National Security Assessment of the

C-17 GLOBEMASTER CARGO AIRCRAFT'S ECONOMIC & INDUSTRIAL BASE IMPACTS

U.S. DEPARTMENT OF COMMERCE
Bureau of Industry and Security
Office of Strategic Industries and Economic Security
Strategic Analysis Division

DRAFT FINAL REPORT

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Acronyms

AMC	= Air Mobility Command
BIS	= Bureau of Industry and Security
CRAF	= Civil Reserve Air Fleet
DOC	= U.S. Department of Commerce
DOD	= U.S. Department of Defense
DPA	= Defense Production Act
FCS	= Future Combat System
FOL	= Forward Operating Location
HASC	= House Armed Service Committee
ITAR	= International Traffic in Arms Regulations
MCR	= Mission Capable Rate
MOPS	= Minimum Operational Performance Standards
MRS	= Mobility Requirements Study
MT	= Metric Tons
MTM/D	= Million Ton Miles per Day
MTW	= Multi-Theater War
MYP	= Multi-Year Procurement
OEF	= Operation Enduring Freedom
OIF	= Operation Iraqi Freedom
RO-RO	= Roll On, Roll Off
SIES	= Office of Strategic Industries and Economic Security
USAF	= United States Air Force

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Executive Summary

Airlift capability is critical to the U.S. Department of Defense's (DOD) strategy for protecting U.S. national security interests around the globe. The Boeing Company C-17 Globemaster aircraft has played an important role in recent DOD operations, enabling the Armed Forces to do things that previously were impossible — to transport oversize, heavy equipment and large quantities of material to places that other aircraft were incapable of servicing.

There are a number of challenging questions before policymakers in DOD and in the U.S. Congress regarding the future of the C-17 program. All aircraft have a finite production life-cycle and at some point a decision to cease manufacturing the C-17 must be made -- production of C-17s is currently scheduled to end in 2008. There are economic, employment, and industrial base impacts as well as DOD budget and overall airlift capability effects for the military associated with such a decision.

To better understand the economic and industrial base issues surrounding the C-17 program, the Office of the Deputy Assistant Secretary of the Air Force for Acquisition Integration requested that the U.S. Department of Commerce, Bureau of Industry and Security (BIS), Office of Strategic Industries and Economic Security (SIES) undertake an assessment of the C-17 program. The Air Force and BIS signed a memorandum of understanding on January 19, 2005, authorizing the assessment.

SIES performed this assessment under authority vested in the Department of Commerce through Section 705 of the Defense Production Act (DPA) of 1950, as amended (50 U.S.C. App. Sec. 2155) and related Executive Order 12656. The DPA authority enables SIES to conduct surveys, study defense-related industries and technologies, and monitor economic and trade issues affecting the U.S. defense industrial base. In the past, SIES has performed studies on a broad range of U.S. industrial and technology sectors including munitions power sources, biotechnology, ship building and repair, air delivery systems, welding, ball and roller bearings, and optoelectronics.[1]

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[1] See the U.S. DOC/BIS/SIES web site for a full listing of published reports: *http://www.bis.doc.gov/osies.*

For this assessment, data collected on the C-17 program from Boeing and 10 key subcontractors was augmented with site visits, interviews, and reviews of other studies on airlift requirements and economic activity. Specifically, the assessment examines and provides findings regarding the:

- Economic and employment activities associated with C-17 production in the United States;
- Dependence of the U.S. defense industrial base supply chain on C-17 production;
- Costs of closing, then restarting C-17 production, if more C-17s are required beyond 2008;
- Potential sale of C-17s in the military export market and entry into the cargo industry.

By agreement with the Office of the Deputy Assistant Secretary of the Air Force for Acquisition Integration, this study does not contain specific recommendations for DOD or Congress on the number or type of cargo aircraft that DOD should maintain in its fleet.

Background

The C-17, manufactured by The Boeing Company in Long Beach, California, provides the U.S. Air Force with a complete air mobility package: flexibility, speed, room for heavy and outsize cargo, and austere landing capability. Although designed and utilized for military transport in DOD operations, the C-17 has been used in numerous humanitarian and disaster relief applications around the world. There also exists the potential for the airlift platform to be deployed in commercial cargo markets; however, this concept currently is at an early developmental stage.

The C-17 has the long-range, heavy lift and outsize cargo functions of the older and larger C-5 aircraft – and much of the tactical, austere landing capabilities of the smaller C-130 aircraft. The C-17 can haul some 170,900 lbs. (78 tons) and land on a non-finished, dirt runway of less than 3,000 feet. More than a cargo hauler, the C-17 also provides the U.S. Armed Forces with tactical advantages in warfare. It has a demonstrated capability to deliver a 40-ton load using an airstrip just 1,800 feet in length. No current heavy lift aircraft in the U.S. cargo fleet matches the C-17's capabilities.[2]

[2] See: www.af.mil/factsheets.

In recent DOD operations, the C-17 also has transported Abrams M-1 tanks, Bradley fighting vehicles, and Apache helicopters to U.S. forces in Iraq and Afghanistan in addition to normal cargo loads and troops. Powered by four Pratt & Whitney turbofan jet engines (F117-PW-100s), the C-17 can refuel in-flight, thereby reducing the need for fuel assets in landing areas. The C-17 has greater runway maneuverability, lands on shorter runways, and can operate on unpaved, austere airfields – unlike military C-5s or commercial B-747s.

The C-17 has proven to be a highly reliable aircraft. In many instances, the aircraft has demonstrated mission-capability rates on the order of 96 percent; the minimum performance specification is 81 percent.[3] Similarly, the C-17 also has demonstrated departure reliability rates of 96 percent, exceeding requirements.[4] This performance record far exceeds other heavy lift aircraft.

Findings

There are currently 137 C-17 aircraft in operation, and DOD is committed to procure a total of 180 units through 2008. The production of C-17s has fluctuated from six to 16 units per annum from 1995 through 2004. Optimization of production processes has lowered C-17 costs considerably since 1991. At a production rate of 15 units a year, the aircraft's current price is $167 million, excluding engines. This price is 45 percent below the $305 million cost of the first unit delivered in 1993.

If additional C-17s are required, the cost of the aircraft is projected to rise slightly for years 2008-2012 to a range of $168-$178 million, assuming production of about 15 units a year. Were DOD to continue to buy C-17s, but reduce the annual buy-rate of C-17s, unit costs would increase considerably because fixed costs would be spread over a smaller number of aircraft.

There is an ongoing debate about the need for additional airlift capacity in the U.S. military and the kinds of aircraft required. In the case of the C-17, some argue that there is a need for at least

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[3] See discussion in *Chapter 2* on the mission capable rate (MCR).
[4] Bolkom, Christopher*, Military Airlift: C-17 Aircraft Program,* CRS Report for Congress, August 19, 2005, p. 5.

222 aircraft. Others contend that budget constraints and competing priorities require termination of the C-17 program.

Charges & Impacts

Should a decision to cease C-17 procurement occur, there are two choices for how to proceed:

- Mothball the production facility and special tooling; or
- Permanently close the production facility.

A decision to mothball operations would allow for the restart of C-17 production at a later date. This approach also might enable the government to overcome current budget challenges, including funding the purchase or refurbishing of other kinds of airlift (e.g., C-130Js and refurbished C-5s). Permanent closure of Boeing's production facility would effectively eliminate U.S. capability to further manufacture this aircraft. Either action will have large costs and industrial base consequences. These include:

- localized economic and employment disruption in regions across the United States,
- impacts on future aerospace industrial base technical and production capability,
- significant termination fees and restart expenses,
- forfeiture of potential military aircraft export market sales, and
- lost potential U.S. cargo carrier opportunities in global heavy lift, oversize markets.

Parts, components, services, and systems for the C-17 are purchased by Boeing from more than 700 companies located in 42 states. Boeing estimates that total annual economic activity in the United States associated with the manufacture and servicing of C-17s amounts to $8.4 billion.[5] In total, an estimated 25,000 jobs are linked to C-17 production and related activities.

Survey data collected by SIES highlights that Boeing directly employs about 7,800 full-time workers[6] in the production of the C-17. Some 6,094 of the positions are in California. Indirect California employment supported by the C-17 could be as high as 15,884 jobs. At its St. Louis manufacturing facility, Boeing employs 787 personnel engaged in manufacturing the aircraft's

[5] Boeing's estimate is based using an economic activity multiplier of 2.5.
[6] U.S. DOC/BIS/SIES Survey 2005.

cargo ramp and door, cockpit and flight deck, and main landing gear pods and pylons. Some 777 workers at Boeing's manufacturing plant in Macon, Georgia, produce C-17 structural subassemblies. Another 142 people are employed at Boeing's Mesa, Arizona facility to manufacture C-17 wire harnesses, and Boeing's Shared Services Group employs 271 workers in a variety of C-17 production tasks.

Closure of the C-17 production line is likely to affect segments of the U.S. aerospace supply chain as well. Survey data collected by SIES demonstrate that some suppliers are very dependent on C-17 business. For example, close to 40 percent of the workforces of Ducommun AeroStructures' Gardena, California operations and the Armament and Technical Products business of General Dynamics in Marion, Virginia, are tied to C-17 contracts. The ten C-17 suppliers surveyed by SIES emply nearly 2,000 employees in nine states.

California state and local officials are concerned about broader impacts – a permanent loss of high-wage, high-skilled personnel and a decline in the number of manufacturers of aerospace components in the Los Angeles area as well as across the state. More than 32 percent of the components and systems used to build the C-17 are manufactured in California either by Boeing or its contractors.

The closure of the Long Beach assembly facilities could have an impact beyond the job losses at Boeing. Economists in the region reported that the aerospace business environment in the Los Angeles area and across the state could be eroded to a point where aerospace suppliers can no longer participate in the industry..

Termination of C-17 production could be quite costly if it is determined at a later date that additional aircraft are required. It would be possible to reestablish production, but how readily this could occur would depend on DOD planning decisions at the time of shutdown – and the number of years that pass before a decision is made to order additional C-17s. Under any scenario, it could take four years before the first C-17 rolls off a restarted production line. Boeing, and many of its suppliers, would require significant lead time for training skilled workers, qualifying new vendors, and building new production facilities.

A decision to shut down C-17 production, regardless of future actions, will result in $500 million in contract close-out charges, dismantlement costs of $597 million, and $165 million in severance payments – for a total of $1.26 billion.[7] Boeing and DOD total expenditures to date for production equipment and facilities at Long Beach, California are estimated at $2.78 billion.[8] Restarting mothballed production at this location after a shutdown would cost of $472 million according to SIES survey data.

Restart expenses at Long Beach would be higher if DOD fails to lay away tooling. Lay-away costs are estimated at $336 million; and total restart and lay-away costs are estimated at $808.1 million,[9] the price of nearly five C-17 airframes.[10] Restart expenses also would be incurred by C-17 vendors. SIES survey data for just 10 of Boeing's 700+ suppliers show their restart costs to be at least $170 million.

The U.S. Government would sustain much higher charges if more than a few years pass before the decision to resume manufacture of C-17s were made. The reason: Boeing would likely sell off its 424-acre site at Long Beach for commercial, residential, and light industrial use. The cost of reestablishing production capability at a new site, according to SIES survey data, is approximately $3.2 billion, or the cost of nearly 17 aircraft. In current dollars, the cost of closing down the Long Beach site, restarting at a new site in the United States, and then having to close it down again after a short production run – is about $5.7 billion.

Foreign Military Sales

Another factor DOD may consider in terminating or mothballing C-17 production is the potential for export sales of C-17s to U.S. allies. The United Kingdom currently is leasing four C-17s, which will be purchased at the end of their lease term. The U.K. has publicly stated that it will acquire at least one additional aircraft, but would like to expand the fleet up to eight aircraft. In addition, Australia, Canada, Italy, Japan, Spain, and Sweden have expressed interest in acquiring or leasing one or more C-17 aircraft.[11]

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[7] Under a mothball scenario, there would be $335.2 million in lay-away costs and $165 million in severance expenses.
[8] Actual dollar expenditures since the start of the C-17 program.
[9] U.S. DOC/BIS/SIES Survey 2005.
[10] Aircraft delivery price to U.S. Air Force in 2005 is estimated at $192 million per unit, including engines supplied by Pratt & Whitney. Boeing supplied C-17 airframes cost about $167 million per unit.
[11] The Boeing Company.

Potential exists for other transactions to occur over the next five years or so, but these sales only can be realized if Boeing's production line in Long Beach remains open. Boeing is planning to initiate production-closing procedures in 2006 in anticipation of the last scheduled C-17 shipment in 2008.

Potential Dual Roles: Commerce & Security

No C-17 aircraft operate in the global commercial air cargo market today. All C-17 aircraft are owned and controlled by the U.S. Air Force[12] and are used only for military, humanitarian, and disaster relief purposes. However, there are potential commercial applications for this aircraft.

Most air cargo today is shipped on passenger aircraft or converted passenger planes such as the Boeing 747 and McDonnell Douglas MD-11.[13] There are rising requirements today for commercial cargo aircraft with outsize, heavy lift capability, including planes that can operate in remote and austere environments.

The C-17 could participate in the heavy and outsized lift market; and the aircraft would have a competitive advantage in a subset known as the short, austere lift market. By one estimate, there is potential for a fleet of commercial C-17s to capture billions[14] of dollars in air cargo business. The heavy lift, oversize market at present is dominated by European carriers using AN-124 (Russia, Ukraine) and Airbus A300-600 ST Beluga (France) aircraft.

The U.S. Air Force and industry consultants have been examining the concept of retiring older C-17s – an initial lot of around 10 aircraft – and selling them to U.S.-based commercial cargo carriers. There may be some incentive to do this to avoid incurring future fleet maintenance and operating costs. The proceeds from the sale of used C-17 aircraft, an estimated $90 million per unit, would then be used by the Air Force to help purchase new C-17s.

As a condition for selling used C-17s to cargo companies, the Air Force would require that these aircraft become part of the Civil Reserve Air Fleet (CRAF). This approach would enable DOD

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[12] The United Kingdom's Royal Air Force currently is leasing four C-17 aircraft.
[13] The MD-11 was originally developed by McDonnell Douglas, which was acquired by The Boeing Company in 1997.
[14] Boeing estimates that a commercial C-17 cargo fleet would generate average annual revenues of $2.5 billion over an eight-year period. See *Risk Reduction Report on the Short Austere Market*, Council for Logistics Research, Inc., September 2003, p. 9.

and other U.S. Government agencies to use the aircraft in times of national need or war.[15] Currently, there are no heavy-lift, outsize cargo planes (such as the C-17 or C-5) in the CRAF. At this time, however, the Air Force may not be able to retire any C-17s, since DOD is perceived in many quarters as having insufficient oversize cargo airlift capacity.[16]

[15] DOD relies on the CRAF to supplement the Air Force fleet in a time of war (*see Appendix IX*). The CRAF fleet consists of commercial passenger planes and cargo aircraft (often these are converted passenger planes).

