and operator stations are in a forward fuselage module, and the weapons modules are in the mid and aft sections of the aircraft.

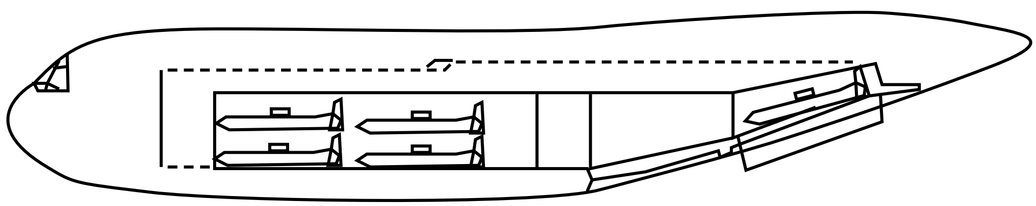

Figure 5. The Missile Ejection and Translation System Delivery Method

These delivery methods require a number of aircraft structural modifications. Custom cargo doors replace the current C-17 ramps and door assemblies, thus creating "bomb bay" type openings for weapons to pass without having to open the doors entirely (fig. 5).[21] The C-5B would require new ramp, pressure, and petal door assemblies; however, the modified C-17 and C-5 doors will not have an adverse effect on conventional transport operations.[22] Nitrogen or carbon dioxide gas provides an overpressure that ejects the weapon, much like a torpedo launch from a submarine, or similar to weapons ejections from conventional bomb racks. The aircraft can remain pressurized during launch (though the fuselage modules are internally depressurized), and there are no altitude or airspeed limitations, resulting in minimal potential and kinetic energy loss to the missile.[23] On the KC-10 or B-747-400, rotary weapons launchers move in circular fashion on rail type assemblies, stopping at the aft cargo doors to eject the weapons. The storage and launch areas are depressurized during launches.[24] The advantages of the METS delivery method include (1) the ability to rapidly salvo weapons, (2) the ability for the crew area to remain pressurized under most conditions, (3) the minimal loss of weapons' potential and/or kinetic energy in the employment sequence, and (4) they are the most researched delivery methods. The disadvantages include (1) the requirement for new doors on all four aircraft, (2) the length of mission reconfiguration time for the KC-10 and B-747-400, and (3) the requirement to depressurize prior to launch for the KC-10 and B-747-400. Boeing, McDonnell Douglas, and Lockheed all believe the METS delivery method is currently feasible.[25]

Of the three methods, the METS delivery method appears to be the most viable, followed by the air-drop and manual delivery methods respectively. The METS delivery method exceeds the others in all eight measured areas. Within the METS delivery category, the C-5 and C-17 appear to be better suited to the transport bomber role than the KC-10 or B-747-400. The C-17 has good capabilities and no obvious limitations in any of the graded areas, while the C-5 is degraded in one category, and the KC-10 and B-747-400 are degraded in four and three areas respectively. The transport-bomber delivery capabilities in table 7 provide a summary of the manual insertion, air-drop, and the METS delivery methods across the four transport types.

Table 7

Transport-Bomber Delivery Capabilities

	Manual Delivery				**Air-drop Delivery**				**METS Delivery**			
Aircraft	1	2	3	4	1	2	3	4	1	2	3	4
Rapid Salvo Capability	R	R	R	R	Y	Y	R	R	G	G	G	G
Pressurized during Launch	R	R	R	R	R	R	R	R	Y	G	Y	Y
Altitude Limitation	Y	Y	Y	Y	Y	Y	Y	Y	G	G	G	G
Airspeed Limitation	Y	G	Y	Y	Y	G	R	R	G	G	Y	Y
Potential/Kinetic Energy Loss of Weapon at Launch	Y	G	Y	Y	Y	G	R	R	G	G	G	G
Aircraft Reconfiguration ≥ 4.25 Hrs *	Y	Y	R	R	G	G	R	R	G	G	Y	Y
Mission Turn Times ≥ 4.25 Hrs	G	G	R	R	G	G	R	R	G	G	Y	G

1 = C-5B, 2 = C-17, 3 = KC-10, 4 = B-747-400
G = Good Capability / No Limitations, Y = Marginal or Questionable Capability / Moderate Limitations
R = No Capability / Severe Limitations

*Assumes assets available and on station

Source: "Stoplight Chart" ratings are subjective assessments by this author based on engineering data, technological assessments, and aircraft DASH-1 technical manual limitations provided by McDonnell Douglas, Boeing, and Lockheed representatives.

Conclusion

The transport-bomber concept is technologically feasible. The aircraft can strike fixed infrastructure targets using preprogrammed ALCMs. It also has the flexibility to operate against mobile targets using off-board sensors and data links to locate, identify, and track targets and reprogram weapons against these targets in flight. It operates best in the permissive environment using long-range, standoff munitions, though it can operate in medium threat environments with RTIC. ALCMs require power, velocities, mission profile information, and cooling air from the host aircraft, and transport aircraft can service these requirements today with the addition of mil-std data buses and strap-on computer systems.

Weapons carriage and deployment pose no major problems in any of the four transport options when delivered by the METS delivery method. There are significant problems for the KC-10 and B-747-400 aircraft in employing weapons from the manual and air-drop methods. Weapons employment in these two methods from the C-5B and C-17 is feasible, but perhaps not as efficient, as the METS delivery. Using preloaded palletized and/or modular components reduces the mission reconfiguration and mission turn times. This, in turn, translates into higher utilization rates. Considering the variables addressed in this chapter, the C-5B and C-17A, using the METS delivery method, are the best transport-bomber candidates. Since the transport bomber will compete for funding against all other DOD modernization programs, it must be affordable in numbers that make it militarily significant. Chapter 4 investigates this issue in an attempt to link ways and means.

