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C-12A LANDING GEAR CAPABILITY TESTS.(U)
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C-12A LANDING GEAR CAPABILITY TESTS

FINAL REPORT

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MARCH 1977

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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The United States Army Aviation Engineering Flight Activity conducted an evaluation of the C-12A aircraft, manufactured by Beech Aircraft Corporation, Wichita, Kansas, between 23 March and 1 April 1976 at Edwards Air Force Base and Harper Dry Lake, California. During the test program four flights totaling 3.8 hours were flown. Soft soil and simulated rough terrain operations were conducted. The C-12A met the requirements of the prime item development → next page

(continued)

20. Abstract

cont.

specification for operating on soft soil. If the aircraft is to be operated on rough/unprepared terrain, one deficiency was found during this test program: failure of the right main landing gear while braking over simulated rough terrain.

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INTRODUCTION

BACKGROUND

1. The United States Army Aviation Engineering Flight Activity (USAAEFA) conducted an airworthiness and flight characteristics (A&FC) evaluation on the C-12A aircraft at Edwards Air Force Base, California (ref 1, app A). The objectives of those tests were to quantitatively and qualitatively evaluate the C-12A aircraft for contract compliance with performance guarantees and the stability and control requirements of the prime item development specification (PIDS) (ref 2). The aircraft was also evaluated against the requirements of Federal Aviation Administration Regulation FAR Part 23 (ref 3) and selected portions of military specification MIL-F-8785B(ASG) (ref 4). During that test program, sufficient inquiries were received from operators in the field that further investigation was warranted to determine the operational capabilities of the aircraft while operating on soft and rough terrain with the standard landing gear installed. USAAEFA was directed by the United States Army Aviation Systems Command (AVSCOM) to conduct those tests on the C-12A aircraft to make such a determination (ref 5).

TEST OBJECTIVE

2. The objective of this test program was to determine the capability of the C-12A to operate into and out of rough fields and soft soil with a California Bearing Ratio of 4 (CBR 4).

DESCRIPTION

3. The C-12A is a normal category fixed wing twin-engine turboprop aircraft capable of transporting passengers and cargo in all weather conditions. The aircraft is equipped with retractable tricycle landing gear with two 18-by-5.5 8-ply tires on each of the main gear and a 6.50-by-10 6-ply tire on the nose wheel. The aircraft has a T-tail and cockpit/cabin pressurization. A description and photographs of the C-12A are presented in appendix B and a more detailed description is contained in the PIDS.

TEST SCOPE

4. The evaluation was conducted on a production C-12A aircraft at Edwards Air Force Base, California (2302 feet) and an auxiliary test site at Harper Dry Lake (2000 feet) near Edwards Air Force Base. Four flights totaling 2 productive flight hours were conducted between 23 March and 1 April 1976. Landing gear structural load limitations were obtained from the contractor and were set forth in a safety-of-flight release issued by AVSCOM (ref 6, app A). Soft field tests

were initially conducted on soil with a CBR of 4. Following the soft field tests, a build-up program was planned whereby the rough terrain capability was first to be evaluated under controlled taxiing conditions over simulated rough terrain. Both artificial protuberances and depressions of the same magnitude were to be tested. The next phase of testing would have involved operating the aircraft on several airfields with varying degrees of roughness. Testing was terminated prior to completion of all planned phases of testing due to failure of the right main landing gear while conducting simulated rough terrain taxi tests. The aircraft configuration tested was 12,000 pounds gross weight and a mid center-of-gravity (cg) location for the rough terrain tests and a forward cg location for soft soil tests.

TEST METHODOLOGY

5. The test techniques and methods used are discussed in the applicable sections of this report. Data were recorded with an on-board magnetic tape system. Hand-recorded cockpit data from sensitive cockpit indicators were used to facilitate correlation of the magnetic tape-recorded data. In addition to the detailed list of test instrumentation contained in appendix C, the landing gear was strain-gaged and calibrated by Beech Aircraft Corporation (BAC) (ref 7, app A). Landing gear loads were telemetered to a ground station for real time monitoring and recorded on the on-board tape system. Soft field takeoff distances were measured from the ground with a recording optical instrument (ROI). Prior to initiation of the rough terrain tests the critical airframe and landing gear dynamic characteristics were determined by the US Army Engineer Waterways Experiment Station (WES) located at Vicksburg, Mississippi (ref 8). Ground speeds for the rough terrain tests were measured with a calibrated pace vehicle.