[16] A number of current and former Air Force officials, academics, and consultants argue that a fleet of 222 C-17 aircraft is the minimum number necessary to meet DOD lift needs. In the last year, some Air Force leaders and members of Congress have called for building 42 or more additional C-17s beyond the 180 units now authorized.

1. Introduction

Airlift capability is critical to the U.S. Department of Defense's (DOD) strategy for protecting U.S. national security interests around the globe. Long before the first C-17 Globemaster rolled out of the production hangar at the McDonnell Douglas assembly facilities in Long Beach, California in 1991, the importance of this aircraft to the United States armed services was evident. Military leaders recognized that this particular cargo plane would enable the armed forces to do things that previously were impossible — to transport oversize, heavy equipment and large quantities of material to places that other aircraft were incapable of servicing (see *Appendix I*).

The production of the C-17 also has left its mark in another way, generating a large amount of economic activity and technology development across the United States. The Boeing Company, which acquired McDonnell Douglas in 1997, continues to produce the aircraft in Long Beach. Boeing also depends on parts, components, systems, and services from subcontractors located in more than 42 states and seven countries. In total, an estimated 25,000 jobs are linked to C-17 production and related activities.

There are a number of challenging questions before policymakers in DOD and in the U.S. Congress regarding the C-17. All aircraft have a finite production life-cycle and at some point a decision to cease manufacturing the plane must be made – production of C-17s is currently scheduled to end in 2008. There are economic, employment, and industrial base impacts as well as DOD budget and overall airlift capability effects for the military associated with such a decision.

To better understand the economic and industrial base issues surrounding the C-17 program, the Office of the Deputy Assistant Secretary of the Air Force for Acquisition Integration approached the U.S. Department of Commerce, Bureau of Industry and Security (BIS), Office of Strategic Industries and Economic Security (SIES) to undertake an assessment of the C-17 program. The Air Force and BIS signed a memorandum of understanding on January 19, 2005, authorizing the assessment.

SIES performed this assessment using data collected under authority vested in the Department of Commerce through Section 705 of the Defense Production Act (DPA) of 1950, as amended (50 U.S.C. App. Sec. 2155) and related Executive Order 12656. The DPA authority enables SIES to conduct surveys, study defense-related industries and technologies, and to monitor economic and trade issues affecting the U.S. defense industrial base. In the past, SIES has performed studies on a broad range of industrial issues including munitions power sources, biotechnology, ship building and repair, air delivery systems, welding, ball and roller bearings, and optoelectronics.[17]

Data collected for this report from Boeing and 10 key subcontractors was augmented with site visits, interviews, and reviews of other studies on airlift requirements and economic activity. Specifically, the assessment examines and provides findings regarding:

- Economic and employment activities associated with C-17 production in the United States;
- Dependence of the U.S. defense industrial base supply chain on C-17 production;
- Costs of closing, then restarting C-17 production, if more C-17s are needed beyond 2008;
- .Potential sale of C-17s in the military export market and entry into the cargo industry.

By agreement with the Office of the Deputy Assistant Secretary of the Air Force for Acquisition Integration, this study does not contain recommendations for DOD or Congress on the numbers or types of cargo aircraft that DOD should maintain in its fleet. With regard to the assessment's findings on the C-17's economic impacts and related issues surrounding its continued production, SIES makes no recommendations on how DOD should proceed, actions that C-17 contractors should consider, or remedies that the U.S. Congress might undertake.

C-17 Globemaster Background

The C-17 provides the U.S. Air Force with a complete air mobility package: flexibility, speed, room for heavy and outsize cargo, and austere landing capability. Although designed and utilized for military transport in DOD operations, the C-17 has been used in numerous humanitarian and disaster relief applications. There also exists the potential for the C-17 to be

[17] See the U.S. DOC/BIS/SIES web site: *http://www.bis.doc.gov/osies*

deployed in commercial cargo markets; however, this concept currently is at an early developmental stage.

In the late 1970s the U.S. Congress, having determined that the U.S. Air Force lacked sufficient airlift capability, authorized research and development funding for a new cargo aircraft – the C-17. The massive cargo plane was designed with capabilities and speed that C-130s and C-141s in inventory did not possess. The C-17 augmented the Air Force's cargo fleet, providing superior heavy- and outsize-lift capability and new mobility reach needed for future force structure requirements.

The C-17 has the long-range and heavy-lift, outsize-cargo functions of the C-5, and much of the tactical, austere landing capabilities of the C-130. The C-17 can haul some 170,900 lbs. (78 tons) and land on a non-finished, dirt runway of less than 3,000 feet. More than a cargo hauler, the C-17 also provides the U.S. Armed Forces with tactical advantages in warfare. It has a demonstrated capability to deliver a 40-ton load using an airstrip just 1,800 feet in length.

Table 1.1 -- ***C-17 Specifications***

Length	174 Feet (53 Meters)
Wingspan	169 Feet 10 Inches (51.76 Meters)
Height	55 Feet 1 Inch (16.79 Meters)
Speed	450 Knots at 28,000 Feet (Mach 0.74)
Service Ceiling	45,000 Feet (13,716 Meters)
Range	5,060 Miles (8,142 Kilometers)
Crew	3 (2 Pilots and 1 Loadmaster)
Passengers, or Cargo Load	102 Troops; or 36 Litters and 54 Patients and Attendants
	170,900 Pounds (78 Tons) of Cargo

Source: The Boeing Company; *U.S. Air Force* (*see* www.af.mil/factsheets).

In recent DOD operations, the C-17 also has transported Abrams M-1 tanks, Bradley fighting vehicles, and Apache helicopters to U.S. forces in Iraq and Afghanistan. Four turbofan jet engines — Pratt & Whitney F117-PW-100s — power the C-17. The aircraft can refuel in-flight, reducing the need for fuel assets in landing areas. This heavy lift platform also has more runway maneuverability than a C-5 or B-747, a critical platform feature in inter- and intra-theater cargo transport.

Boeing encountered some production difficulties and cost overruns in the initial C-17 manufacturing effort in the early 1990s. However, over several years, Boeing initiated manufacturing improvements, technology enhancements and cost reductions. DOD subsequently increased its orders for the aircraft in the late 1990s and in 2001.

The C-17 has proven to be a highly reliable aircraft. In many instances, the aircraft has demonstrated mission-capability rates on the order of 96 percent; the minimum performance specification is 81 percent.[18] Similarly, the C-17 also has demonstrated departure reliability rates of 96 percent, exceeding requirements.[19] This performance record far exceeds other heavy lift aircraft.

There are currently 137 C-17 aircraft in operation, and DOD is obligated to procure a total of 180 units. This figure potentially could rise to 222 units in the future. However, that decision is on hold while Congress and DOD are reconciling competing fiscal demands with mobility needs and future force structure requirements. The outcome of these deliberations — a decision to increase C-17 production or to shut it down — will affect U.S. opportunities to further pursue military export markets for the aircraft and the C-17's use in the commercial oversize-cargo market.

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[18] See discussion in *Chapter 2* on the mission capable rate (MCR).
[19] Bolkom, Christopher, *Military Airlift: C-17 Aircraft Program,* CRS Report for Congress, August 19, 2005, p. 5.

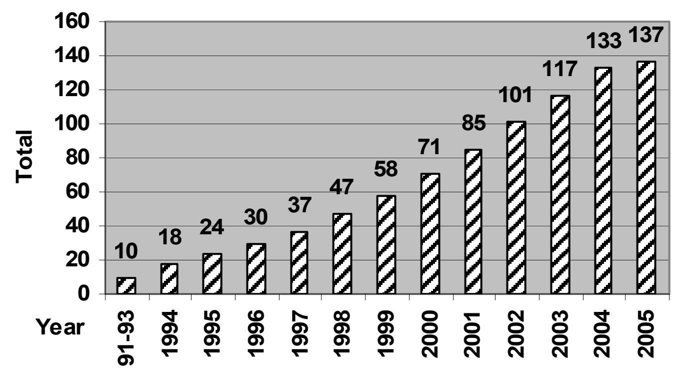
2. DOD and Congressional Challenges Related to the C-17

<u>*Cargo Airlift Requirements*</u>

There is an ongoing debate about the need for additional airlift capacity in the U.S. military and the types of aircraft required. Fiscal constraints, national security requirements, and lift mobility recommendations are key considerations that will affect decisions on future C-17 procurements.

Traditionally, DOD orders for cargo airlift capacity[20] have been guided by studies on mobility requirements. These reports take into account the number of multi theater wars that the United States might have to wage simultaneously, existing lift mobility capacity, and the duration of possible DOD operations.

Chart 2-1 - **C-17 Units in Service***



**Boeing is set to deliver the last of 180 aircraft in 2008.*
Source: U.S. DOC/BIS/SIES Survey, 2005.

DOD operations require a portfolio of heavy lift aircraft with diverse performance capabilities. There is no single line of aircraft that can meet all inter- or intra-theater lift requirements. The U.S. Armed Forces in its operations at times must resort to alternative solutions using non-designate_aircraft for heavy lift, such as helicopter "sling loads" or retrofitted fuel tankers. These airlift alternatives can present considerable risks, such as loss of aircraft and personnel and/or mission failure, but may also produce rewards in terms of reduced response time relative to conventional cargo aircraft.[21]

In the last several years, DOD has seen its existing cargo airlift capacity utilized at higher than expected levels for (1) military operations in Afghanistan and Iraq; and for (2) humanitarian and disaster relief (e.g. countries in Southeast Asia affected by the 2004 tsunami). By all counts, C-130Js, C-17s, and C-5s have incurred a lot of use.[22] At the same time, airlift capacity has

[20] The lift requirement measures the projected lift for two major theater wars, potential humanitarian crises, and special operations. The airlift measure is also a negotiated number and reflects a moderate-risk scenario.
[21] Guadiano, Nicole*, Retiring USAF Chief: Tankers Can Airlift, Too*, Defense News, September 5, 2005. p. 16
[22] SIES Interview with Richard Aboulaffia, Vice President of Analysis, Teal Group Corp., Washington, DC, September 2005.

been diminished by the retirement of aging C-141s and the extended maintenance times of C-5s.

Another factor affecting cargo airlift requirements is that actual available capability typically falls far short of standing fleet capacity. "Millions of ton miles per day is a measure of capacity – and airlift capacity is degraded for many reasons, including aircraft readiness, crew availability, and logistical efficiency. What you are left with is capability," explains David Merrill, senior analyst at U.S. Air Force's Air Mobility Command.

On any given day, he notes, as little as one-third of cargo airlift capacity may be available. That view is shared by Robert Owen of the College of Aviation Instruction at Embry-Riddle Aeronautical University. "If you are getting 60 percent of *capacity*," he observes, then you're doing pretty well."

The production of C-17s has fluctuated from 6 to 16 units per annum from 1995 through 2004 (see *Table 2-1*). Optimization of production processes has lowered the C-17s cost considerably since 1991. At a production rate of 15 units a year, the aircraft's price is $167 million, excluding engines.

This price is 45 percent below the $305 million cost of the first unit delivered in 1993. Cost of the aircraft is projected to rise slightly for years 2008-2012 to a range of $168-$178 million,

Table 2-1 -- **Specifications of Select DOD & Commercial Cargo Aircraft**

Cargo Plane	*Maximum Payload (Pounds)*	*Maximum Range* [Nautical Miles]*	*Min. Runway Required** (Feet)]*	*Requires Paved Runway*	*Requires Airport Support*	*Current Fleet Size*
C-17***	170,900 lb	2,400*	1,400	No	No	137
C-130****	42,000-44,000*	1,250-2,100	1,428-2,417	No	No	186
C-5A	261,000	2,982	4,900	Yes	Yes	76
C-5B	261,000	2,982	4,900	Yes	Yes	50
B-747-400F	248,300	5,800	7,500	Yes	Yes	95
AN-124	240,000	2,796	7,585	Yes	Yes	56

**Maximum range will vary depending on cargo weight. Data shown assumes no in-flight refueling. **Minimum runway requirements depend on weight of cargo onboard. ***C-17 specifications are based on a cargo load of 44 tons landing on a paved runway.Source*: The Boeing Company, Lockheed Martin Corp., *U.S. Air Force* (see www.af.mil/factsheets).
*****Most C-130 aircraft have a maximum payload of 42,000 lbs; C-130J-30 series (stretch version) can carry 44,000 lbs. All C-130 aircraft require paved runways for high tonnage loads (see* USAF Rethinks Tanker Theater Airlift, *Defense News, October 3, 2005. p. 72).*

Future Rapid Response Requirements: The "Unknown" in Airlift Need Estimates

Meeting mobility requirements in major theater wars (MTWs) involves significant logistical planning. In the event of a disruption to transport aircraft availability or landing infrastructure, TRANSCOM and Air Mobility Command (AMC) must respond rapidly. The inability to refuel, for instance, or to meet planned rates of refueling, stretches logistical capabilities. DOD's mix in cargo aircraft, therefore, needs to have the flexibility to meet a range of base scenarios.

Rapid response in airlift mobility is often dependent on the infrastructure that exists in theater and the willingness of allies to cooperate with U.S. operations. For instance, in recent Iraqi operations, opening a northern front proved difficult in the face of Turkish opposition to granting the United States over-flight rights. Moreover, diplomatic incidents can also affect mobility infrastructure, such as Uzbekistan's recent demands that DOD abandon local base facilities. In each instance, developments outside of the U.S. Government's control altered regional lift planning and eroded capabilities.

In addition to threatening rapid response requirements, foreign base closure also lessens the capacity to move warfighters and support personnel to and from the theater of operations. The transport routes that BRAC (Base Closure and Realignment Commission) closure and foreign realignment might threaten are inherent to inter- and intra-theater cargo lift plans. In the recent shifting of AMC infrastructure, in Germany and Hawaii, for instance, DOD is responding to changes in regional platform requirements.