Notes

1. Department of the Air Force, Multi-Command Manual 3-1, vol. 1, *Tactical Employment, General Planning & Employment Considerations* (S), 17 March 1995, 9-5, 9-6. This manual defines four threat levels that include permissive, low, medium, and high threat environments.

"Permissive (U): The environment permits operations with virtually no probability of combat or enemy detection leading to engagement.

Low (U): The environment contains limited threats; however, the dispersal, concentration and warfare capabilities of the enemy permit operations to proceed with passive measures taken to avoid detection. If the enemy engages, it will do so with low density small arms, hand-held SAMs, rocket propelled grenades, and light, optically-guided AAA (up to .50 caliber/14.4 MM).

Medium (U): The environment contains significant threats. The dispersal, concentration, mobility, and warfare capabilities of the enemy require active measures to be taken to avoid detection and threats. In addition to the low-threat environment systems, the enemy will typically have a partially integrated air defense system with early generation SAMS, radar controlled AAA, and fighter aircraft without effective lookdown/shootdown and/or all weather capability.

High (U): A high threat environment features widely dispersed, densely concentrated forces including a fully integrated air defense system, advanced or late generation SAMs, fighter aircraft with all generation look-down/shoot-down capabilities, modern ground-based radars and/or passive detection systems, electronic warning capabilities, and highly trained/mobile ground forces."

2. For more detailed information on sensor-to-fire control interface see David A. Fulghum's article titled, "F-16 HTS, Rivet Joint Develop New Radar Killing Skills," *Aviation Week & Space Technology* 123, no. 22 (27 November 1995): 51–52.

3. For more information on bomber offensive avionics systems see Maj Daniel E. Hobbs, *Adapting Strategic Aircraft Assets to a Changing World: Technology Insertion to Provide Flexibility*, Research Report no. AU-ARI-92-10 (Maxwell AFB, Ala.: Air University Press, September 1994), 24–25.

4. GPS may or may not be considered an autonomous system depending on the threat. The system does depend on external signals from the GPS space-based constellation. Modern militaries equipped with antisatellite weapons or jammers may disrupt or deny GPS signals. This will degrade the accuracy of the weapons at best, or make them useless in the worst case.

5. These weapons may be equipped with steerable control surfaces and autopilots to create some standoff capability. They may also be "lofted" by the host platform. However, in either case, they still travel under their own kinetic energy.

6. The B-52 has undergone numerous modernization upgrades since the decision to convert it to an ALCM platform.

7. T. T. Dougherty, Alternate Cruise Missile Carrier Aircraft Study (U), General Dynamics, Convair Division, 2 March 1990.

8. Maj Stephen R. Hess, chief, CALCM Strike Team, Det. 1, 608th Air Operations Group, Cruise Missile Division, telephone interview with author, 4 March 1996.

9. For example (notional), say Headquarters Air Combat Command wanted ultrahigh frequency (UHF) satellite communications on all 66 B-52s for the antishipping role, but planners knew the likelihood of being tasked with an antishipping mission was small. To save money and reduce aircraft weight, you could mount the antennas and install the wiring on all the aircraft (considered group A-kits). However, the command would purchase a limited number of radio shipsets (group B-kits) and collocate these with the antishipping munitions.

10. This phenomena is formally known as Moore's Law after Intel Corporation's cofounder, Gordon Moore. George Gilder, "The Bandwidth Tidal Wave, " *Forbes ASAP*, 5 December 1994, 1.

11. Hobbs, 22.

12. The 1760A upgrade alone is expensive. Known as the B-52H Integrated Conventional Stores Management System (ICSMS), this upgrade will cost well over $80 million for 66 aircraft before being completed in FY 2001. Cost does not include RDT&E, installation, or moneys spent prior to FY 1992. *Program Management Directive for B-52, Integrated Weapon System Management (IWSM)*, 13 October 1994, 10.

13. Depot numbers provided by Headquarters AMC/LGAA briefing slides for the period of 18–22 March 1996.

14. METS is not a fielded system per se, but a concept that uses modules and existing bomb rack units to store and house missiles aboard transport aircraft. After the missiles are readied for launch, they are mechanically moved (translated) to the open cargo doors where they are ejected into the airstream.

15. The Scientific Advisory Board believes that "airlifters equipped with belly doors could deploy cargo randomly, and release precision could be much higher than for deployment through rear doors." "Summary Volume," *New World Vistas Air and Space Power for the 21st Century*, 15 December 1995, 32.

16. This technical assessment is a spinoff of McDonnell Douglas Corporation's unmanned aerial vehicle delivery concept from C-17s. *C-17 Globemaster III, Ideas for the Future: Mission Modules and Advanced Derivatives*, McDonnell Douglas Aerospace, C-17 Improvements and Derivatives Branch, December 1994, 9.

17. Though the illustration portrays a C-17 fuselage, any of the suggested host aircraft could conduct the manual insertion delivery method. McDonnell Douglas Corporation, 13–14.

18. An open center cargo door in flight restricts the C-5 to 205 knots calibrated airspeed; however, ALCMs' flying airspeed is greater than that (exact speed classified). While the weapon's software may allow it to use a prolonged gliding descent to gain the airspeed required for sustained flight, its super critical wings and low "g" tolerance require a slow pull-up from the resulting dive. Consequently, this requires high drop altitudes.