RESULTS AND DISCUSSION

GENERAL

6. Takeoff and landing tests were conducted to determine the capability of the C-12A to operate on soft dry soil with a CBR of 4. Taxi tests were conducted to determine the aircraft's capability to operate on rough terrain when configured with the standard landing gear. One deficiency was found: failure of the right main landing gear drag brace support assembly while operating over simulated rough terrain.

SOFT SOIL OPERATION

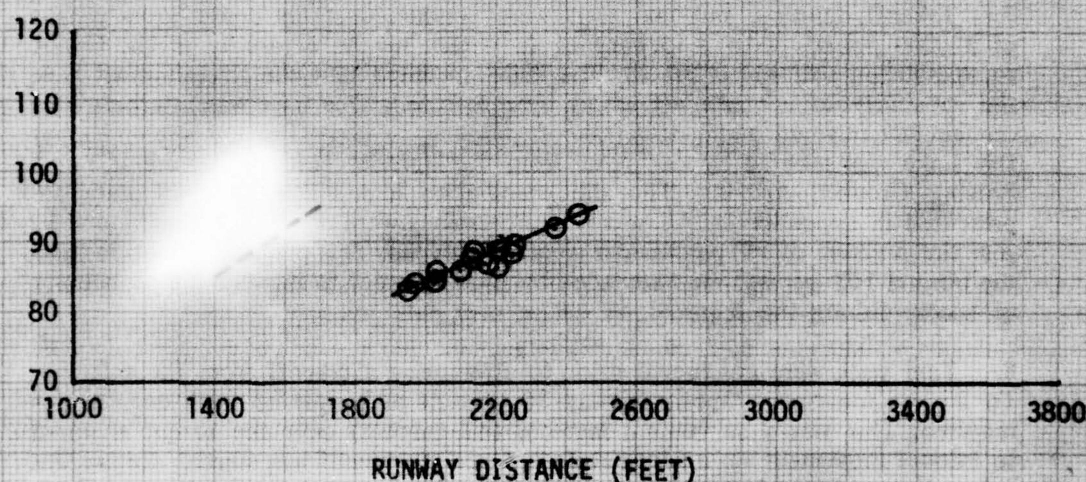
7. Takeoff, landing, and taxi tests were conducted at the design gross weight of 12,000 pounds with a forward cg to determine the capability of the C-12A to operate on soft soil (CBR 4). The PIDS specified that the aircraft must have the capability to conduct 40 passes over soft soil. One pass was interpreted as one aircraft traversal of the area (takeoff, landing, or taxi). The test site on Harper Dry Lake was selected by personnel from the Materiel Test Directorate at Yuma Proving Ground, Arizona. The site preparation and soil consistency data are presented in appendix D. All soft field operations were done with a main landing gear tire pressure of 95 pounds per square inch (psi). This pressure reduction from the normal 102 psi was recommended by BAC in order to increase the probability of accomplishing the required 40 passes over soft soil.