Foreign base closures, furthermore, alter airlift requirements. Less infrastructure in theater means: (1) changes in response time, and (2) reduced flexibility in fleet planning and maintenance. If the cargo aircraft mix includes a significant number of high-mileage/outsized airlift transports, such as the C-17, then there is less need for foreign bases.

the aircraft is projected to rise slightly for years 2008-2012 to a range of $168-$178 million, assuming production of about 15 units a year (see *Chart 2-2*). Were DOD to reduce the annual buy-rate of C-17s, the unit costs would increase considerably because fixed costs would be spread over a smaller number of aircraft.

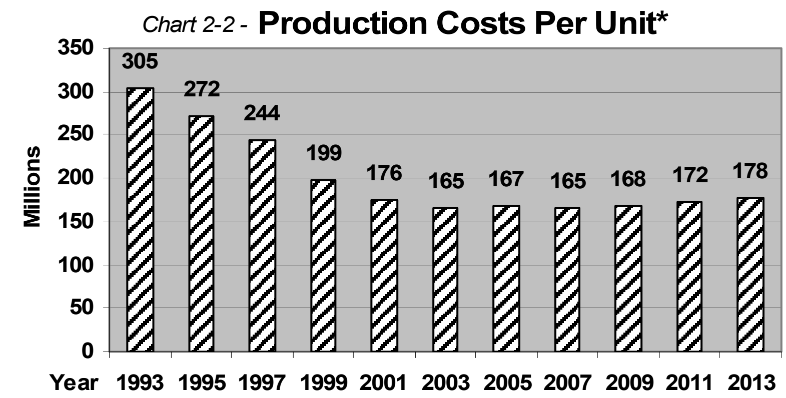
Timing the Halt of Production

Most heavy lift demands are met with a combination of different aircraft, including the C-5 (A/B), C-17, AN-124, and B-747-400F for outsized cargo and personnel; and the C-130J for lighter cargo and personnel (see *Table 2-1*). No current heavy lift design, however, matches the C-17's capabilities.[23]

Another factor DOD may consider is the potential for additional sales of C-17s to U.S. allies. The United Kingdom already is leasing four C-17s, which will be purchased at the end of their lease term. They have publicly stated that they will acquire an additional aircraft, but would

[23] See: *www.af.mil/factsheets*

like to expand the fleet up to eight aircraft. In addition, Australia, Canada, Italy, Japan, Spain, and Sweden have expressed interest in acquiring or leasing one or more C-17 aircraft.[24]



*Boeing is set to deliver the last of 180 aircraft in 2008.
**Unit prices shown are for the airframe and do not include the cost of engines supplied by Pratt & Whitney.
Source: U.S. DOC/BIS/SIES Survey, 2005.

Sales of C-17s to foreign buyers in the next five years or so can be realized only if Boeing's production line in Long Beach remains open. Foreign sales can take years to develop, but at this time Boeing's C-17 production line is scheduled to initiate "closing procedures" in 2006, in anticipation of the last scheduled C-17 shipment in 2008.

Similarly, the ability to have the C-17 participate in heavy lift commercial markets could also be impacted by the current 2008 production schedule. Issues concerning the potential use of C-17 aircraft for commercial markets are revisited in *Chapter 6*.

[24] The Boeing Company.

3. Cessation of C-17 Production: Options & Impacts

Retaining Production Capability

In 2008, DOD is scheduled to halt production of the C-17 aircraft. Should a decision to cease C-17 production occur, there are two choices for how to proceed that policymakers may want to consider:

- Mothball the production facility and special tooling; or
- Permanently close the production facility.

Given the range of opinions on the number of C-17 aircraft that DOD should have in its fleet, the concept of mothballing C-17 manufacturing facilities has been cited as a potential option for the government. This approach could allow the restart of production at a later date. The other attraction of mothballing production tooling (see *Appendix III*) is that it might enable the government to overcome current budget challenges, including funding the purchase or refurbishing of other kinds of airlift (e.g., C-130Js and refurbished C-5s).

Whether this approach is truly practical, however, is far from certain. There appear to be significant costs and risks associated with mothballing C-17 production facilities. Furthermore, the challenges in attempting to restart the production line are many, including:

- retention of the skilled workforce;
- erosion of corporate institutional history;
- continued availability of vendors;
- long lead-times for key components; and
- local pressures to develop or otherwise transform an idle C-17 production site.

The logistics of mothballing the C-17 production system are not trivial. Important parts and components of the C-17 require specific tooling. Complicating matters further, not all tooling for C-17 parts and components would be mothballed on site. Some might be warehoused in a formal way while others may simply be placed in an open storage yard. In addition, a uniform process of mothballing would have to be implemented by Boeing's suppliers for key tooling as well.

To assure that specialized tooling is available, if or when the decision is made to restart production of the C-17, Boeing officials say that it would be necessary in some instances for the company to physically secure tooling used by its vendors. This tooling would have to be removed from production floors, inventoried, and then shipped to a building at the Long Beach C-17 production site for storage. Once a restart of production is ordered, the tooling would be removed from storage and shipped to C-17 vendors for reconfiguration on a production line.

Another complication in restarting the C-17 production line is that some of the vendors that currently manufacture parts, components, and systems may no longer be in business, or may be unable to take on C-17 production orders in a timely fashion. In the latter case, problems may occur because suppliers: (1) have committed manufacturing capacity to other activities, (2) no longer have the required capabilities, and/or (3) have lost critical staff.

Table 3-1 -- **C-17 Business Dependency**

Company	*C-17 Payroll/ % Total Business Unit*	*C-17 Workers Total**	*C-17 Workers/ % of Total Business Unit*
Pratt & Whitney Military Engines	N/A	584	3.3%
Ducommun AeroStructures	40%	109	39.9%
Eaton Fluid Power Division*	1.6%	12	2.1%
General Dynamics Armament & Technical Products**	39.2%	387	38%
Goodrich Landing Gear	11.3%	213	11.1%
Hamilton Sunstrand Aerospace	N/A	N/A	N/A
Hitco Carbon Composites	5%	26	8.6%
Honeywell Airline & Avionics	16.9%	145	13.3%
Telephonics Communications	7.3%	128	12.6%
Vought Aircraft Industries	5%	347	5.9%

**Jackson, MS ** Marion, VA N/A = Not Available*
Source: U.S. DOC/BIS/SIES Survey 2005.

The ability of today's C-17 vendors to retain their capabilities and resume production quickly varies from company to company, according to data collected by SIES. For example, Ducommun AeroStructures of Gardena, California, advised SIES that it would have to reduce its skilled workforce and physical plant by about 50 percent.[25] C-17 work currently

[25] SIES interview with Greg Valencia, Manager for Business Management, Ducommun AeroStructures, during a site-visit, July 2005.

accounts for nearly 40 percent of all business and payroll expenses at Ducommun AeroStructures.

Ducommun manufactures large aircraft fuselage skin sections for the C-17 and the Space Shuttle. The company owns a unique aluminum-sheet stretching press,[26] the only one of its kind in North America. It is not certain whether the company could justify retaining this tool once C-17 production ceases. In total, the company produces about 95 parts for the C-17, including wing leading edges, wing tips, and other items.

General Dynamics' Armament & Technical Products Division in Marion, Virginia, also would likely undergo significant downsizing. Some 38 percent of its workforce (381 people) is engaged in C-17 work. The company produces C-17 radomes, wing flaps, landing gear doors, and winglets.

Both companies stated that replacing skilled workers in the event of a restart of production of the C-17 could be difficult and time consuming.

Table 3-2 – **C-17 Supplier Restart Schedules***

Company	*Lead-Times for Restart/* *(Months)*	*Restart To First Unit Delivery* *(Months)*	***Total*** *(Months)*
Pratt & Whitney Military Engines	6*	14**	**20**
Ducommun AeroStructures	6	6	**12**
Eaton Fluid Power Division*	10	1	**11**
General Dynamics Armament & Technical Products**	12	24	**36**
Goodrich Landing Gear	9	27	**36**
Hamilton Sunstrand Aerospace	23	13	**36**
Hitco Carbon Composites	5	7	**12**
Honeywell Airline & Avionics	6	8-18	**14-24**
Telephonics Communications	6	20	**26**
Vought Aircraft Industries	24	8	**32**

**Twenty four weeks of training required for production restart.*
***Minimum.*
Source: U.S. DOC/BIS/SIES Survey 2005.

Not all C-17 suppliers are as heavily dependent on the aircraft's production. In some cases, C-17 activity accounts for just a few percent to about 13 percent of its workforce (see *Table 3-1*). Lower overall business dependency on the C-17 does not necessarily mean, however, that the supplier will be capable of responding quickly at the time a restart of C-17 production is ordered. Some companies may commit the required production capacity to other customers, and still others may not remain in the business.

[26] Sheridan STC-1500. See www.ducommunaero.com/equip_list.html; also see Appendix VI.

Even in instances where companies remain capable of producing C-17 parts, components, and systems after a period of sustained suspension of production, the restart of part delivery will likely be lengthy. Data collected by SIES from 10 Boeing suppliers show that it could easily take 36 months before a restarted assembly line can deliver the first parts (see *Table 3-2*). Contributing to the lead-time requirements is the need to set up tooling, fit the C-17 part orders into production schedules, obtain materials, parts, and components from other suppliers, perform trial tests, and secure product quality re-certifications from Boeing, DOD or other entities.

Extensive lead times among the suppliers are the rule, not the exception. Pratt & Whitney (P&W), which produces four F117-PW-100 engines for each C-17, reports that it would require at least 20 months to begin delivering units for the aircraft. The engine used by the C-17 is built on a production line that is used to manufacture a number of other P&W engines. Meanwhile, Hamilton Sunstrand's Electric Systems division, which builds emergency power systems for the C-17, would require a lead time of three years before its first delivery from a restarted assembly line. Similarly, General Dynamics' Armament & Technical Products, Goodrich, and Vought Aircraft, would require 36 months, 36 months, and 32 months, respectively.

None of the suppliers surveyed by SIES could deliver parts for a restarted production line in less than 11 months. The SIES survey data on suppliers is consistent with Boeing's own assessment of how long it would take to restart C-17 production. The company states that it could take some suppliers as long as 40 months[27] to deliver components or systems.

As for Boeing's own manufacturing and assembly operations, it would require at minimum 18 months to resume C-17 production, and then another 12 months before the first aircraft would be delivered. This calculation assumes that there are neither raw material shortages nor capacity restraints on suppliers that would delay the resumption of production.

In addition to time factors, there are significant costs associated with mothballing the C-17's production tooling and restarting assembly lines. Lay-away costs are estimated at $336 million for Boeing's own tooling, dedicated design and engineering facilities, administrative facilities and equipment, and other items. To restart solely Boeing's C-17 production lines would cost

[27] U.S. DOC/BIS/SIES Survey 2005.

another $472.1 million. Total costs for production tooling lay-away and restart activities for Boeing is estimated at $808.1 million[28] – the price of nearly five C-17 airframes.[29]

Total costs for mothballing and restart that would be incurred by Boeing's more than 700 suppliers and their respective supply chains can not be estimated with the data obtained for this report. It appears, however, that it could easily run into the hundreds of millions of dollars. Data collected by SIES from just 10 suppliers show that the mothballing and restart expenses for these companies alone could approach $170 million dollars (see *Table 3-3*).

Table 3-3 – **Examples of C-17 Mothballing Costs***

(Millions of Dollars)

Company	*Lay-Away Costs*	*Retraining Costs*	*Restart Costs*	***Total***
Pratt & Whitney Military Engines	0.0	1.30	7.4	**8.7**
Ducommun AeroStructures	1.0	0.50	1.0	**2.5**
Eaton Fluid Power Division*	0.0	0.0	0.0	**0.0**
General Dynamics Armament & Technical Products**	1.00	1.82	0.97	**3.79**
Goodrich Landing Gear	0.05	1.80	8.20	**10.05**
Hamilton Sunstrand Aerospace	0.20	0.00	5 - 25	**5.2 - 25.2**
Hitco Carbon Composites	0.10	0.185	0.70	**0.985**
Honeywell Airline & Avionics	0.32	0.95	0.75	**2.02**
Telephonics Communications	0.25	0.10	1.20	**1.55**
Vought Aircraft Industries	0.10	5.50	110	**115.6**
Total*	**$3.0**	**$12.2**	**$155.2**	**$170.4**

**Total costs for these 10 suppliers could be as little as $150.4 million.*
***After five years a complete redesign of some electronic components could be required as a result of product obsolescence, adding $20 million in costs.*
Source: U.S. DOC/BIS/SIES Survey 2005, follow-up phone interviews.

And what drives this expense? Stephan Harmon, C-17 Program Manager for Vought Aircraft Industries, Inc., states that mothballing his company's array of C-17 production equipment would be a complicated process requiring extensive record keeping. Vought produces a range of parts for the C-17, including vertical and horizontal stabilizers, propulsion subsystems, control surfaces, ailerons, rudders, elevators, push rods, and nacelles.

In the case of Vought, the tooling for each of its products, according to Harmon, would have to be dismantled, inventoried, prepared for storage, and then stored. At the restart, tooling would have to be collected, inventoried, shipped, set up to meet precise tolerances, and tested. Tools

[28] U.S. DOC/BIS/SIES Survey 2005.
[29] Aircraft delivery price to U.S. Air Force in 2005 is estimated at $192 million per unit, including engines supplied by Pratt & Whitney. Boeing supplied C-17 airframes cost about $167 million per unit.

may include 1,000 or more templates associated with producing parts for the C-17. It is a major undertaking, Harmon notes, to break down an assembly process and preserve it for future use.

Production Termination

While there are significant costs associated with mothballing C-17 production facilities, facility closure also is a very expensive undertaking. Boeing anticipates that it would have to spend on the order of $760 million to close and dismantle C-17 production facilities in California, Georgia, Texas, Missouri and elsewhere. The close-out figure excludes costs for lay-away[30] of any tooling, should DOD want that to occur. Environmental remediation costs could also be higher than the $36 million identified by Boeing for the Long Beach site if other problems are found (see *Table 3-4*).

Boeing's estimates also do not include any shut-down costs associated with the manufacture of Pratt & Whitney C-17 engines. In addition, there would be a "tail up" payment made by DOD to Boeing because of higher costs associated with aircraft production as unit volume winds down, worker productivity decreases, and supplier unit costs increase. This cost is estimated at $500 million.[31]

There is little prospect for the C-17 assembly and manufacturing facilities in Long Beach being used to produce other aircraft. ,Much of the tooling and assembly equipment is custom-built to produce C-17s (see *Appendix III*) and therefore is not readily adapted to manufacturing other aircraft models. Moreover, Boeing recently closed its B-717 production line in Long Beach.