19. Richard Chalfan and Bob Larson, principal engineers, Air Launched Missiles Division, Boeing Defense & Space Group, telephone interview with author, 28 March 1996.

20. Harold Brown, memorandum from the secretary of defense to the secretary of the Air Force, subject: Wide Body Cruise Missile Carrier Demonstration, 3 February 1978.

21. METS drawings are provided by Andy Garcia, aerospace engineer, C-17 Derivatives Division, McDonnell Douglas Corporation. Illustration shows the three modules, as well as profile view of new rear cargo doors. There are only 20 missiles in the figure; however, there is clearly room to place up to 10 more, depending on the translation system used to move the weapons rearward.

22. Andy Garcia, McDonnell Douglas Corporation, telephone interview with author, 29 March 1996.

23. McDonnell Douglas Corporation, 10.

24. Richard G. O'Lone, "Boeing Proposes 747 as Missile Launcher," *Aviation Week & Space Technology* 107, no. 10 (5 September 1977): 17.

25. These manufacturers provided technical assessments and cost effectiveness data on the B-747, B-707, YC-14, DC-10, YC-15, L-1011, C-5, and C-141 aircraft. Kelly H. Burke, *Program Management Directive for Cruise Missile Carrier Aircraft*, Headquarters USAF/DOR, 11 April 1979, 1.

Chapter 4

Budgetary and Operational Considerations

The determination of United States strategy has become a more or less incidental byproduct of the administrative process of the defense budget.

—Maxwell D. Taylor
The Uncertain Trumpet

The transport-bomber concept appears operationally viable and technologically feasible, but it comes at some cost. The first battle the transport bomber must win is probably the battle of the budget. Policy makers and planners can minimize the budgetary cost and operational risk of the transport bomber, however, through sound business practices. To this end, chapter 4 investigates the budgetary aspects of the METS delivery method including a cost comparison of host aircraft, weapons procurement costs, force mix options, and potential budget offsets. It also deals with operational implications of the transport-bomber concept, such as how removing airlift capability from current time phased force and deployment data (TPFDD) affects the war-fighting commanders. A second operational issue to examine is how transport bombers increase employment options, and a third addresses how the concept can compete against sister service alternatives. Finally, this chapter looks at ways to improve the interoperability of mobility and bomber planning and command and control activities and thereby increase the effective and efficient use of assets.

Budgetary Issues

There are three components to the transport-bomber concept that affect program cost: procurement of host aircraft, the modification of the aircraft to accommodate the bomber mission, and the procurement of weapons and support equipment. The transport-bomber cost analysis at table 8 addresses the first issue.

The transport-bomber cost analysis information at table 8 compares acquisition costs, annual operations and support (O&S) costs and 20-year life cycle costs for buying additional C-17, C-5, and B-747-400 aircraft to serve as transport bombers. The analysis compares one, two, and three squadrons of aircraft in an attempt to determine absolute costs. Though the study specifically addressed the KC-10 in previous chapters, it overlooks that aircraft in the financial analysis because it is no longer in production.[1] Though the C-5 is out of production, Lockheed has expressed its ability to restart the line to produce the C-5D as a replacement for the C-5A.

The C-17 serves as a point of comparison in the transport-bomber cost analysis because by FY 2005, the AMC will have designated it the core air-

Table 8

Transport-Bomber Cost Analysis

Weapon System	**TAI / PAA***[a]	Unit Flyaway Cost ($ Millions)[b]	Total Force Acquisition Costs ($ Millions)[c]	Total Force Annual Operating & Support Cost ($ Millions)[d]	20-Year Life Cycle Cost ($ Millions)[e]
C-17	14/12 27/24 40/36	$ 160 $ 160 $ 160	$2,464 $4,752 $7,040	$ 161 $ 310 $ 440	$ 5,684 $10,982 $15,840
C-5D ***C-17 BEP*******	14/12 32/28 40/36	$ 184.3 $ 170 $ 168	$3,096 $6,528 $8,064	$ 161 $ 362 $ 452	$ 6,316 $13,768 $17,104
B-747-400 ***C-17 BEP—>***	18/14 28/25 45/40	$ 160 $ 160 $ 160	$3,312 $5,152 $8,280	$ 180 $ 280 $ 450	$ 6,912 $10,752 $17,280
C-130J[f]	14/12 27/24 40/36	$ 50M $ 50M $ 50M	$ 770 $1,485 $2,310	$ 56 $ 108 $ 156	$ 1,890 $ 3,645 $ 5,535
USN Arsenal Ship*[g]	4 6	$ 560M $ 560M	$2,576 $3,864	$ 31[h] $ 47	$ 3,198 $ 4,804

*All data based on FY 1995 constant dollars. All weapon system costs are exclusive of missile costs.
**Total aircraft inventory
***Primary aircraft assigned/authorized
****Breakeven point

Sources: (a) Total Aircraft Inventory (TAI) equals 12 PAA squadrons plus one aircraft backup aircraft inventory plus one aircraft for training. An additional aircraft is added every second squadron to account for fractions of aircraft in depot maintenance. For C-5s and B-747-400s, 28 Primary Aircraft Inventory (PAI) and 25 PAI respectively equals the airlift capacity (s/t) of 40 C-17s. The study analyzed lift capacity rather than aircraft numbers to keep pricing data relative.

(b) Unit flyaway costs are based on: (1) C-17 production aircraft #120 cost of $160 million; (2) C-5D Lockheed proposal of $167.6 million per unit for 50 aircraft. Price extrapolated to account for differences in lot purchases; and (3) B-747-400 cost of $160 million based on Boeing Aircraft Corporation proposal for 18 aircraft. Maj Phillip Bossert, Headquarters AMC, Plans Directorate, interview, 21 March 1996.

