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National Security and
International Affairs Division

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September 7, 1993

The Honorable John Conyers
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

In response to your request, we are providing information on takeoff and landing distances for the C-17 aircraft. Takeoff and landing distance information and performance information, such as cargo weight and delivery distance, was obtained from the Safety Supplement to the C-17 Flight Manual and the Systems Operational Requirements Document (SORD).

BACKGROUND

The C-17 military transport is designed to airlift substantial payloads over long ranges without refueling. It is also being designed to carry a full range of military cargo directly into small, austere airfields--runways as short as 3,000 feet. The C-17 entered operational service on June 14, 1993, when the first production aircraft was delivered to Charleston Air Force Base, South Carolina.

Pending completion of flight testing, the C-17 must operate under flight restrictions that affect takeoff and landing distances. The Air Force's revised C-17 Flight Manual Performance Data Safety Supplement, dated June 10, 1993, therefore requires flight crews to use the tabular data in the Supplement to determine takeoff and landing distances. The Safety Supplement displays takeoff and landing distances based on various combinations of aircraft gross weight, temperature, and altitude. It is Department of Defense (DOD) practice to restrict the use of a new aircraft until the test program is complete. This is implemented through the temporary issuance of a Safety Supplement.

RESULTS IN BRIEF

Takeoff and landing distances for the C-17 under normal operating conditions have yet to be finally determined by the Air Force. Takeoff and landing distances in the Safety Supplement are greater than those contained in the SORD, which establishes operational requirements for the C-17, or those based on the predicted capability of the aircraft established by the contractor. The longer distances reflect safety of flight restrictions placed on the C-17 while flight testing is in progress. The Safety Supplement does not include landing or takeoff distances as short as 3,000 feet for any combination of weight, altitude, and temperature. According to DOD officials, the C-17 is projected to meet all takeoff and landing distance requirements.

SAFETY SUPPLEMENT RESTRICTIONS AFFECT C-17 TAKEOFF AND LANDING DISTANCES

The C-17 Flight Manual Safety Supplement contains a number of assumptions about performance data, for example, landing approach angle and speed, flap settings, braking capability, and rotation speed, which increase takeoff and landing distances. Additionally, a 1,000-foot safety margin has been added to takeoff and landing distances in the Supplement. To demonstrate the differences in landing distance based on the contractor's predicted capability data and Safety Supplement data, the contractor provided landing distances for a C-17 weighing 468,900 pounds and landing at sea level on a 90-degrees fahrenheit day. According to the capability data, the estimated landing distance would be 2,570 feet. According to the Supplement, the landing distance is 5,860 feet, a difference of 3,290 feet. The difference between the Safety Supplement performance data and the contractor's predicted capability data is discussed below.

C-17 landing performance is based on the use of 3/4 flaps for conventional approaches and full flaps for steep approaches. Under normal operating conditions, the flight crew must select the type of landing approach, either conventional or steep, to compute landing distance. For a conventional approach, the approach path angle is 3 degrees; for a steep approach, it is 5 degrees. A steep approach, using full flaps, is used to minimize landing

distances for short, austere airfield operations. The conventional approach, using a 3-degree angle and 3/4 flaps setting, adds approximately 1,000 feet to the landing distance. Currently, the Safety Supplement restricts a C-17 pilot to using the conventional landing approach.

Approach speed also affects landing distance. Approach speed is the speed used on the final approach with flaps and slats in the landing configuration. Increased approach speed results in increased landing distance but provides (1) additional safety margin against stalls caused by wind gusts and engine failure, (2) additional thrust margin for headwind, and (3) improved directional control for crosswind. The Safety Supplement has allowed for a 10-knot increased approach speed. According to a contractor official, this adjustment to approach speed increases landing distance by approximately 350 feet.

In addition, contractor officials have indicated that conservative assumptions regarding the predicted C-17 braking and stopping capability contained in the Supplement adds approximately another 900 feet to the landing distance. In total, these safety adjustments, when added to the 1,000-foot safety margin, account for 3,250 feet of the 3,290-foot difference between the C-17's predicted landing capability and the Safety Supplement distance in the contractor's example.

The Safety Supplement also contains adjustments for computing C-17 takeoff distances. For example, rotation speed is one of the factors that affects takeoff distance. Rotation speed is the speed at which the aircraft's nose begins to lift upward into a takeoff position. Increasing the rotation speed provides for increased stall margin and directional control; however, it also increases the takeoff distance. According to the contractor, a 10-knot increase in rotation speed would add about 600 feet to the takeoff distance of a C-17 weighing 395,000 pounds and taking off at sea level on a 90-degrees fahrenheit day. Takeoff distance is a function of gross weight, temperature, and altitude. As these increase, rotation speed increases, thereby increasing takeoff distance. Combined with the 1,000-foot safety margin, total takeoff distance would be increased by at least 1,600 feet.

COMPARISON OF C-17 LANDING AND TAKEOFF DISTANCES BASED ON SAFETY SUPPLEMENT AND THE SORD

The C-17 SORD establishes general operating requirements for the C-17. Among other things, the May 23, 1991, SORD identifies takeoff and landing performance characteristics for given cargo payloads, delivery ranges, and outside air temperatures. Using the Safety Supplement, we identified takeoff and landing distances corresponding to selected C-17 performance requirements called for in the SORD and the system specification document.

C-17 Takeoff Distances

The SORD requires that the C-17 must be able to takeoff from a 8,500-foot runway with 160,000 pounds of cargo and fly 2,400 nautical miles unrefueled. Based on this requirement, the gross weight of the C-17 would be about 592,000 pounds. The SORD also requires that the C-17 takeoff from a 3,000-foot small, austere airfield with 75,000 pounds of cargo and enough fuel to fly 500 nautical miles. Based on this requirement, the gross weight of the aircraft is about 395,000 pounds. Both requirements allow for an aircraft weight of approximately 277,000 pounds and assume the airfield is at sea level and the outside temperature is 90 degrees fahrenheit. For these operational requirements, table 1 shows takeoff distances contained in the SORD and in the Safety Supplement.