Boeing officials advised SIES that the company would likely turn over the 424-acre site to its Boeing Realty division to liquidate or develop, much as it is doing with a 260-acre track of land on the north side of Long Beach Airport. Although there is a shortage of industrial space in the City of Long Beach, it is unlikely to remain in a form useable for aircraft manufacturing. There

[30] Lay-away costs for tooling, records, and other equipment associated with the production of the C-17 airframe is estimated at $335.2 million (*see Table 3-4*).
[31] Source: U.S. DOC/BIS/SIES Survey 2005; Richard C. Ullman, Director – Contracts, Pricing & Estimating, Integrated Defense Systems, The Boeing Company.

would be strong pressures to develop the property for residential, retail, and light commercial activities, according to city and state officials and local economists.[32]

Table 3-4 – **Boeing Facility Shut-Down Costs* Associated with C-17 Production** *(Millions of Dollars -2004)*					
	Dismantle-ment Costs	*Lay-away Costs***	*Severance Cost*	*Environmental Remediation*	*Commercial Value/ Liquidation Value*
Land	N/A	0.0	0.30	36.3	98.9
Buildings	0.67	0.0		0.0	0.0
Utilities Infrastructure	0.0	0.8	0.0	0.0	0.0
Roads & Rails	N/A	N/A	N/A	N/A	N/A
Assembly Line(s)	N/A	N/A	N/A	0.0	0.0
On-site Fabrication Tooling	189.9	168.2	25.0	0.0	0.0
Off-site Fabrication Tooling	52.4	111.4	30.2	0.0	0.0
Dedicated On-site Design and Engineering Facilities	200.2	22.2	27.4	0.0	0.0
Dedicated Off-site Design and Engineering Facilities	20.0	0.0	2.2	0.0	0.0
Dedicated On-site Administrative Facilities & Equipment	81.5	32.3	45.3	0.0	0.0
Dedicated Off-site Administrative Facilities & Equipment	37.9	0.0	19.2	0.0	0.0
Security Systems	0.0	1.1	0.0	0.0	0.0
Other	14.7	0.0	13.0	0.0	0.0
Total	***597.3***	***335.2***	***162.3***	***36.3.0***	***98.9***
**All figures are estimated. N/A = Not applicable. **The extent of lay-away costs incurred in shut down would depend on DOD requests for records preservation and tool mothballing. Source: U.S. DOC/BIS/SIES Survey 2005; The Boeing Company.*					

[32] Robert M. Swazey, Economic Development Bureau Manager, City of Long Beach; Joseph P. Magaddino, Chairman, Department of Economics, California State University, Long Beach.

Table 3-5 -- **Boeing Company C-17 Personnel Demographics**								
Location	*Long Beach*	*Palmdale*	*SSG*	*Total Calif.*	*Macon, Georgia*	*Mesa, Ariz.*	*St. Louis, Missouri*	*Total C-17*
Professionals, Designers, Engineers	2,057	0	0	2,057	209	19	86	2,371
Production – Assembly and Manufacturing	2,395	15	0	4,210	458	106	413	3,387
Administration	726	12	42	780	49	13	19	861
Other	572	46	229	847	61	4	269	1,181
Total	***5,750***	***73***	***271***	***6,094***	***777***	***142***	***787***	***7,800***
Source: U.S. DOC/BIS/SIES Survey 2005.								

Not only would Boeing close its Long Beach facilities and terminate 5,750 workers there, it also would dismiss many workers at its Palmdale and Supplied Services Group facilities in California (see *Table 3-5*). As for C-17 work at Boeing's Mesa, Arizona and St. Louis, Missouri, facilities, 142 and 787 positions, respectively, would be lost.[33]

The plant at Macon, Georgia, would be closed as well, thereby eliminating 777 manufacturing positions tied to the C-17. As a result, Chinnook and Apache helicopter production work currently performed at that location would likely be shifted to another Boeing facility. Moreover, there would be substantial job losses at Boeing's more than 700 suppliers and across their respective supply chains.

Also lost with the cessation of C-17 production would be significant federal government, Boeing – and to a lesser extent, supplier investments in capital facilities and tooling used to produce the C-17. Initial investments in manufacturing buildings, tooling, engineering and administrative infrastructure required of Boeing and the U.S. Government to establish C-17 production is estimated to have totaled $2.52 billion. Subsequent additional investments of $264 million were made by Boeing and DOD for improvements in manufacturing capability, bringing the total to $2.78 billion (see *Appendix II, Table 5-1*).

[33] Some C-17 workers at St. Louis might be transferred to F/A-18 and F-15 work – but such shifts would displace or bump existing workers producing those fighter aircraft. Source: U.S. DOC/BIS/SIES Survey 2005; Boeing Company response to follow-up questions, September 2005.

4. Economic Effects and U.S. Aerospace Industrial Base Impacts

The C-17 as an Economic Driver

The C-17 has been a sustaining force in the U.S. aerospace industry. It is the most advanced cargo aircraft in the U.S. military fleet in terms of mission flexibility, capabilities and performance, and in the application of advanced manufacturing methods and production technology. This cargo aircraft also has functioned as a significant economic driver in several regions of the United States.

The parts, components, and systems supplied for the C-17 require high skill levels to design, engineer, and manufacture. These activities generate numerous professional (administrative, design, engineering, financial, and legal) positions and production jobs with average to above-average salaries in many instances.

Boeing purchases parts, components, and systems from more than 700 companies located in 42 states. The economic stimulus of the aircraft manufacturing program, however, runs much deeper. Boeing's direct vendors, in many instances, rely on second- and third-tier suppliers to provide them materials, components, and services related to products supplied to Boeing for the C-17.

Table 4-1 – **Major C-17 Activities Conducted at Long Beach**

Business Activity	*Yes*	*Business Activity*	*Yes*
Design	☑	Inspection	☑
Manufacture of Components	☑	Test & Evaluation	☑
Integration	☑	Repair and Overhaul	☑
Assembly	☑	Research	☑

Source: U.S. DOC/BIS/SIES Survey 2005.

Boeing directly employs about 7,800 full-time workers[34] in the production of the C-17. Some 6,094 of the positions are in California. At its St. Louis manufacturing facility, Boeing employs 787 personnel engaged in manufacturing the aircraft's cargo ramp and door, cockpit, including the flight deck, and main landing gear pods and pylons. Some 777 workers at Boeing's manufacturing plant in Macon, Georgia, produce C-17 structural subassemblies. At its Mesa, Arizona, facility, another 142

[34] U.S. DOC/BIS/SIES Survey 2005.

people manufacture C-17 wire harnesses, and Boeing's Shared Services Group employs 271 workers in a variety of C-17 production tasks.

As already noted, beyond Boeing's direct employment, a substantial number of jobs attributable to the C-17 program is generated by key suppliers. SIES surveyed 10 of these companies to gain insights into employment levels and the extent of economic activity generated by C-17-related contract work. Collectively, these 10 suppliers employ about 2,000 people to design, engineer, and manufacture C-17 parts, components, and systems.

Table 4-2 -- **Employment at Ten C-17 Suppliers**

Company	*Total Business Unit Workers*	*Total C-17 Workers **	*% of Total*
Pratt & Whitney Military Engines	17,883	584	3.2%
Ducommun AeroStructures	273	109	39.9%
Eaton Fluid Power Division*	557	12	2.1%
General Dynamics Armament & Technical Products**	1,001	381	38%
Goodrich Landing Gear	1,924	213	11.1%
Hamilton Sunstrand Aerospace	159	N/A	N/A
Hitco Carbon Composites	301	26	8.6%
Honeywell Airline & Avionics	1,090	145	13.3%
Telephonics Communications	1,017	128	12.6%
Vought Aircraft Industries	5,859	347	5.9%
Total		***1,945***	

**Estimated full-time equivalent.*
N/A = Not applicable. Data not available.
Source: U.S. DOC/BIS/SIES Survey 2005.

In addition, there is substantial employment associated with second and third-tier C-17 supplier contracts. Boeing estimates that as many as 25,000 people in the United States are employed in C-17 manufacturing- and service-related operations across the domestic supply chain.

Excluded from this estimate are jobs created in Canada, France, Germany, Italy, South Korea, Sweden, and the United Kingdom,[35] in companies that provide components and services for the manufacture of the aircraft. Total annual economic activity in the United States associated with the manufacture and servicing of C-17s amounts to about $8.4 billion.[36]

[35] U.S. DOC/BIS/SIES Survey 2005.
[36] Boeing's estimate is based on an economic activity multiplier of 2.5.

Pratt & Whitney (P&W) is the single largest supplier for the C-17, producing engines that cost $5.65 million each – or about $22.6 million per aircraft. Full-time equivalent employment associated with production of the F117-PW-100 engines is estimated by P&W at 584 positions – with most of them concentrated in Connecticut. P&W provides engines under contract to DOD, which then transfers them to Boeing for final integration into the aircraft.

Other suppliers employ significant numbers of workers as well. General Dynamics in Marion, Virginia, employs 381 people producing C-17 composite parts. Vought Aircraft Industries of Dallas, Texas, has a similar workforce, employing 347. Goodrich Corp. of Cleveland, Ohio, employs 213 workers dedicated to C-17 products.

As can be seen in *Table 4-2,* companies such as Honeywell Airline & Avionics of Redmond, Washington, Ducommun AeroStructures of Gardena, California, and Telephonics of Farmingdale, New York, have significant work forces ranging from 109 to 145 people. Other suppliers of the C-17 have fewer than 100 employees. Vickers Fluid Power of Jackson, Mississippi, has the equivalent of just 12 full-time employees supplying C-17 products; and Hitco Carbon Composites employs 26 in its manufacturing activities.

Local Economic Stimulation

In terms of *direct* employment associated with the production of the C-17, no other state in the United States benefits more than California. Boeing employs some 5,750 personnel at its facility in Long Beach.[37] Contractors employ 439 workers at this production site.[38] Boeing also has another 73 employees engaged in C-17 work at its Palmdale facility and 271 support personnel working through its Shared Service Group offices in the state (see *Table 4-3*).

The employment figures provided by Boeing are significant not only for their sheer numbers, but because many of the jobs are of high quality. More than 2,000 of the positions at Long Beach are non-administrative professional positions such as engineers and designers. In addition, there

[37] U.S. DOC/BIS/SIES Survey 2005. Note: Part-time employees account for 42 of the 5750 employees that Boeing employs at Long Beach, California.
[38] U.S. DOC/BIS/SIES Survey 2005. Note: Part-time employees account for 121 of the 439 contractor workers at Boeings C-17 facility in Long Beach, California.

are nearly 2,400 production-related assembly and manufacturing jobs in Long Beach along with 726 administrative positions and another 572 miscellaneous positions. Along with the employment at other sites across the state, Boeing employs 6,094 people in C-17 program work in California.

In addition to providing high-skill employment, the wages paid C-17 workers are competitive (see *Table 4-4*). In 2004, an estimated 3,712 people working at Boeing's Long Beach facilities – 65 percent of the workforce – were earning between \$60,000 and \$100,000 a year. About 13.6 percent of employees earned more than \$100,000 annually.[39] Only 4.4 percent of Boeing's Long Beach workforce earned \$30,000 or less. In total, Boeing's 2004 payroll for full-time employees involved in the C-17 program was \$438.6 million.

Table 4-3 – **Boeing California C-17 Employment - 2004**

Location	*Long Beach*	*Palmdale*	*SSG*	*Total California*
Professionals – Designers, Engineers, etc	2,057	0	0	2,057
Production – Assembly and Manufacturing	2,395	15	0	2,410
Administrative	726	12	42	780
Other	572	46	229	847
Total	5,750	73	271	6,094

Source: U.S. DOC/BIS/SIES Survey 2005.

In addition, the contractor payroll for 439 full- and part-time employees at Boeing's Long Beach facilities in 2004 totaled \$31.5 million. Nearly 26 percent of the contractors at Boeing's Long Beach facilities earned salaries in excess of \$100,000 per year. Some 21 percent of the contractors were paid between \$60,000 and \$100,000 annually, and another 21 percent earned between \$30,000 and \$60,000.[40]

Beyond employment at the Long Beach site, and related facilities, California receives an economic stimulus in the form of direct Boeing contracts for parts, components, systems, and services. Boeing estimates that it purchased goods and services from 340 separate California-based companies in 2004. The value of these direct purchases totaled \$286 million in 2004.

Although Boeing buys less than one percent of the goods and services required to build a single C-17 aircraft from companies in Long Beach, its state-wide contracts in 2004 accounted for 32.4

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[39] U.S. DOC/BIS/SIES Survey 2005. Percentages are based on total full-time employment of 5,708 for 2004 at Boeing's Long Beach facility.
[40] U.S. DOC/BIS/SIES Survey 2005.

percent of all such purchases (see *Table 4-5*). According to Boeing's estimates, in 2004 its contracts to California companies for a single aircraft totaled $27.1 million. When multiplied by the number of aircraft delivered (16) in 2004, this amounted to $433.6 million in purchases from California-based companies that are direct suppliers to Boeing.

Table 4-4 – **Boeing Compensation Rates - Long Beach**

Annual Wages	*Percent of Workers*
$30,000 or less	4.4
$30,000 - $60,000	17
$60,000 - $100,000	65
Over $100,000	13.6

Source: U.S. DOC/BIS/SIES Survey 2005.

The full economic impact of Boeing's C-17 production activities on the State of California's economy, however, is much larger than the sum of payroll expenses and purchases of related goods and services. Boeing employment on the C-17 program has a far-reaching ripple effect throughout the state. The C-17 program not only generates jobs in the aerospace industry in California, but it also creates jobs throughout the economy, such as in housing, transportation, education, and multiple service sectors. In the case of aircraft manufacturing, the multiplier in the state can be as high as 3.6.[41] This means that beyond the 6,094 positions at Boeing, additional California employment generated by the C-17 could be as high as 15,884 jobs, bringing total program-dependent jobs throughout the state to 21,938.

Multipliers, however, can overstate the actual number of positions created. The City of Long Beach uses a lower multiplier of 2.5[42] to calculate total job creation resulting from the manufacture of C-17 aircraft. The lower multiplier is used because not everyone employed at Boeing's Long Beach facilities resides in the city, and thus they do not necessarily spend significant portions of income in Long Beach. Many Boeing workers engaged in C-17 work reside outside of the city and their spending generates economic activity in neighboring areas.