(c) Acquisition costs include procurement (unit flyaway costs x TAI), R&D, initial spares, and military construction. Last three items based on 10 percent/15 percent/20 percent of procurement costs of C-17/B-747-400/C-5 respectively.

(d) Costing data is quoted directly when applicable or extrapolated when necessary to address the excursions within the table. W. L. Greer, Cost and Operational Effectiveness Analysis of the C-17 Program, Institute for Defense Analysis, December 1993, B-25, B-26.

(e) Life cycle cost determined by adding acquisition costs and total operating and support (O&S) costs (O&S x TAI x 20 years).

(f) C-130J flyaway cost of $50 million (calendar year [CY] 1995 dollars), O&S cost equals 11 percent of acquisition cost. Remainder of costing methodology parallels that of other aircraft. "First Flight of C-130J Delayed," *Aviation Week & Space Technology,* 1 January 1996, 24.

(g) Initial research, development, and acquisition cost of $560 million. United States Department of Defense Press Releases, *Navy, DARPA Ink Agreement For Arsenal Ship,* and *Navy Sets Sea Missile Goal,* 25 March 1996.

(h) O&S cost for a guided missile destroyer (DDG)-51 Arleigh Burke class is $5.1 million per year excluding amortization costs, refueling costs or personnel costs (provided by CINCLANFLT Financial Program Comptrollers Office. Personnel costs based on CY 1996 dollars for 42 enlisted, eight officers = $2.67 million/year (provided by Headquarters AMC/FM, Mr. Fred McNett).

lifter. The analysis looks at the C-17, C-5, and B-747-400 in terms of suggested numbers of PAI and TAI aircraft.[2] It also analyzed standard 12 PAI squadrons except for the second squadron of C-5s and B-747s, where it used 28 and 25 aircraft respectively. These specific numbers are significant because they equate to three squadrons of C-17 lift capacity in terms of gross weight carrying capacity (measured in s/t). This is identified as the C-17 breakeven point (BEP) on table 8. One important fact not captured in the table is the number of 463L-sized pallets each can carry because aircraft loads are often volume, not weight constrained. Each C-17, C-5, and B-747-400 can carry 18, 36, and 47 pallets respectively. Evaluating volume (numbers of total pallets) against the C-17 BEPs is even more telling. Three squadrons of C-17s can carry 648 pallets; two squadrons of C-5s (28 aircraft) can carry 1,008; and two squadrons of B-747s (25) can carry 1,175 pallets—or nearly twice that of the C-17. That is important considering the cost of each aircraft and the daily value it can add to America's global reach strategy.

In terms of C-17 equivalents, the B-747 is the cheapest platform to procure and operate, the C-5 is the next, and the C-17 is the most expensive. However, because of its direct delivery capability, the C-17 has very little transload requirement—the necessity to move cargo from an aerial port of debarkation to a forward (usually smaller) operating base. Consequently, the C-5 and B-747 require six and eight C-130 loads respectively to carry their bulk cargo. The C-17 also has the capability to land at over 2,000 more airfields than the C-5 and B-747 which, in turn, translates into more flexibility for the war-fighting CINC. These points are significant in that in terms of transport capability, the B-747-400 appears to be a better monetary value for amount of volume carried, while the C-17 appears to provide more operational flexibility. The C-17 is the most expensive system in terms of acquisition and life cycle costs, while the B-747-400 is the least expensive (again, measured at the C-17 BEP).

Weapons systems with price tags into the tens of billions of dollars require sizable financial offsets to survive today's budget battles. There are a number of such projects capable of producing the required offsets without sacrificing needed national capabilities. One potential offset pertains to replacing some aging C-130E aircraft with C-17s instead of with C-130Js. A second option is competing the transport bomber against the US Navy's (USN) arsenal ship.

The C-17 is the only aircraft of the three transport-bomber candidates with operating characteristics suitable to perform the C-130 intratheater role. Recent operations by the C-17 in Bosnia demonstrate its capabilities and flexibility relative to other aircraft in the theater, including the C-130. In fact, C-17 throughput in-theater was over six times that of C-130s, though it flew 25 percent fewer sorties.[3] Table 8 illustrates that three squadrons of C-130Js cost nearly the same as a single squadron of C-17s, but probably offers less flexibility. There are over 200 C-130E model aircraft in the active and reserve inventories.[4] Replacing 12 PAA unit equipped C-130 squadrons with four PAA C-17 transport squadrons costs less; and since each air component commander has operational control over his theater's C-130s, it might make the tasking between missions less complicated.[5]

A second option, and one with potentially greater impact, is competing the transport-bomber concept against the US Navy's cruise missile carrying ships and, more specifically, the new arsenal ship concept. First, the arsenal ship's concept of operations includes the capability to fire up to 500 vertically launched weapons in support of ground forces. The Navy envisions the ship as a global power projection platform, much as the USAF does with its bombers. Navy leaders envision using small vessels (DDG class) with no more than 50 crew members and would ultimately like to have four to six in the inventory.[6] The transport-bomber concept competes favorably in that the aircraft, by virtue of its inherent characteristics, can be on station anywhere in the world within 24 hours, versus days for the arsenal ship. Second, the arsenal ship cannot compete with the transport bomber in terms of the scope and breadth of peacetime and contingency missions it can serve. Third, in crises smaller than MRCs, planners can tailor the transport-bomber elements, both in terms of package sizes and in weapons mix, thus providing war-fighting commanders options between "all or nothing." Fourth, the arsenal ship presents a lucrative target, especially if it has over $1 billion in weapons on it. This will invariably require additional ships to provide defensive protection that will, in turn, increase its cost. A single squadron of transport bombers is cheaper to acquire than six arsenal ships. Fifth, the arsenal ships have no rapid reload capability, so when they employ all of their weapons, they must return to a port facility to reload weapons.