Table 1: C-17 Takeoff Distances for Selected Performance Requirements

Performance requirement	Takeoff distance in the SORD	Supplement takeoff distance [1]
Maximum takeoff: C-17 weight, 160,000 lb. cargo, and fuel for 2,400 nautical miles (about 592,000 lbs.)	8,500 feet	Not listed
Small, Austere Air Field: C-17 weight, 75,000 lb. cargo, and fuel for 500 nautical miles (about 395,000 lbs.)	3,000 feet	5,170 feet

[1]Safety Supplement temperatures are in celsius readings. Thirty-one degrees celsius converts to about 88 degrees fahrenheit which is the temperature closest to 90 degrees.

The maximum gross takeoff weight for the C-17 is currently 585,000 pounds instead of 592,000 pounds. The Safety Supplement does not list a takeoff distance for the C-17 at a gross weight greater than 560,000 pounds. However, at a gross weight of 560,000 pounds, the Supplement shows a takeoff distance of 9,460 feet, assuming the airfield is at sea level and the outside temperature is about 90 degrees.

The Safety Supplement lists a takeoff distance of 5,170 feet for the C-17 with a gross takeoff weight of about 395,000 pounds, including a 75,000 pound payload and fuel to fly 500 nautical miles. The supplement does not include a takeoff distance as short as 3,000 feet for any combination of weight, altitude, and temperature.

In addition, using the Safety Supplement, we selected takeoff distances for the C-17, using different aircraft gross weights, air temperatures, and elevations for other

selected mission requirements. This information is shown in table 2.

Table 2: C-17 Safety Supplement Takeoff Distances

	Takeoff distance		
Mission requirement	88-deg. F/ sea level	84-deg. F/ 1,000 feet	81-deg. F/ 2,000 feet
Medium logistic mission: C-17 weight, 120,000 lb. cargo, and fuel for 2,800 nautical miles (about 560,000 lbs.)	9,460 feet	Not listed	Not Listed
Ferry mission: C-17 weight, no cargo, and fuel for 4,600 nautical miles (about 467,000 lbs.)	6,650 feet	7,110 feet	7,440 feet

C-17 Landing Distances

The SORD also establishes landing performance requirements for normal and maximum payload landings. Specifically, the C-17 is required to make routine landings on a 4,000-foot runway, with a payload of 160,000 pounds and enough fuel remaining to fly 500 nautical miles with zero payload. It is also required to make a maximum 160,000 pound payload landing on a 3,000-foot runway and enough fuel remaining to fly 300 nautical miles with zero payload. Both requirements are based on a field elevation of sea level and a temperature of 90 degrees fahrenheit. For these performance requirements, table 3 shows landing distances contained in the SORD and the Safety Supplement.

Table 3: C-17 Landing Distances for Selected Performance Requirements

Performance requirement	Landing distance in the SORD	Supplement landing distance
Normal landing: C-17 weight, 160,000 lb. cargo, and fuel remaining for 500 nautical miles (about 475,000 lbs.)	4,000 feet	5,860 feet
Maximum landing: C-17 weight, 160,000 lb. cargo, and fuel remaining for 300 nautical miles (about 469,000 lbs.)	3,000 feet	5,860 feet

As shown in table 3, the Safety Supplement, which only allows for a conventional landing approach, lists a landing distance of 5,860 feet for both mission requirements. This is because the Supplement only identifies takeoff and landing distances for gross weights at 20,000-pound increments and requires rounding to the next highest gross weight. The landing distances required by the SORD are based on a steep approach--full flaps and a 5-degree approach path angle. The Supplement does not include a landing distance as short as 3,000 feet for any combination of weight, altitude, and temperature. The shortest landing distance in the Supplement is 4,490 feet and assumes a conventional approach with a 3-degree approach path angle and 3/4 flaps setting, a gross weight of 280,000 pounds, a 59-degrees fahrenheit day, and sea level elevation.

In addition, using the Safety Supplement, we also identified landing distances for the C-17, using a conventional approach, different aircraft weights, air temperatures, and field elevations for other mission requirements. This information is shown in table 4.

Table 4: C-17 Safety Supplement Landing Distances

Performance requirement	Landing distance 88-deg. F/ sea level	84-deg. F/ 1,000 feet	81-deg. F/ 2,000 feet
Maximum effort landing: C-17 weight, 120,000 lb. cargo, and fuel remaining for 500 nautical miles (about 435,000 lbs.)	5,570 feet	5,680 feet	5,780 feet
Maximum effort landing: C-17 weight, 130,000 lb. cargo, and fuel remaining for 1,900 nautical miles (about 493,000 lbs.)	6,090 feet	6,220 feet	6,360 feet

OBSERVATIONS OF DOD OFFICIALS

We discussed our analysis with DOD and Air Force officials. They said that they update the C-17 Safety Supplement as flight test data is collected. Also, DOD officials said that based on current engineering and test data, the C-17 is projected to meet all projected landing and takeoff distance requirements.

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As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this letter until 30 days from its date. At that time, we will send copies to the Secretaries of Defense and the Air Force; Director, Office of Management and Budget; and other interested congressional committees. Copies of this letter will also be made available to others on request.

If you or your staff have any questions regarding this information, please contact me at (202) 512-4841. Major contributors to this product are Robert Stolba, James Elgas, Noel Lance, and David Hubbell.

Sincerely yours,

Louis J. Rodrigues
Director, Systems Development
and Production Issues

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