The 2.5 multiplier suggests that around 14,375 jobs in the city are connected with C-17 production, including the 5,750 Boeing positions at its Long Beach facility. For Los Angeles

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[41] RIMS II Multipliers (July 2002) for the State of California for aircraft, *Using Multipliers to Measure Economic Impacts,* California Technology, Trade and Commerce Agency, Economic Strategy and Research division, October 2002.
[42] Robert Swayze, Manager, Economic Development Bureau, City of Long Beach, California, July 2005. Swayze advised SIES that his office uses a smaller multiplier in part because a lot of Boeing workers commute to the city, rather than reside in Long Beach.

County, a multiplier of 2.9 is used.[43] Consequently, total employment across the county stemming from Boeing's C-17 assembly operations could be on the order of 16,675 positions. This includes 10,925 jobs in addition to the 5,570 Boeing workers at Long Beach.[44]

Impact on California Aerospace Infrastructure

California leaders recognize the significant contributions that the C-17 program makes to the local and state economies. They also know that it is inevitable that this economic engine will be turned off at some time in the future, perhaps as early as 2008. That prospect poses problems beyond the employment losses that will occur in Long Beach. There is also concern about the ability of the Los Angeles region and the state to retain its aerospace industrial base.

Specifically, Los Angeles area leaders fear that they could lose a critical mass of suppliers and employees with appropriate skill sets in the region once Boeing halts production of the C-17. These suppliers provide parts and systems to aircraft manufacturers across the United States, in Europe, and elsewhere.

"The C-17 program could be a linchpin for a lot of these people," asserts Jack Kyser, senior economist at the Los Angeles County Economic Development Corporation (LAEDC), noting that the fall off in business after C-17 production ends may result in "a lot of the suppliers going away."[45]

Table 4-5 – **C-17 Component & Systems Sourcing***

C-17 Components & Systems Produced In:	*Percent*	*Value Per Aircraft (Millions of Dollars)*
California	32.4	27.13
Long Beach Region**	0.1	0.06
United States	61.4	51.37
Foreign Countries	6.1	5.08

**Dollar values are for a single C-17 aircraft built in 2004. Boeing delivered 16 aircraft. **City of Long Beach.*
Source: U.S. DOC/BIS/SIES Survey 2005.

That view is shared by Robert Swayze, manager of the City of Long Beach's Economic Development Bureau. Closure of the C-17 plant, according to Swayze, would substantially

[43] Jack Kyser, Senior Economist, Los Angeles County Economic Development Corp., from July 2005 interview with SIES.
[44] Economic multipliers for aerospace were developed for these localities at their request by the Department of Commerce's Bureau of Economic Analysis using its *RIMS II Regional Input-Output Multipliers* model. See *http://www.bea.gov/bea/regional/rims/.*
[45] Jack Kyser, Senior Economist, Los Angeles County Economic Development Corp., from July 2005 interview with SIES.

weaken the Long Beach economy.[46] The business environment would become more difficult for many companies that provide high-value parts, systems and services to Boeing and other aerospace enterprises. Statistically, the manufacturing sector, as a share of the city's economy, would shrink dramatically.

Aircraft production and associated manufacturing industries are important elements of the employment base of the City of Long Beach and the region. These types of jobs pay substantially more than many service-sector positions. Manufacturing-related activities account for about 11 percent of all jobs in Long Beach. Aerospace is the single largest industrial sector, accounting for 10,368 of 17,000 jobs in 2003.[47]

However, Long Beach has steadily lost these kinds of high-end manufacturing positions over the past decade. Just 13 years ago, Boeing's predecessor in Long Beach, McDonnell Douglas, employed more than 36,000 people.[48] From 1997 through 2003, the city lost 10,309 high paying manufacturing jobs — a 37 percent decline from a level of 24,500 positions. These jobs have largely been replaced in the city's economy with lower paying retail and tourism positions.[49]

The region has sustained significant cutbacks in aerospace manufacturing, particularly in aircraft production. Much of this reduction has occurred at Boeing's operations in Long Beach. In 2002, some 6,000 positions were lost with the halt of the MD-11 commercial airliner and another 1,000 positions were cut in early 2005 with Boeing's decision to cease production of the B-717 (formerly the MD-90).[50] At this time, Los Angeles County employs approximately 41,000 people in the aerospace industry, including aircraft manufacturing and parts production.[51]

"We like aerospace manufacturing," Kyser stresses. "It does support a lot of other manufacturing activity here. Manufacturing was the stair-step in the past to the middle class. We want to retain these jobs."[52]

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[46] Robert M. Swayze, Manager, Economic Development Bureau, City of Long Beach, from July 2005 interview with SIES.
[47] *Long Beach Economic & Market Analysis, Volume II*, p. 38, Marie Jones Consulting, March 2005, p. 37.
[48] Robert Swayze, Manager, Economic Development Bureau, City of Long Beach, California, July 2005.
[49] Ibid, p. 38.
[50] Ibid, p. 38.
[51] *Mid-Year Update: 2005-2006 Economic Forecast & Industry Outlook*, Los Angeles County Economic Development Corp., July 2005, p. 56.
[52] SIES interview, July 2005.

The economies of the City of Long Beach and Los Angeles County were able to weather the 2002 and 2005 layoffs at Boeing without great upheaval, largely because of new job formation in the transportation, health, and retail sectors. However, Long Beach's Swayze warns that the economic repercussions of a shutdown of the Boeing C-17 production will hurt the region.

5. Reviving C-17 Production After A Terminal Shutdown

Were DOD and the Congress to decide to permanently halt production of the C-17 at 180 units only to subsequently determine that additional C-17 aircraft were needed, could production capability be restored? Moreover, what would it cost and how long would it take?

It would be possible to restart production, according to discussions with Boeing personnel. Boeing officials suggest that adequate records would be preserved on key aspects of aircraft assembly, critical components, and materials. Also, much information regarding key C-17 production technologies would remain in the supplier base.

Table 5-1 – ***Boeing, U.S. Government Sunk Investment – C-17 Production Facilities at Long Beach, CA***

(Millions of Dollars)

C-17 Production Sunk Investments	*Initial Costs**	*Cost of Upgrades, Expansions*	*Total*
Land	14.8	N/A	**14.8**
Buildings	148.7	80.5	**229.2**
Utilities Infrastructure	See Buildings	See Buildings	See Buildings
Roads & Rails	See Buildings	See Buildings	See Buildings
Assembly Line(s)	See On-site Fab. Tooling	See On-site Fab. Tooling	See On-site Fab. Tooling
On-site Fabrication Tooling	675.4E*	80.7	**756.1**
Off-site Fabrication Tooling	913.4E*	15.3	**928.7**
Dedicated On-site Design and Engineering Facilities	374.2*	13.9	**388.1**
Dedicated Off-site Design and Engineering Facilities	385.2E*	11.9	**397.1**
Dedicated On-site Administrative Facilities and Equip.	0.70	57.9	**58.6**
Dedicated Off-site Administrative Facilities and Equip.	11.4	3.8	**15.2**
Security Systems	In Admin. Facilities	In Admin. Facilities	In Admin. Facilities
Total	***$2,523.8***	***$264***	***$2,787.8***

**Includes U.S. Government Furnished Equipment   N/A = Not Applicable*
Source: U.S. DOC/SIES Survey 2005.

This is not to say, however, that restarting production of the C-17 almost from scratch could be done quickly, or inexpensively. Closing the Long Beach site effectively abandons $2.8 billion in sunk investment in property, plants, and equipment (see *Table 5-1*), much of which would have to be replaced. Data collected by SIES suggest that reestablishing production would be a lengthy process, requiring the securing of a new production site and the construction of entirely new facilities.

The cost of building a new manufacturing complex for the C-17 at a "greenfield" site would be expensive. DOD would incur these higher costs through outlays for tooling, buildings, related infrastructure, and through higher prices for C-17 airframes and higher costs for P&W engines.

Once the Long Beach C-17 facility is closed and the existing manufacturing infrastructure and workforce are lost, a new facility would not likely be opened in Southern California. According to Boeing, California would not be an optimal location for establishing a new aircraft assembly plant because of high labor, tax, and energy costs and environmental restrictions.

Table 5-2 -- **C-17 Production – New Site Costs, Schedules**

Factors	*Replacement Costs** (Millions of Dollars)	*Lead-Time for Re-Start*at a New Facility* (Months)	*Time from Re-start to 1st Unit Delivery** (Months)
Land	3.4	N/A	N/A
Buildings	508.6	N/A	N/A
Utilities Infrastructure	89.7	N/A	N/A
Roads & Rails	N/A**	N/A	N/A
Assembly Line(s)	336.2	18	12
On-site Fabrication Tooling	622.5	18	12
Off-site Fabrication Tooling	907.6	18	40
Dedicated On-site Design and Engineering Facilities	367.0	18	12
Dedicated Off-site Design and Engineering Facilities	385.2	18	40
Dedicated On-site Admin. Facilities & Equipment	12.5	18	12
Dedicated Off-site Admin. Facilities & Equipment	4.9	18	40
Security Systems	0.0	18	12
Other	0.0	18	40

**Estimated. **N/A = Not Applicable.*
Source: U.S. DOC/BIS/SIES Survey 2005.

To hold down costs, Boeing says that it would probably select a site in the southeastern region of the United States where land is less expensive and labor rates are lower than in more urbanized areas of the nation.

From the time that Boeing acquires land, it could take 18-24 months[53] to build new production facilities. The lead time necessary to configure tools and production lines to assemble aircraft is

[53] Richard C. Ullman, Director – Contracts, Pricing & Estimating, Integrated Defense Systems, The Boeing Company, September 2005.

about 18 months (see *Table 5-2*) – like that for restarting from a dormant C-17 production facility. Delivery time for the first aircraft from the time of land acquisition could be 36-40 months, if not longer.

While it appears that Boeing's suppliers would be able to resume delivery of parts and components on a schedule similar to restarting at the Long Beach site (see *Table 3-2*), some manufacturers might require additional time, because there is no assurance that all existing suppliers will be available in future years. There is evidence that the manufacturing capabilities of some suppliers to Boeing could be significantly diminished, if not lost.[54]

Boeing acknowledges that for some components and systems, particularly major parts, it does not typically have alternative suppliers readily available that can step in to substitute. "…[T]hese systems require complex technical capability, available capacity, available material, especially in the case of landing gears that require long-lead forgings and castings. Qualification [to produce these systems] …can take anywhere from one to two years on most of these items," Boeing states.[55]

Table 5-3 – **C-17 Closeout & Restart Costs**

(Millions of Dollars)

Long Beach Shut-Down Costs	*Greenfield Start-Up*	*Greenfield Shut-Down Costs**	*Total****
$1,260*	$3,237**	$1,260***	$5,757

*Assumes packing and shipping of tools and program data. Air Force could elect to scrap tooling and program data.
**Costs could be higher if Air Force scraps tooling after Long Beach closure.
***Today's dollars. Shut-down costs for a greenfield location would be similar to that incurred for Boeing's Long Beach production facilities, but after accounting for inflation, actual outlays would be higher.
Source: U.S. DOC/BIS//SIES Survey 2005.

The cost of reestablishing C-17 production at a new location (see *Table 5-3*) is estimated at $3.237 billion,[56] a sum sufficient to buy nearly 17 such aircraft at current prices.[57] Almost $600 million of this total would be allocated to new buildings and infrastructure; and another $752 million would be for new design and engineering facilities to support renewed production activities. Other significant costs ($1.866 billion) are associated with the purchase of tooling by Boeing and DOD to reinstate production. Boeing has stated that about half of the tools now used to manufacture

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[54] Ducommun AeroStructures advised DOC/SIES that it would likely have to dramatically reduce its production floor space and workforce, unless substitute business for the C-17 is found.
[55] U.S. DOC/BIS/SIES Survey 2005; Marta L. Schaper, Air vehicle IPT/Supplier Management, Airlift and Tanker Program, The Boeing Company, September 2005.
[56] Projection is based on a capability to produce 15 planes a year; assumes that the total land area is equal to the site at Long Beach, California; and allows for assembly buildings and related facilities equal in size to the 2,137,734 sq. ft. that Boeing now occupies at Long Beach, California.
[57] Based on a delivered price of $192 million per aircraft with engines installed.

the C-17 and its components would be redesigned to improve functionality, increase production efficiency, and lower costs.

In the future, after production of the C-17 is halted at the *new site*, DOD would again incur project termination costs on a scale like those described for project cessation in *Chapter 3.* However, in the case of shutting down a new site, costs would be higher, reflecting inflation factors and a new closeout "tail up" charge. As noted in *Chapter 3,* the "tail up" cost associated with termination of C-17 production at Long Beach today is estimated at $500 million, which excludes dismantling and severance costs of $760 million (see *Chapter 3, Table 3-4*). Total costs for shutting down the Long Beach facility, building a new production site in the U.S., and then eventually closing the *new site* is estimated at a minimum of $5.7 billion.[58]

Lessons from the Past

The production of the C-5 Galaxy aircraft is instructive in understanding the challenges associated with terminating production of a major aircraft program. In the early 1960s DOD determined it needed more effective airlift capability. At that time, as many as 200 aircraft were thought to be needed to meet new requirements for moving cargo and personnel. Production contracts were awarded to Lockheed-Georgia Co. (now Lockheed Martin Corp.) in 1965 for an initial run of 58 C-5 Galaxy aircraft and another 57 units were to follow. A final production run of 85 C-5s was then expected to bring the fleet to 200 aircraft.[59]

However, production orders were reduced radically by Congress to a total of 81 aircraft[60] in 1971, in part because of technical difficulties and cost overruns associated with the aircraft; subsequently, production ended in 1973. By late 1973, just two years after a decision to reduce the C-5 fleet purchase, DOD officials recognized a need for an expanded airlift capacity to move cargo and personnel. Specifically, DOD highlighted requirements for more C-5 aircraft and the

[58] BIS estimate based on Department of Commerce/SIES survey data and discussions with Boeing. Not all costs are captured in this estimate. This figure does not take into account the write-off of $2.8 billion in sunk infrastructure investment at Boeing's Long Beach production site (see *Table 5-1*).
[59] *Military Airlift And Aircraft Procurement: The Case of the C-5A*, p.34, Marcelle Size Knaack, Air Force History & Museums Program, 1998.
[60] Ibid, p.34.

Air Force initiated steps that would lead to a restart of the production line, which took nearly eight years to realize.

In 1981, Lockheed reopened the C-5 production to produce C-5Bs, which incorporated design changes to overcome problems associated with the C-5A series.[61] This history may prove instructive for DOD and Congressional decision-makers because it demonstrates that (1) perceptions of strategic airlift needs can change quickly, and (2) once a decision is made to halt production, restarting production can be a long and costly process.