The second major budgetary issue deals with aircraft modifications necessary to make transport aircraft mission ready for the transport-bomber role. Current C-17 and C-5B aircraft, as well as any future acquisitions, require bomber upgrades subsequent to becoming mission certified. Chapter 3 detailed the requirements the command and control and weapons modules needed in terms of access to the aircraft's central air data computer, or mission computer, aircraft power, and cooling air. They will also need modified doors to conduct the METS delivery method. Costing data is immature, given the limited amount of technical engineering dedicated to this project; however, rough order of magnitude assessments cost the modernization program at $3 million per aircraft or $120 million total cost for 40 aircraft.[7] Once modernized to accept weapons, the aircraft need mission planning computers and offensive avionics systems. Chapter 3 highlighted the necessity of snap-on, modular systems, and the budgetary analysis in this chapter supports that finding. Engineers can palletize an offensive avionics system similar to a B-52's and place it on 48 shipsets for well less than $1 million per shipset.[8] The aircraft will be ready to receive weapons once contractors build the MPC and offensive avionics systems.

The cost of long-range (considered over 600 kilometers) ALCMs for the transport-bomber concept represents the most expensive component of this concept and is the third major budgetary issue. The concept requires approximately 10,000 weapons based on the quantity of fixed infrastructure and suppression of enemy air defenses (SEAD) targets identified in the master targets list for two MRCs (see table 2). Applying an 85 percent probability of success (P_S) to the 4,000 missiles launched results in a "refly" of more than 600 missiles. In other words, planners must employ another 600 missiles to provide full target coverage. This adds up to over 9,200 missiles for the two MRCs. The balance (800) of the weapons are available for lesser contingencies, testing, and other operational requirements.

Current cruise missile programs are more expensive weapons relative to most aerially delivered ordnance. The AGM-86 cost over $1 million in the early 1980s, and the USN TLAM is almost $2 million per weapon.[9] Procuring the desired 10,000 weapons at a unit cost of $1.2 million requires $12 billion. There do appear to be cheaper alternatives. "One US defense contractor reported his company could build a cruise missile with 300 NM range for $100,000."[10] Some current precision weapons are much more expensive, such as the GBU-36 ($143,000), GBU-15 ($204,000), and AGM-130 ($424,000). At $500,000, the ALCM would still appear to be competitive with these weapons.[11] The weapons procurement costs detract from the concept's value, but without the weapons there is no force to apply.

Current treaties restrict the US's ability to retrofit nuclear armed cruise missiles with conventional warheads. The START II counts all AGM-86 ALCMs and AGM-129 advanced cruise missiles against the nuclear threshold. All ALCMs initially flight-tested from heavy bombers on or before 31 December 1988 (AGM-86), or those that do not have external differences that distinguish conventional from nuclear weapons by national technical means fall into this category.[12] In other words, starting a new conventional only cruise missile program for transport bombers bypasses the restrictions within START I and II, while meeting the needs of the war-fighting commanders.

Operational Considerations

The USAF can create a transport-bomber force element with a relatively small investment (excluding weapons cost) by using existing transport forces. Doing this, however, would be at the expense of lift capacity and would delay closing forces currently required in the TPFDD. As chapter 2 addressed, there are advantages in using the aircraft in this role, especially if their use aids in halting the invasion forces earlier than would have occurred otherwise. However, a potentially larger payoff exists by procuring additional lift assets, using them in the transport role to fulfill the peacetime shortfall and, if required, by employing them in a force application role as an integral part of the Phase I halting force. Tables 9–11 depict a series of excursions in which up to three squadrons of C-5/C-17/KC-10/B-747-400s, operating from the CONUS, employ 4,600 ALCMs against targets in MRC-E. The quantity of ALCMs is significant because it represents the number of fixed infrastructure and enemy air defense targets listed in table 2 (chapter 2) plus an additional 15 percent

Table 9

Single Squadron Transport-Bomber Excursions

Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	12	4,600	48	96	13,000	423	31	10.87	2.83	4.24	22.58	6,229.17
C-17	12	4,600	30	153	13,000	410	32	15.15	2.09	5.73	26.74	6,900.00
KC-10	12	4,600	30	153	10,000	445	29	12.50	2.34	5.13	29.86	6,133.33
747-400	12	4,600	72	84	13,000	450	29	15.15	1.91	6.29	10.15	4,663.89
Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	12	4,600	48	96	5,000	423	12	10.87	1.09	11.04	8.67	2,947.59
C-17	12	4,600	30	153	5,000	410	12	15.15	0.80	14.92	10.29	3,169.88
KC-10	12	4,600	30	153	5,000	445	11	12.50	0.90	13.35	11.49	2,769.74
747-400	12	4,600	72	84	5,000	450	11	15.15	0.73	16.36	3.90	2,712.59
Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	12	4,600	48	96	1,200	423	3	10.87	0.26	36.00	4.66	1,837.93
C-17	12	4,600	30	153	1,200	410	3	15.15	0.19	48.00	5.19	1,856.28
KC-10	12	4,600	30	153	1,200	445	3	12.50	0.22	36.00	6.26	1,696.32
747-400	12	4,600	72	64	1,200	450	3	15.15	0.18	36.00	3.77	2,652.86