It should be understood that the production history of the C-5s is not a mirror image of the C-17 environment today. The C-17 is not burdened with major design problems and production costs for the aircraft are on target. However, SIES data and analyses demonstrate that resuming the C-17 program, once production has been shut down, will be an expensive and timely undertaking. Unlike the case of the C-5, whose Georgia manufacturing site remained open so production could resume, it is doubtful that the existing C-17 production facilities in Long Beach, once shut down, would be available for production of the aircraft.

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61 There are 112 C-5 series aircraft in operation; six have been lost in service since 1970. Sources: Lockheed Martin. See: http://www.lockheedmartin.com/wms/findPage.do?dsp=fec&ci=17123&rsbci=11168&fti=134&ti=0&sc=400; Global Security. Org. See: http://www.globalsecurity.org/military/systems/aircraft/c-5.htm

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6. The C-17's Potential Dual Roles: Commerce & Security

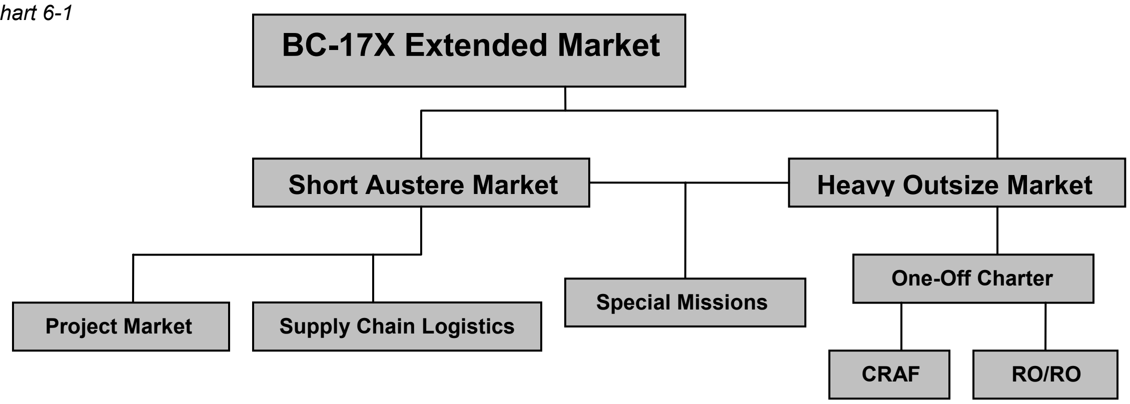
__Heavy and Outsized Airlift Market Potential__

Today, the C-17 aircraft does not operate in the global commercial air cargo market. All C-17 aircraft are owned and controlled by the U.S. Air Force[62] and are used only for military, humanitarian, and disaster relief purposes. However, there are potential commercial applications for this aircraft, which possesses operational characteristics unmatched by other cargo aircraft.

Most air cargo today is shipped on passenger aircraft or converted passenger planes like the Boeing 747 and McDonnell Douglas MD-11.[63] There are rising requirements today for commercial cargo aircraft with outsize, heavy lift capability. In addition, there is also a need for aircraft that can operate in remote and austere environments. This latter niche is an under-served market, one in which there are just a handful of aircraft types suitable for providing service.

Several applications have been identified for the C-17, should the aircraft become available to the cargo industry. The C-17 could perform in many areas of the heavy and outsized lift market (HOM) and would have a competitive advantage in a subset known as the short, austere lift market (SAM). By one estimate, there is potential for a fleet of commercial C-17s to capture billions[64] of dollars in air cargo business.

Chart 6-1



CRAF = Civil Reserve Air Fleet
RO/RO = Roll On/Roll Off

Source: *Risk Reduction Report on the Short Austere Market*, Council for Logistics Research, Inc.

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[62] The United Kingdom's Royal Air Force currently is leasing four C-17 aircraft.
[63] The MD-11 was originally developed by McDonnell Douglas, which was acquired by The Boeing Company.
[64] Boeing estimates that a commercial C-17 cargo fleet would generate average annual revenues of $2.5 billion over an eight-year period. See *Risk Reduction Report on the Short Austere Market*, Council for Logistics Research, Inc., September 2003, p. 9.

Currently, competing commercial air cargo lifters in the HOM market are the Airbus A300-600 ST Beluga and the Russian-Ukrainian AN-124 (see *Table 6-1*). Carriers in France (Airbus Beluga) and Russia and the Ukraine (AN-124) operate these aircraft. No U.S. carriers have equivalent capability and no U.S.-made planes are competing in this growing market segment. Aircraft such as B-747s and MD-11s cannot handle oversize cargo, which DOD generally defines as cargo that cannot fit through the door of a B-747 or an MD-11.[65]

The commercial C-17 cargo lifter could service numerous industries, including aircraft, construction, mining, oil and gas equipment, power generation, railroad, and satellite companies.[66] These business sectors often have a need to quickly transport heavy, oversize equipment. The C-17's ability to hold very large, heavy items (e.g. an M-1 Abrams battle tank) and its roll-on-roll-off cargo handling capability make it an attractive cargo vehicle. Unlike a

Table 6-1 – **C-17, Commercial Cargo Aircraft Characteristics**

Market Requirements	*Boeing C-17*	*Airbus A300-600-ST Beluga*	*AN-124*	*Airbus A-400M**	*Boeing 747-400F*
Total Aircraft Units Built	137	5	56	0	95 (108**)
Units Carrying Commercial Cargo	0	5	27	N/A	95 (108**)
Min. Landing Runway*** (feet)	1,800	5,000	7,585	3,000	7,500
Dispatch Reliability	High	High	Medium	N/A	High
International Range (NM) 75% PL	3,850	1,800	4,050	2,600	5,800
Ease of Loading	Roller Floor, Winch, RO-RO****	Roller Floor	Crane, RO-RO	Roller Floor, RO-RO	External Lifts, Pallet/Bulk, Lower/Upper Decks
Pressurizing Cargo Area	Yes	No	No	Yes	Yes
Maintenance Infrastructure	Yes	Yes	Performed in Russia	Yes	Yes
Commercial Engines	Yes	Yes	No	Yes	Yes
Crew Size	3	3	6 - 7	3	2
Payload Weight (metric tons)	79	47	120	37	114
Volume (cu. ft.)	19,483	49,440	40,673	12,572	27,467
Acquisition Cost ($1999)	$192 Million*****	$200 Million	Unknown	$100 Million	$200 Million
Short Field Capability	Yes	No	No	Yes	No

**Not in service at this time; initial production underway. **This includes 13 747-400ERF (extended range freighters).*
**** Runway landing requirements increase for each aircraft cited as cargo load weight increases.*
****RO-RO = Roll-on, Roll-off. *****Approximately. NM = nautical miles. PL = Payload
Sources: U.S, Air Force, Airbus S.A.S., BC-17X Market and Aircraft Summary*, The Boeing Company, August 2002.*

65 *Expanding the Civil Reserve Air Fleet With Outsize Cargo Capacity*, draft of the Final Report to the House Armed Services Committee, Senate Armed Services Committee, U.S. Air Force, January 2005, p. 1.

modified B-747, special lifts and handling equipment are not needed to load and unload cargo from a C-17.

The C-17 has landed on an airstrip as short as 1,800 feet with half a load of cargo (40 tons). For commercial operations, however, civil aviation regulations may restrict the aircraft to airfields of about 3,800 feet for takeoff.[67] Moreover, the C-17 does not require a paved runway and it can turn around on a runway segment with a width of just 80 feet. A wide-body freighter such as a Boeing 747-400F requires a paved runway of 7,500 feet;[68] and an AN-124 needs 7,585 feet of paved runway for landing (see *Table 6-1*).

The cargo delivery flexibility of a commercial C-17 can produce significant savings for companies operating in remote areas. The capability enables rapid delivery of equipment and materials to dramatically compress project completion schedules and thus slash labor and other operating costs. Expedited delivery of high-value systems or parts via air cargo allows construction, mining, oil and gas, and power generation operations to greatly improve productivity relative to using slower moving ship and truck transportation modes.[69]

Studies sponsored by Boeing suggest that the SAM segment of the HOM cargo market (see *Chart 6-1*) would support at least 10 C-17 aircraft with relatively little competition, and perhaps as many as 30-50 aircraft by 2015, depending on market growth and penetration rates for the C-17.[70] Projections take into account competition from the larger AN-124 aircraft, which has greater cargo capability (see *Table 6-1*) in terms of volume, the maximum size of objects carried, and total weight load. The Council for Logistics Research[71] suggests that the entire HOM market might eventually justify up to 60 C-17 commercial cargo aircraft.

C-17's Commercial Future Is Uncertain

Whether the commercial cargo market opportunity projected for the C-17 will be realized remains to be seen. There are questions about demand levels in the HOM and SAM markets. It

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[66] *BC-17X Typical Operator Financial Plan*, The Boeing Company, October 2003, p. 7.
[67] Federal Aviation Administration, Part 25 for a standard day, sea level at 59 degrees Fahrenheit. Minimum take-off runway may be revised downward to 2,500 feet under Federal Aviation Regulation 21.27. Source: The Boeing Company.
[68] Landing runway length requirements are governed by multiple factors. See Boeing' website: http://www.boeing.com/assocproducts/aircompat/acaps/7474sec3.pdf
[69] *USAF: Commercial C-17 Effort on Track, Market Shows Promise*, Inside the Air Force, August 15, 2003.
[70] *BC17-X Market and Aircraft Summary,* The Boeing Company, August 2002, p. 18
[71] *Risk Reduction Report on the Short Austere Market*, Council for Logistics Research, Inc., September 2003,

is not certain that these markets will be sufficiently predictable and provide adequate traffic over the long term to sustain a fleet of commercial cargo C-17s.

Regulatory requirements and costs associated with getting the military aircraft certified for commercial service represent one set of uncertainties.[72] Other operational issues such as fuel costs and staffing requirements are other variables affecting profitability. Even with such factors within acceptable ranges, the cost of buying new "commercial" C-17s (also known as the BC-17X) to service the cargo market may prove prohibitive.

Cargo aircraft companies typically purchase used commercial aircraft at a fraction of the cost of a new plane, and then convert them for cargo transport. The purchase price for a new C-17, at $227 million,[73] may be too high, in terms of capital and business risks. Air cargo companies have to weigh uncertainties related to the business volume the HOM market will generate. A single C-17 represents a large investment for these companies, particularly in comparison to a conventional cargo aircraft.

The economic viability of using the C-17 in commercial cargo service, however, improves if used aircraft become available.[74] The U.S. Air Force has been examining the concept of retiring some older C-17s – an initial lot of around 10 aircraft – and selling them to U.S.-based commercial cargo carriers. The proceeds from the sale of used C-17 aircraft, an estimated $90 million per unit, would then be used by the Air Force to help purchase new C-17s. In addition to this expense, a commercial operator would incur conversion costs of about $10 million per aircraft[75] in order to convert and certify the plane for commercial cargo operations.

C-17 Cargo Aircraft Could Bolster CRAF

As a condition for selling used C-17s to cargo companies, the Air Force would require that the planes become part of the Civil Reserve Air Fleet (CRAF). Thus in times of national need or

[72] The C-17 is a military aircraft with U.S. Munitions List (USML) status and also must obtain Federal Aviation Administration certification.
[73] The Boeing Company, October 2005. Previously, the cost was estimated at $208 million, but inflation has increased the price. See:.*BC-17X Typical Operator Financing Plan*, The Boeing Company, October 2003, p. 44.
[74] *BC-17X LLC Business Financial Plan*, The Boeing Company, May 2004, p. 19.
[75] The Boeing Company, October 2005. Earlier studies estimated conversion costs of $25-30 million per aircraft, but clarification of regulatory certification requirements have lowered those costs.

war, commercial cargo C-17s would be available to DOD and other U.S. Government agencies. DOD relies on the CRAF to supplement the Air Force fleet in a time of war; and the CRAF could be required in other kinds of national emergencies as well (see *Appendix IX*).

The CRAF fleet consists of commercial passenger planes and cargo aircraft (see *Table 6-2*). In the event of a surge in airlift requirements, DOD calls up the aircraft in three stages (see *Appendix VIII*), depending on the scale of lift needs. There are currently no outsize cargo lift planes, such as the C-17 or C-5, in the CRAF.

The concept of making C-17 aircraft available to the commercial cargo industry and the CRAF has been under review by the Air Force for several years, as part of the Commercial Application of Military Airlift Aircraft (CAMAA) initiative.[76] Not only could the C-17 boost the competitive position of the U.S. air cargo industry in the heavy lift market, it might also expand economic activity in terms of overall cargo industry revenue.

Moreover, DOD would be freed from bearing the rising maintenance costs incurred by keeping the older C-17s in service during peacetime. These expenses would be borne by the commercial operators. Finally, to the extent that commercial demand for C-17 cargo aircraft services grows, market conditions might enable production of additional new C-17 aircraft.

Table 6-2 – **Civil Reserve Air Fleet (CRAF) Cargo Inventory**

*Type of Cargo Aircraft**	*Outsize Heavy Lift; Austere Landing Capability*	*Call-Up Stage 1*	*Call-Up Stage 2*	*Call-Up Stage 3*	***Total Available***
DC8-61F / 62F / 63F	None	0	1	12	**13**
DC8-71F / 73F	None	4	7	22	**33**
DC8-62 COMBI	None	0	2	4	**6**
B747-100F / 200F	None	11	23	77	**111**
B747-400F	None	3	9	17	**29**
B767-200SF	None	2	4	4	**8**
DC/MD10-10F	None	0	0	57	**59**
DC/MD10-30F / CF	None	5	7	28	**40**
MD-11F / CF	None	8	24	59	**91**

*All aircraft shown above were originally manufactured to serve as passenger planes. None have a capability to haul oversize cargo and none routinely landing on unpaved runways. Commercial aircraft enrolled in CRAF are called into duty in stages based on DOD requirements and the scale of the national emergency. ** As of October 2005.
Source: Air Mobility Command HQ Form 312, 20020901 (EF-V2). October 2005; Lt. Col. Jim Dice, Air Mobility Command.

[76] *Expanding the Civil Reserve Air Fleet With Outsize Cargo Capacity*, report to the House Committee on Armed Services, Senate Committee on Armed Services Committee, U.S. Air Force, January 2005.

Efforts to expand the CRAF to include permanent outsize cargo aircraft, such as the C-17, are meant to mitigate deficiencies in DOD's current, organic outsize-cargo fleet. For instance, in recent times, the Air Mobility Command has had to contract for the use of AN-124s from foreign cargo carriers[77] to support DOD operations. However, AN-124s, which are owned and controlled by Russian and Ukrainian companies, may not always be available to the United States in times of national emergency.