UTE—objective utilization rate

Table 10

Two Squadron Transport-Bomber Excursions

Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	24	4,600	48	96	13,000	423	31	10.87	2.83	8.49	11.29	6,229.17
C-17	24	4,600	30	153	13,000	410	32	15.15	2.09	11.47	13.37	6,900.00
KC-10	24	4,600	30	153	13,000	445	29	12.50	2.34	10.27	14.93	6,133.33
747-400	24	4,600	72	64	13,000	450	29	15.15	1.91	12.59	5.08	4,670.28
Aircraft Type	**Number**	**Aimpoints**	**Missiles/ Aircraft**	**Required Sorties**	**Total Distance (NM)**	**Block Speed**	**Sortie Duration (Hours)**	**UTE RATE (Hours)**	**Fly Factor**	**Sq Sorties/Day**	**Days in Bomber Mission**	**Opportunity Costs Total S/T**
C-5	24	4,600	48	96	5,000	423	12	10.87	1.09	22.07	4.34	3,499.36
C-17	24	4,600	30	153	5,000	410	12	15.15	0.80	29.82	5.14	7,932.06
KC-10	24	4,600	30	153	5,000	445	11	12.50	0.90	26.70	5.74	3,180.51
747-400	24	4,600	72	64	5,000	450	11	15.15	0.73	32.72	1.95	3,631.38
Aircraft Type	**Number**	**Aimpoints**	**Missiles/ Aircraft**	**Required Sorties**	**Total Distance (NM)**	**Block Speed**	**Sortie Duration (Hours)**	**UTE RATE (Hours)**	**Fly Factor**	**Sq Sorties/Day**	**Days in Bomber Mission**	**Opportunity Costs Total S/T**
C-5	24	4,600	48	96	1,200	423	3	10.87	0.26	72.00	3.33	2,941.45
C-17	24	4,600	30	153	1,200	410	3	15.15	0.19	96.00	3.60	2,888.35
KC-10	24	4,600	30	153	1,200	445	3	12.50	0.22	72.00	4.13	2,517.86
747-400	24	4,600	72	64	1,200	450	3	15.15	0.18	72.00	2.89	4,490.44

UTE—objective utilization rate

Table 11

Three Squadron Transport-Bomber Excursions

Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	36	4,600	48	96	13,000	423	31	10.87	2.83	12.73	7.53	6,229.17
C-17	36	4,600	30	153	13,000	410	32	15.15	2.09	17.20	8.91	6,900.00
KC-10	36	4,600	30	153	13,000	445	29	12.50	2.34	15.40	9.95	6,133.33
747-400	36	4,600	72	64	13,000	450	29	15.15	1.91	18.88	3.38	4,670.28
Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	36	4,600	48	96	5,000	423	12	10.87	1.09	33.11	2.89	4,051.12
C-17	36	4,600	30	153	5,000	410	12	15.15	0.80	44.72	3.43	4,201.94
KC-10	36	4,600	30	153	5,000	445	11	12.50	0.90	40.05	3.83	3,591.28
747-400	36	4,600	72	64	5,000	450	11	15.15	0.73	49.09	1.30	4,550.17
Aircraft Type	Number	Aimpoints	Missiles/ Aircraft	Required Sorties	Total Distance (NM)	Block Speed	Sortie Duration (Hours)	UTE RATE (Hours)	Fly Factor	Sq Sorties/Day	Days in Bomber Mission	Opportunity Costs Total S/T
C-5	36	4,600	48	96	1,200	423	3	10.87	0.26	108.00	2.89	4,044.97
C-17	36	4,600	30	153	1,200	410	3	15.15	0.19	144.00	3.06	3,920.41
KC-10	36	4,600	30	153	1,200	445	3	12.50	0.22	108.00	3.42	3,339.40
747-400	36	4,600	72	64	1,200	450	3	15.15	0.18	108.00	2.59	6,328.02

UTE—objective utilization rate

refly increment to account for ineffective missiles (P_S=.85). As table 9 shows, a squadron of C-5s will fly 4.24 sorties per day and employ the 4,600 missiles in 22.58 days. In comparison, the B-747-400, carrying 72 missiles per sortie, attacks its targets in a little over 10 days! The real value of striking the fixed targets is that it frees bombers from the mission, allowing them to carry heavier weapons loads and concentrate their efforts against the mobile fielded forces.

Clearly there are opportunity costs associated with this concept, both in terms of cargo not delivered when operating in the bomber role and missiles not delivered while operating in the transport role. The opportunity cost for the C-5 after 23 days is approximately 6,230 s/t. This represents a cargo throughput reduction of 5.2 percent from the total organic lift capability (1.686 of 32 MTM/D military capability).

US Transportation Command recently validated these excursions against the actual MRC-E TPFDD.[13] In the excursion, planners decremented available airlift forces by one squadron of C-17 equivalents for seven, 15, and 30 days. This resulted in an increase in closure time by 2 percent, 4.3 percent, and 6.8 percent respectively. These small decrements indicate that there is sufficient lift available to transport bomber elements, fighter squadrons, and other forces capable of immediately attacking the invading forces. While the 6,230 s/t may still appear to be significant, and it is, it equates to less than an armored battalion's worth of forces and their sustainment for 45 days.[14] For comparative purposes, table 12 provides an illustration of the size and requirement of US Army forces. As chapter 2 posits, the operational benefits of striking 4,000 targets immediately outweighs the risk of closing a battalion of equipment 23 days late.

Table 12

US Army Air Transportation Requirements

Required Aircraft Loads					
Unit Type	**Cargo (S/T)**	**C-17**	**C-5**	**B-747-400**	**FT2 Required**
Air Assault Division	44,573	991	685	610	891,460
Airborne Division	29,568	657	455	405	591,360
Armored Division	121,318	2,696	1,867	1,660	2,426,360
Infantry Division	74,150	1,648	1,141	1,015	1,483,000
Mechanized Division	120,663	2,682	1,857	1,651	2,413,260
Armored Cavalry Regiment	36,943	821	568	506	738,860
Light Infantry Division	20,995	467	323	287	419,900

Source: Military Traffic Management Command, *Transportation Analysis Report Generator,* Table of Organization and Equipment/Standard Equipment Configuration File, October 1993, 58.

Operational Advantages and Concepts

The transport bomber offers the CINC and joint forces air component commander (JFACC) an array of options that presently do not exist. Historically, aircraft have been typecast with an identifiable mission. Obviously, bombers have but one mission—force application. Treaty verification agreements, the aircraft's size, and basing restrictions make the aircraft susceptible to constant surveillance. In fact, if the United States has a nuclear bomber withhold and is trying to send an unambiguous warning to an aggressor, the bombers will often be placed in locations to make it easier for the aggressor to collect intelligence. The fact that transports are ubiquitous and capable of employing force add an element of uncertainty, thus complicating their ability to track and estimate our relative firepower. The transport bomber exploits this uncertainty through the element of surprise. Clausewitz recognized as much and stated, "whenever it is achieved on a grand scale, it confuses the enemy and lowers his morale."[15]

Transport bombers have the potential to be the "gunship" of the future. Transport bombers could be capable of carrying a wide variety of cruise missile rounds, including high explosive, antiarmor/antipersonnel/runway cratering submunitions, antiradiation, reconnaissance, and decoys. The ability to retarget weapons in flight enhances this flexibility. Ostensibly, the aircraft could loiter in a standoff orbit awaiting orders to attack targets, much the same as current fighters and gunships do today. This concept also allows for immediate restrike of targets upon receipt of negative battle damage assessment reports.

The ability of transport bombers to operate anywhere in the world and deliver a sizable payload offers numerous options for future commanders. One option would be to use them to replace current US Army Corps assets such as the Army tactical cruise missile system. Transforming the platform into aerial support moves forces and assets from the theater front to the rear (worst case), or out of the theater altogether (best case). The greater the distance between the forces/assets and the enemy threat, the smaller the security and logistical requirement. This also, in turn, reduces airlift and sea lift deployment requirements. Obviously, the ability to coordinate and execute between services, as well as mobility and bomber organizations will be increasingly tested.

The transport-bomber element within the force must be able to integrate with both the mobility organizations and force application organizations. Scheduling priorities and coordination are two areas for potential conflict. The theater air commander's focus is on conducting an effective theater air campaign while the mobility commander's responsibilities lean more towards the nation's mobility requirements. This is not to say that the two could not be the same objective. It does say, however, that a natural friction exists between the two. The AC-130, having at times served two masters under the theater special operations commander and the JFACC, may provide some lessons regarding operations across functional lines. Certainly, there are organizational concepts that can ease the natural tensions between the two components, as well as the administrative elements.

There are a number of organizational changes the USAF can make to increase the efficiency and effectiveness of transport-bomber forces. The first includes creating new organizations, similar in concept to Aeromedical Evacuation Squadron, that are responsible for the "back end of the aircraft" during bomber operations. These units would be responsible for all operations and functions pertaining to the bomber mission except for aircraft operations. Its responsibilities would include providing the mission planners, workstation operators, and weapons programmers required for in-flight operations and all loaders, maintenance personnel, and oversight of weapons and MPC, offensive avionics system, and weapons modules. Programmers should collocate these weapons units with their weapons; however, they do not need to collocate the weapons on transport bases. This employment concept allows both the front-end and back-end crews to focus on their core tasks, just as flight crews and aeromedical evacuation crews do today.

Conclusions

The transport-bomber element provides the CINC with increased capability at some absolute and relative cost. Aircraft and weapons procurement are expensive programs. Programmers can mitigate costs by substituting some of the new C-130J aircraft they may acquire with C-17s, and by redirecting money from duplicative programs that offer less flexibility like the USN arsenal ship. Programmers and service chiefs may elect to build a transport-bomber capability from existing force structure. It comes, however, at the expense of mobility requirements both in peacetime and in war.

Notes

1. The MD-11 could have been included in its place; however, the B-747-400 was the leading competitor to the C-17 in side-by-side analysis and has often been cited in wide body cruise missile carrier studies, making it the logical off-the-shelf commercial platform of choice.

2. PAI are those aircraft provided for the performance of the mission. TAI are aircraft assigned to operating forces for mission, training, test or maintenance. This includes primary, backup, attrition, and reconstitution reserve aircraft. In terms of the C-5, Lockheed still maintains the capability to produce the C-5, as indicated by their submission of a C-5D proposal in the NDAA analysis. "USAF Almanac," *Air Force Magazine* 78, no. 5 (May 1995): 51.

3. The first wave of the Balkan airlift in Operation Joint Endeavor lasted from 4 December 1995 to 18 January 1996. At the time, C-130s flew 490 missions and carried 445 passengers and 1,542 s/t of cargo, while C-17s flew 367 missions and carried 3,166 passengers and 9,250 s/t. "The Air Force in the Balkans, " *Air Force Magazine* 79, no. 3 (March 1996): 26.

4. "USAF Almanac," 52–53.

5. The acquisition costs for four C-130J squadrons is $2,650 million versus $2,464; while the O&S costs are $202 million and $161 million respectively.