The successful launch of the C-17 as a commercial cargo carrier, even if sold as used aircraft to cargo companies, will hinge to some degree on market conditions and the cost of capital (lending rates). It is not known at this time whether federal assistance in the form of government loan guarantees[78] might be required to help launch this new segment of the U.S. cargo industry. Whether the provision of this assistance would be supported by DOD and the Congress is not known. For the moment, according to Boeing, it does not appear that such assistance is needed.

There are also questions about whether the Air Force can retire any C-17s in the near future, since DOD is perceived in some quarters as having insufficient airlift capacity. Current C-17 utilization rates are twice that anticipated by the Air Force. Higher usage is causing greater wear and tear[79] and thus accelerating the decline of the aircrafts' remaining useful life. Unless the Air Force expands the C-17 fleet, it may not be possible to give serious consideration to retiring older C-17s for transfer to U.S. air cargo carriers and enrollment in the CRAF.

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[77] The Air Force obtains access to AN-124 aircraft to carry oversize cargo through Civil Reserve Air Fleet member companies, which subcontract the work out to Volga-Dnepr Airlines, a division of Volga-Dnepr Group of Russia. DOD has certified Volga-Dnepr Airlines as an approved carrier. Source: U.S. Air Force.

[78] *Bullet Background Paper on CAMAA*, as reported by Col. Greg Lockhart, C-17 Program Element Monitor. U.S. Air Force Secretariat Directorate of Long-Range Power Projection, SAF/AQQ/588-7756/19 March 2001; *Pentagon Proposes Trading Older C-17s to Boeing to Grow CRAF*, Inside the Air Force, April 22, 2005.

[79] SIES interviews with: David Merrill, Senior Analyst, Air Mobility Command, TRANSCOM, U.S. Air Force; Gen. John Handy (Ret.), Air Mobility Command, U.S. Air Force.

7. Appendices

Appendix I: C-17 Specifications

Appendix II: Investment C-17 Manufacturing Infrastructure – Long Beach CA

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Appendix IX: Civil Reserve Air Fleet

Appendix X: Cargo Aircraft Mobilization Value (MV) – Civil Reserve Air Fleet

Appendix XI: Boeing BC-17X Specifications

Appendix XII: DOC/SIES Publications List

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Appendix I – Boeing C-17 Globemaster Specifications

Boeing C-17 Globemaster –Airframe Specifications	
GENERAL DESCRIPTION: The C-17 Globemaster III is a high-wing, four-engine, T-tailed military transport.	
EXTERNAL DIMENSIONS	
Wingspan to winglet tip	169.8 feet (51.74 m)
Length	174 feet (53.04 m)
Height at tail	55.1 feet (16.79 m)
Fuselage diameter	22.5 feet (6.86 m)
ENGINES: Four Pratt & Whitney PW2040 (military designation F117-PW-100) 40,440 pounds thrust each	
CARGO COMPARTMENT	
Cargo compartment crew	One loadmaster
Cargo floor length	68.2 feet (20.78 m)
Ramp length	21.4 feet (6.52 m) structural length
Loadable width	18 feet (5.49 m)
Loadable height (under wing)	12.3 feet (3.76m)
Loadable height (aft of wing)	14.8 feet (4.50m)
Ramp to ground angle	9 degrees
Ramp capacity	40,000 lbs. (18,144 kg)
Aerial delivery system capacity	
Pallets	Eleven 463L pallets (including 2 on ramp)
Single load airdrop	60,000 pound platform (27,216 kg)
Sequential loads airdrop	110,000 pounds (49,895 kg) (60 feet of platforms) (18.29 m)
Logistic rail system capacity	Eighteen 463L pallets (including 4 on ramp)
Dual-row airdrop system	Up to eight 18 foot platforms or 12 463L pallets
Combat offload	All pallets from ADS or logistic rail systems
SEATING	
Sidewall (permanently installed)	54 (27 each side, 18 inches wide, 24 inch spacing center to center)
Centerline (stored on board)	48 (in sets of six back-to-back, 8 sets)
Palletized (10-passenger pallets)	80 on 8 pallets, plus 54 passengers on sidewall seats
AEROMEDICAL EVACUATION	
Litter stations (onboard)	Three (3 litters each)
Litter stations (additional kit)	Nine
Source: The Boeing Company, 2005. See: http://www.boeing.com/defense-space/military/c17/c17spec.htm	

<u>Appendix I</u> – Boeing C-17 Globemaster Specifications – *continued*

Boeing C-17 Globemaster –Airframe Specifications – *continued*	
Total capability (contingency)	36 litters and 54 ambulatory
COCKPIT	
Flight crew	2 pilots
Observer positions	2
Instrument displays	2 full-time all-function head-up displays (HUD), 4 multi-function active matrix liquid crystal displays
Navigation system	Digital electronics
Communication	Integrated radio management system with communications system open architecture (COSA)
Flight controls system	Quadruple-redundant electronic flight control with mechanical backup system
WING	
Area	3,800 sq. ft. (353.03 sq. m)
Aspect Radio	7.165
Wing sweep angle	25 degrees
Airfoil type	Supercritical
Flaps	Fixed-vane, double-slotted, simple-hinged
WINGLET	
Height	8.92 feet (2.72 m)
Span	9.21 feet (2.81 m)
Area	35.85 sq. ft. (3.33 m)
Sweep	30 degrees
Angle	15 degrees from vertical
HORIZONTAL TAIL	
Area	845 sq. ft. (78.50 sq. m)
Span	65 feet (19.81 m)
Aspect ratio	5.0
Sweep	27 degrees
LANDING GEAR	
Main, type	Triple Tandem
Width (outside to outside)	33.7 feet (10.26 m)
Tires	50x21-20; 40 x 16 - 14
Nose, type	Single strut, steerable with dual wheels
Wheelbase	65.8 feet (20.06 m)
Source: The Boeing Company, 2005. See: http://www.boeing.com/defense-space/military/c17/c17spec.htm	

Appendix II – U.S. Air Force & Boeing Investment in C-17 Manufacturing Infrastructure – Long Beach CA

Investment* in Long Beach Infrastructure Necessary for C-17 Production
(Millions of Dollars)

	Total R&D, Test, Prototype Costs	***Initial Costs****	***Cost of Major Improvements, Expansions***	***Remaining Useful Life***	***Current Depreciated Value***	***Residual Value***
Land		14.8	N/A	N/A	N/A	14.8
Buildings		148.7	80.5	12 – 480 Periods	124.2	104.9
Utilities Infrastructure		See Buildings	See Buildings	See Buildings	See Buildings	See Buildings
Roads & Rails		See Buildings	See Buildings	See Buildings	See Buildings	See Building
Assembly Line(s)	N/A	See On-Site Fab Tooling	See On-Site Fab Tooling	See On-Site Fab Tooling	See On-Site Fab Tooling	See On-Site Fab Tooling
On-site Fabrication Tooling	N/A	675.4E	80.7	1 - 202 Periods	107.6	26.0
Off-site Fabrication Tooling	N/A	913.4E	15.3	48 - 159 Periods	11.8	9.4
Dedicated On-site Design and Engineering Facilities		374.2E	13.9	1 - 156 Periods	16.4	4.6
Dedicated Off-site Design and Engineering Facilities		385.2E	11.9	18 - 132 Periods	1.3	10.6
Dedicated On-site Administrative Facilities & Equipment		0.7	57.9	1 - 156 Periods	41,7	16.9
Dedicated Off-site Administrative Facilities & Equipment		11.4	3.8	26 - 240 Periods	13.4	1.7

**Includes investment by Boeing, McDonnell Douglas (purchased by Boeing in 1997), and the United States Air Force. ** Includes U.S. Government-furnished equipment.*
E = Estimated N/A = Not Applicable
Source: U.S. DOC/BIS/SIES Survey 2005

<u>Appendix III</u> – Initial DOD-Boeing Investment in C-17 Production Capability

Initial DOD-Boeing Investment in C-17 Production Capability (*Actual Dollars*)			
Investments	*Total Initial Costs*	*U.S. Air Force Investment*	*Boeing Investment*
On-Site Fabrication Tooling	$675,431,369	$622,531,369	$52,900.000
Off-Site Fabrication Tooling	$913,387,752	$5,800,000	$5,800,000
Dedicated On-Site Design & Engineering Facilities	$374,174,471	$907,587,753	$7,200,000
Dedicated Off-Site Design & Engineering Facilities	$385,178,126	$385,178,126	$0.00
Total	***$2,348,171,718.00***	***$1,921,097,248.00***	***$13,052,900.000***
Source: U.S. DOC/BIS/SIES Survey 2005			

Appendix IV – Boeing Direct Suppliers and Estimated Economic Impact

Appendix V-A – Boeing C-17 Manufacturing Operations at Long Beach, California

Construction of gigantic C-17 wing units requires the use of numerous high-precision jigs, alignment tools, and fastening systems.

<u>Appendix V-B</u> – Boeing C-17 Manufacturing Operations at Long Beach, California

C-17 fuselage units are assembled using a massive custom automatic-riveting machine, which fastens aircraft skins to the fuselage frame.

Appendix V-C – Boeing C-17 Manufacturing Operations at Long Beach, California

C-17 Fuselage sections (foreground) stand in assembly jigs in preparation for being joined together with other sections at Long Beach, CA.

Appendix V-D – Boeing C-17 Manufacturing Operations at Long Beach, California

C-17 wing assemblies, including controls, fuel cells and engine pylons, are being prepared and tested prior to being mated to the fuselage.

<u>Appendix V-E</u> – Boeing C-17 Manufacturing Operations at Long Beach, California

Massive C-17 wing assemblies are lowered by crane on top of aircraft fuselage sections where they are joined together.

Appendix V-F – Boeing C-17 Manufacturing Operations at Long Beach, California

C-17 Globemasters advance along the assembly line near the point of completion on Boeing's production facility at Long Beach, CA.

<u>Appendix V-G</u> – Boeing C-17 Manufacturing Operations at Long Beach, California

Completed C-17 Globemasters, each fitted with four Pratt & Whitney F117-PW-100s engines, stand ready for delivery to the U.S. Air Force.

<u>Appendix VI</u> – Stretch Forming Tooling at Ducommun AeroStructures

Hydraulic Stretch Forming Presses			
Equipment Type:	Size:	Capacity:	
Sheridan Gray	34 ft. Between Jaws	24” Extrusion	1100 Ton
Sheridan Gray	50” Die Table Stroke	100” Sheet	600 Ton
Sheridan STC-1500	41 ft. Between Jaws	24” Extrusion	1500 Ton
With Overhead Bulldozer Capability	108” Die Table Stroke	144” Sheet	1500 Ton
Sheridan Gray L-1000	40 ft. Between Jaws	100” Sheet	1000 Ton
	36” Die Table Stroke		
Sheridan Gray T-500	15 ft. Between Jaws	154” Sheet	500 Ton
	80” Die Table Stroke		
HPM 4 Post Press	152” x 48” Guerion Box	24” Stroke	2500 Ton
With Offset Jaw Capability	124” x 180” Sheet		
AHF Custom Sheet Press	34 ft. Between Jaws	128” Sheet	1600 Ton
AHF Custom Lead Edge	28 ft. Between Jaws	48” Sheet Jaws	75 Ton
Cyril Bath			
Radial Extrusion	85" Diameter Table	22 ft. Extrusion	25 Ton
Stretch Press Cyril Bath			
Ercco Stretch Press	72” Jaws	300 Ton	
Ercco Stretch Press	48” Jaws	100 Ton	
AHF Custom Hydro 4 Post Press	24” x 72” Guerion Box		200 Ton
Hufford A-12 Stretch - Wrap	14” x 24 ft. Extrusion		60 Ton
Hufford A-7 Stretch - Wrap	6” x 23 ft. Extrusion		35 Ton
Hufford A-8 Stretch – Wrap	6” x 18 ft. Extrusion		12 Ton
Hufford A-5 Stretch - Wrap	6” x 20 ft. Extrusion		12 Ton
HPM Double Action Press Hydro Form	36” x 38” Guerion Box		300 Ton
Watson-Stillman Hot Joggling and Hydro Press			575 Ton
Clearing Hot Joggle Press			100 Ton
Source: Ducommun AeroStructures. See http://www.ducommunaero.com/equip_list.html			

Appendix VII – History of United Kingdom Lease of C-17 Aircraft

LONG BEACH, Calif., May 17, 2001 — The Boeing Company delivered the first of four C-17 Globemaster III military cargo aircraft to the United Kingdom Royal Air Force (RAF) during ceremonies at the company's assembly facility here today.

The aircraft was then flown to Charleston Air Force Base in South Carolina, where it will pick up support equipment. It is scheduled to arrive at its home station, RAF Brize Norton, on May 23. Wing Commander Malcolm Brecht, commander of the RAF's 99th Squadron, was at the controls for its delivery flight.

All four U.K. C-17s will be delivered this summer. They are being acquired on a seven-year lease arrangement, with training and maintenance support through a separate contract with the U.S. Air Force and Boeing.

The United Kingdom is the first international customer for the C-17 Globemaster III. The U.S. Air Force has received 72 C-17s.

Source: http://www.boeing.com/news/releases/2001/q2/news_release_010517n.htm

Appendix VIII – Civil Reserve Air Fleet, Formula and Staging

The CRAF Incentive and Contract Awards Program

Introduced in the 1950s, the CRAF program is a cooperative effort between the U.S. Department of Transportation (DOT) and the U.S. Department of Defense (DOD). The program permits civil passenger carriers to help preserve DOD airlift capacity in a time of increased lift demand or "surge."

In a time of "lift surge" – meaning a momentary increased in demand for passenger or cargo aircraft – participating carriers in the CRAF program supplement the DOD's fleet of transport planes.

The CRAF is composed of three segments; International, National, and Aeromedical Evacuation. Each aircraft is assigned to a segment based on its capabilities. CRAF can be incrementally activated in three stages in response to defense-oriented situations.

> ***CRAF Stage I*** Only long-range, international airlift assets may be activated at this stage by the Commander-in-Chief, United States Transportation Command (USCINCTRANS) in the event of extraordinary demand for increased airlift. When Stage I is activated, carriers have 24 hours after aircraft call-up to respond with aircraft and crews ready for mission assignments.
>
> ***CRAF Stage II*** USCINCTRANS activates this stage when additional airlift is required for major national security purposes or emergency response. Composed of all CRAF assets excluding Domestic Services,* this stage has a 24-hour response time – except for the Aeromedical Evacuation Segment, which has a 48-hour response time.
>
> ***CRAF Stage III*** USCINCTRANS may activate this stage in a time of war or during a defense-oriented national emergency. This stage is composed of all CRAF segments with a response time of 48 hours.

The right to bid on peacetime DOD contracts remains the key incentive for participating in the CRAF program. Participating carriers receive points for each plane they volunteer to the CRAF. The more points accumulated by a carrier, the more peacetime contracts awarded to the carrier.

The CRAF incentive system employs a proportional methodology where DOD peacetime contract awards are proportional to the number of planes allocated to the CRAF by the carrier. DOD's Air Mobility Command (AMC) calculates the points and subsequently awards the peacetime contracts.

The AMC uses *mobilization value* as the principle basis in determining the number of peacetime awards for each CRAF participant. These awards are made using three contractual methods: **fixed buys**, **expansion buys,** and **tenders**.

For further information, contact the Air Mobility Command, TRANSCOM, Scott Air Force Base.
Phone: 618-229-1751 or 618-229-4801. The AMC CRAF office is A-34 B.

**Domestic Services = National CRAF segments.*

Appendix IX: Plane Allocation for CRAF Participants – Passenger and Cargo Aircraft (Stage 3*)

Passenger and Cargo Carrier CRAF Inventory: Long-Range Section (Minimum of 3,500 Nautical Miles)										
Passenger Planes	*A300-600ER*	*B-757-200/200ER/300ER*	*A-330-300*	*B-747-200*	*B-747-400*	*B-767-200ER/300ER/400ER*	*B-777-200/200ER*	*DC10-10/30 30ER*	*MD-11/11ER*	*L1011-50/100/150/500*
Passenger Carriers										
American Airlines (AAL) and TA-2		124				13	45			
ATA Airlines (AMT) TA-1		14								4
Continental Airlines (COA)		41				15				
Delta Airlines (DAL) TA-2						27	8			
Hawaiian Airlines (HAL)						4				
North American (NAO) TA-3		5				3				
Northwest Airlines (NWA) TA-1		16	18	4	16			21		
Omni Air International (OAE) TA-1		3						8		
Ryan International (RYN) TA-2		2								
United Airlines (UAL) TA-2					31		52			
US Airways (USA) TA-2			9							
World Airways (WOA) TA-2									5	
TOTAL for STAGE 3		**205**	**27**	**4**	**47**	**62**	**105**	**29**	**5**	**4**
Cargo Planes ***(No Oversize, Austere capability)***	*DC-8-61F/62F/63F*	*DC-8-71/73F*	*DC-8-62 COMBI*	*B-747-100F/200F/ 300F*	*B-747-400F*	*B-767- 200SF*	*DC/MD10-10F*	*DC/MD10-30F/CFMD-11F*	*MD-11F/CF*	*L1011-200F*
Cargo Carriers										
ABX Air (ABX) TA-2	8	13				4				
Air Transport Int'l (ATN) TA-1I			4							
Arrow Air (APW) TA-2	4							2		
Atlas Air (GTI) TA-1				19	12					
Astar Air Cargo (DHL) TA-2		9								
Evergreen Int'l (EIA) TA-2				12						
FedEx Airlines (FDX) TA-1							57	17	48	
Gemini Air Cargo (GCO) TA-1								7	4	
Kalitta Air (CKS) TA-3				14						
Northwest Airlines (NWA) TA-1				14						
Polar Air Cargo (PAC) TA-1				3	5					
Southern Air (SOO) TA-3				4						
UPS Airlines (UPS) TA-3				11						
World Airlines (WOA) TA-2								2	5	
TOTAL for STAGE 3	**12**	**22**	**4**	**77**	**17**	**4**	**57**	**28**	**57**	

**Note: Number of planes reflects total aircraft model allocation to the CRAF for a "Stage 3" lift scenario. The highest activated number of CRAF planes occurs in Stage 3; fewer aircraft are activated in "Stages 1" and "Stage 2."*

Source: Form 312, 20020901 (EF-V2), Air Mobility Command, October 1, 2005; U.S. DOC/BIS/SIES interviews and research.

Appendix X – Cargo Aircraft Mobilization Value – Civil Air Reserve Air Fleet

CARGO AIRCRAFT MOBILIZATION VALUE (MV)

Mobilization value (MV) is expressed in terms of million-ton-miles per day (MTM/D). Another standard is widebody [aircraft] equivalent (WBE), a measure of the value DOD places on commercial aircraft for meeting wartime requirements. DOD terms and methods for calculating mobilization values are described below.

WBE is calculated using three factors: payload (PL) capability, average true airspeed (ATA), and productive utilization rate (PUR).

PL is the weight of cargo, in short-tons, or the total combined weight of passengers and baggage an aircraft can carry a specified distance, which is determined by using a range/payload chart to identify payload capability at the required distance.

ATA or average true airspeed is calculated for the required distance and including climb-out and let-down.

PUR is the actual rate at which an aircraft is fully productive. The minimum daily utilization rate of 10 hours per day required for acceptance into CRAF, when multiplied by the airlift productivity factor of 0.47, results in a productive utilization rate of 4.7 hours. See AF Pamphlet 10-1403

MTM/D = PL x ATA x PUR / 1,000,000. Base Cargo Aircraft MTM = 0.1705.

Base Aircraft is the B747-100, a widebody (WB) aircraft, used for calculating all CRAF aircraft capability.

WB equivalent (WBE) is the capability of an aircraft in relationship to the Base Aircraft. It is computed by dividing the MTM of the aircraft in question by the MTM of the Base Aircraft.

MAKING MV CALCULATIONS

To determine MV, first calculate MTM/D and then calculate WBE.

$$\frac{\text{PL x ATA x PUR}}{1{,}000{,}000} = \textbf{MTM/D} \qquad \frac{\text{MTM/D Aircraft in Question}}{\text{Base Aircraft MTM/D}} = \textbf{WBE}$$

CONVERT WBE (as MV) TO POINTS

- Aircraft WBE x 10* = MV points (MVP)

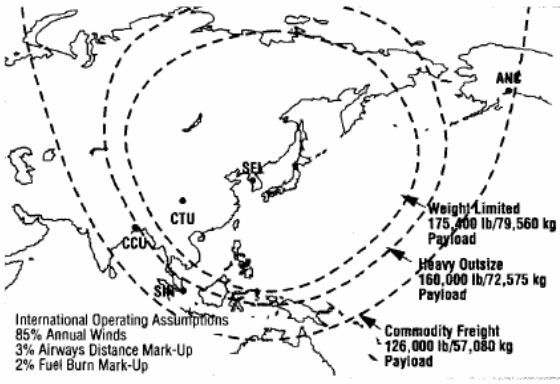
- Air Mobility Command applies a multiplier of 10 to achieve whole numbers.

ADJUSTMENTS TO MV POINTS

Before aircraft are placed in CRAF Stages, MVP can be affected by extended long-range capability, short-field takeoff/landing capability, aircraft operations into austere locations, or other factors that enhance aircraft capability, total capability the carrier offers to CRAF, and overall airlift augmentation capability CRAF provides to DOD.

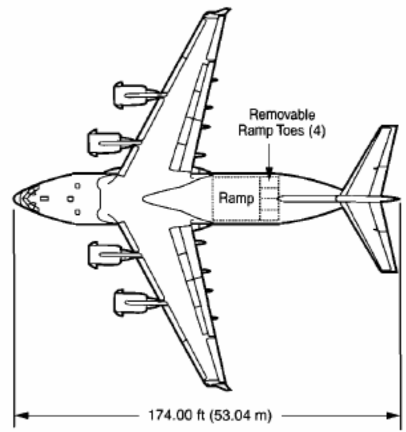
Appendix XI – Boeing BC-17X Specifications

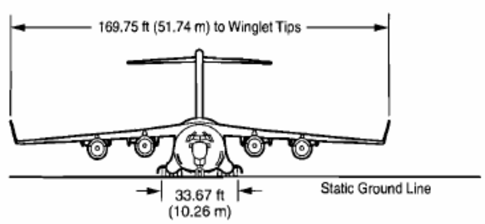
BC-17X Is the 21st Century Logistics Solution

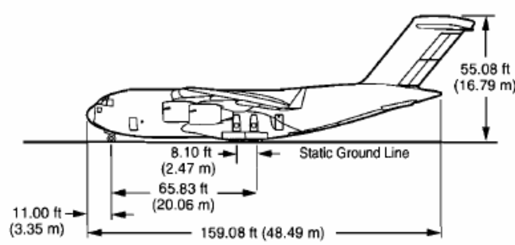


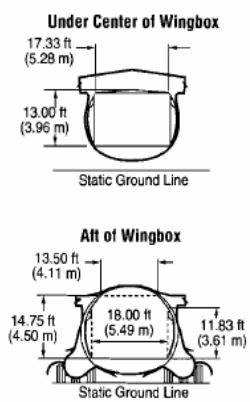
BC-17X has more than enough range to deliver typical payloads rapidly.

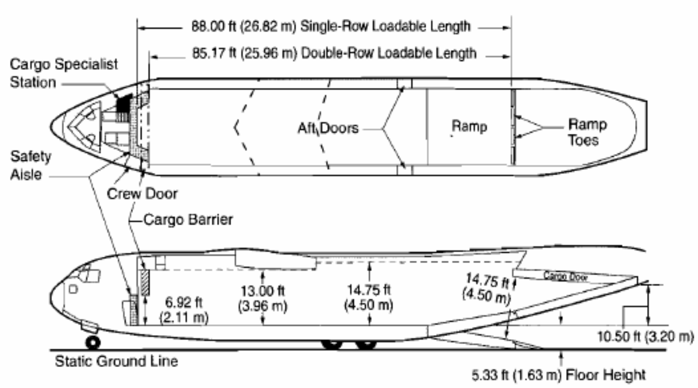
Satellites and aerospace subassemblies are just two of the many kinds of heavy and outsize cargo that benefit from reliable BC-17X direct air delivery.











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Appendix XII – Publications List

OFFICE OF STRATEGIC INDUSTRIES AND ECONOMIC SECURITY

Strategic Analysis Division

PUBLICATIONS LIST

November 1, 2005

The U.S. Department of Commerce's Strategic Analysis Division is the focal point within the Department for conducting assessments of defense-related industries and technologies. The studies are based on detailed industry-specific surveys used to collect information from U.S. companies and are conducted on behalf of the U.S. Congress, the military services, industry associations, or other interested parties.

PUBLICATION TITLE **Bold italics* indicate forthcoming
Defense Industrial Base Assessment: U.S. Imaging and Sensors Industry – February 2006
National Security Assessment of the Cartridge- and Propellant-Actuated Device Industry: Third Review – January 2006
10th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – December 2005
Economic Impact Assessment- Air Force C-17 Program – November 2005
9th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – March 2005
National Security Assessment of the Munitions Power Sources Industry – December 2004
Offsets in Defense Trade and the U.S. Subcontractor Base – August 2004
8th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – July 2004
National Security Assessment of the Air Delivery (Parachute) Industry – May 2004
Industry Attitudes on Collaborating with DoD in R&D – Air Force – January 2004
Army Theater Support Vessel Procurement: Industrial Base/Economic Impact Assessment – December 2003
A Survey of the Use of Biotechnology in U.S. Industry – October 2003
U.S. Textile and Apparel Industries: An Industrial Base Assessment – October 2003
7th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - July 2003
Technology Assessment: U.S. Assistive Technology Industry – February 2003
6th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - February 2003
Heavy Manufacturing Industries: Economic Impact and Productivity of Welding – Navy – June 2002
– Continued on Next Page –

PUBLICATION TITLE
The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security – October 2001
National Security Assessment of the U.S. High-Performance Explosives & Components Sector –June 2001
National Security Assessment of the U.S. Shipbuilding and Repair Industry - May 2001
Statistical Handbook of the Ball and Roller Bearing Industry (Update) - June 2001
5th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - May 2001
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Update - December 2000
The Effect on the National Security of Imports of Crude Oil and Refined Petroleum Products - November 1999
4th Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - October 1999
U.S. Commercial Technology Transfers to The People's Republic of China – January 1999
Critical Technology Assessment: Optoelectronics - October 1998
3rd Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - August 1998
National Security Assessment of the Emergency Aircraft Ejection Seat Sector - November 1997
2nd Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 – August1997
Critical Technology Assessment of the U.S. Semiconductor Materials Industry - April 1997
1st Offsets in Defense Trade - Conducted under §309 of the Defense Production Act of 1950 - May 1996
National Security Assessment of the Cartridge and Propellant Actuated Device Industry - October 1995
A Study of the International Market for Computer Software with Encryption – NSA -1995
The Effect of Imports of Crude Oil and Petroleum Products on the National Security - December 1994
Critical Technology Assessment of U.S. Artificial Intelligence - August 1994
Critical Technology Assessment of U.S. Superconductivity - April 1994
Critical Technology Assessment of U.S. Optoelectronics - February 1994
Critical Technology Assessment of U.S. Advanced Ceramics - December 1993
Critical Technology Assessment of U.S. Advanced Composites - December 1993
The Effect of Imports of Ceramic Semiconductor Packages on the National Security - August 1993
National Security Assessment of the U.S. Beryllium Industry - July 1993
National Security Assessment of the Antifriction Bearings Industry - February 1993
National Security Assessment of the U.S. Forging Industry - December 1992
– Continued on Next Page –

PUBLICATION TITLE
The Effect of Imports of Gears and Gearing Products on the National Security - July 1992
National Security Assessment of the Dom. and For. Subcontractor Base~3 US Navy Systems - March 1992
National Security Assessment of the U.S. Semiconductor Wafer Processing Equipment Industry - April 1991
National Security Assessment of the U.S. Robotics Industry - March 1991
– End –

Archived Studies	
The Effect of Imports of Uranium on the National Security – Sept. 1989	Investment Castings: A Natl. Security Assessment – Dec. 1987
The Effect of Imports of Crude Oil and Refined Petroleum on Natl. Security – Jan. 1989	Joint Logistics Commanders/DOC Precision Optics Study - June 1987
The Effect of Imports of Plastic Injection Molding Machines on Natl. Security – Jan. 1989	An Economic Assessment of the U.S. Industrial Fastener Industry – Mar. 1987
The Effect of Imports of Anti-Friction Bearings on the Natl. Security - July 1988	Joint Logistics Commanders/DOC Bearing Study - June 1986

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