6. DOD Press Releases, *Navy, DARPA Ink Agreement For Arsenal Ship,* and *Navy Sets Sea Missile Goal,* 25 March 1996.

7. Rough order of magnitude costing estimate, C-17 Derivatives Division, McDonnell Douglas Corporation.

8. Contractors can build new offensive avionics and MPC planning computers using off-the-shelf computers today at a cost of less than $200,000. The $1 million figure is a rough order of magnitude costing figure until engineers complete the analysis.

9. USAF Fact Sheet 94-02, *AGM-86B/C Missiles*, February 1994, 2.

10. Jeffery R. Barnett, *Future War: An Assessment of Aerospace Campaigns in 2010* (Maxwell AFB, Ala.: Air University Press, January 1996), 31.

11. USAF Armament Product Group Manager, *1996 Weapons File,* 1 March 1996, 2-6, 5-3, 5-11.

12. Maj Gen Robert E. Linhard, Headquarters, USAF/XOX, memorandum for AFPEO/WP, subject: START I/II Treaty Limits for the Joint Air-to-Surface Standoff Missile (JASSM), 1 March 1996.

13. Maj Mike Scott, USTC J-5, assisted in this validation process by modeling the excursions on the Joint Flow and Analysis System for Transportation against the actual TPFDDs.

14. *The Army Strategic Mobility Program,* Headquarters, Department of the Army, 13 March 1996, 14.

15. Carl von Clausewitz, *On War,* ed. and trans. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1976), 198.

Chapter 5

Conclusions

We should base our security upon military formations which make maximum use of science and technology in order to minimize numbers of men.

—Dwight D. Eisenhower

The transport-bomber concept appears to be viable and offers improved capability that goes beyond the margins of traditional force application and force enhancement roles and missions. As a result, its versatility enhances the overall capabilities of the nation by producing a multirole aircraft that provides payback in times of crisis and in peace.

The transport bomber is operationally viable as an ALCM carrier. Augmenting the halting force, it is capable of providing immediate offensive combat power against fixed infrastructure and surface-to-air defense targets. This, in turn, allows organic bombers to maximize weapons payloads while focusing their efforts on the invading forces.

The transport-bomber concept is technologically feasible in various delivery methods, but only for particular weapon systems. The "Stop Light" chart at table 13 summarizes these findings. The METS delivery method provides the best capability in terms of mission reconfiguration and sortie regeneration, while reducing the number of structural modifications necessary for multirole employment.

Table 13

Summary of Technical Assessment

	Manual Delivery	Air-drop Delivery	METS Delivery
C-5	Yellow	Yellow	Yellow
C-17	Yellow	Green	Green
KC-10	Red	Red	Yellow
B-747-400	Red	Red	Yellow

The cost of the transport-bomber concept, including weapons, is substantial. Table 14 summarizes the costs of the cruise missile carrier program. There are a number of areas that offer opportunities to trim program and operating costs within the aircraft and weapons acquisition programs. In the aggregate, the money spent on the transport-bomber element buys both long range, PGM employment capability and air transport capability.

Table 14

Cruise Missile Carrier Cost Summary

Cruise Missile Carrier	20-Year Life Cycle Cost ($M)	Modernization on ($M)	Weapons 20-Year Life Cycle Cost ($M)*	Total Cost ($M)
USN Arsenal Ship	$ 4,804	$ 0	$45,000**	$49,804
C-17	$15,840	$216	$36,000	$52,056
C-5	$13,768	$216	$36,000	$49,984
B-747-400	$10,752	$216	$36,000	$46,948

*Acquisition cost may be as low as one-tenth that depicted depending on manufacturer and required quantity.
**TLAM costs are higher than ALCMs because of the addition of a rocket booster.

Implications

The transport-bomber concept, if accepted, has far-reaching programming and doctrinal implications. Currently, the Joint Requirements Oversight Council (JROC) uses the joint warfare capabilities assessment (JWCA) process to generate innovative insights as to how to build joint military capabilities.[1] While the JWCA process emphasizes capabilities and not platforms, its efforts largely deal within mission areas and lack the flexibility to consider programs that cross mission areas. For instance, two assessment areas deal with strike and strategic mobility and sustainability. Each also has specific directorates on the Joint Staff responsible for the conduct of the assessments—J8 for strike and J4 for mobility and sustainment. Under which assessment and directorate would the transport-bomber concept belong? Similar arguments can be made within the Air Force. Does Air Mobility Command or Air Combat Command sponsor the program? The subject of ownership pertains to doctrine as well.

The transport-bomber concept requires some reevaluation of mobility and force application doctrine. Currently, the two are separate and distinct. Likewise, planners need to integrate the command and control mechanisms of both. The strength of the transport-bomber concept is the ability of the aircraft to swing its mission on command. It needs a doctrine that accounts for this and the requisite command and control flexibility to maximize its effectiveness and efficiency.

Today's planners and strategists must devise superior employment concepts for future weapons. Technology alone will not be enough to win wars. As in past wars, the side that has the best concept of operations in the future will be victorious.[2] The transport bomber has the potential to be a revolutionary change, and it is the revolutionary change that affects the change in the character of war.

Notes

1. Office of the Vice Chairman of the Joint Chiefs of Staff, *JROC: Planning in a Revolutionary Era* (Washington, D.C.: Institute for Foreign Policy Analysis, 1996), 17.

2. Jeffery R. Barnett, *Future War: An Assessment of Aerospace Campaigns in 2010* (Maxwell AFB, Ala.: Air University Press, January 1996), 29.