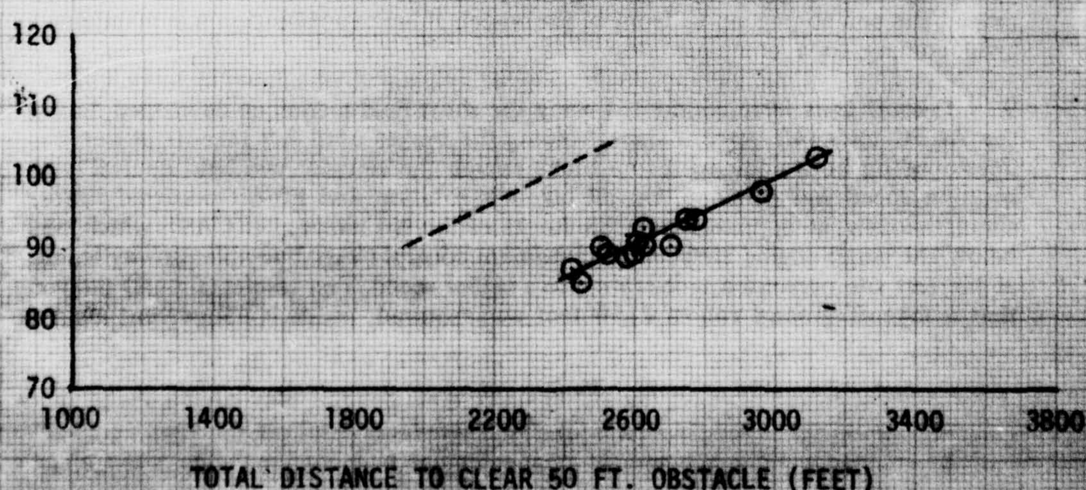
8. Taxi tests were conducted prior to attempting a takeoff from the soft soil. To initiate movement, approximately 30 percent of torque on both engines was required. This was a substantial increase (47 percent) over the torque required to initiate movement on a paved surface. Once movement was started, torque was reduced to approximately 20 percent to maintain nominal taxi speed. Turns (360 degrees) were easily accomplished without the use of brakes. The aircraft could be easily stopped by retarding the power levers to idle. The use of brakes caused the soil to pile up in front of the wheels if brake application was maintained until coming to a complete stop.

9. Takeoff tests were conducted using the short field technique developed during the A&FC tests (40 percent flaps, holding the brakes until full takeoff power was developed on both engines). From brake release the elevator was held neutral until rotation speed was attained. On all takeoffs rotation and lift-off occurred almost simultaneously at approximately 88 knots calibrated airspeed (KCAS), which was below the single-engine airspeed for minimum control (V_{MC}). Usable runway length at the test site prevented accelerating to a higher speed. Test results (fig. A) showed that a takeoff ground roll of 2150 feet was required, which is 45 percent greater

FIGURE A
TAKE OFF PERFORMANCE
C-12A USA S/N 73-22250
SOFT FIELD CBR 4 TO 7
ENGINE MODEL PT6A-38
40 PERCENT FLAPS
GROSS WEIGHT = 12000 POUNDS
CENTER OF GRAVITY = 185(FWD) INCHES
ALTITUDE = 2000 FEET

NOTES:
1. WIND LESS THAN 5 KNOTS.
2. DATA CORRECTED TO ZERO WIND CONDITIONS.
3. SHORT FIELD TECHNIQUE.
4. DATA CORRECTED TO STANDARD DAY CONDITIONS.
5. DASHED LINE INDICATES TAKEOFF PERFORMANCE FROM A DRY PAVED RUNWAY (REF 1).





than that required on a paved surface (1500 feet) using the same technique. Aircraft acceleration during the takeoff roll was somewhat erratic due to the nonuniformity of the soil along the runway.

10. Landing tests were conducted to qualitatively assess the landing characteristics of the C-12A on soft soil. Since there was no requirement to quantitatively measure the landing distance, normal landing techniques were used, with a constant airspeed being maintained throughout the approach. To minimize propeller erosion, reverse thrust was not used. Because of the main wheel lock-up tendency discovered during the A&FC evaluation, brakes were not used after touchdown.

11. A total of 40 passes were successfully completed with the maximum rut depth being approximately 2-1/4 inches (photo A). Additional rut depth data are tabulated in appendix D. After several passes were made, the topsoil had a tendency to compact and subsequent passes produced rut depths somewhat more shallow. Within the scope of these tests, the C-12A met the requirements of the PIDS and displayed satisfactory handling characteristics while operating on soft dry soil when the inflation pressure in the main wheel tires was 95 psi (7 psi below normal).

ROUGH TERRAIN OPERATION

12. Tests were conducted over simulated rough terrain as the initial phase of the program to determine the capability of the C-12A to operate from unimproved airfields. To simulate the rough terrain, multiple raised objects (1 x 4 and 2 x 4 boards) were secured to a smooth, hard dry lakebed and were arranged in the patterns shown in figure B. These obstacle layouts were recommended by WES and were arranged so that all three wheels contacted the obstacles simultaneously. The natural frequencies of the C-12A landing gear determined by WES established the pattern for the board layout. The natural frequencies of the landing gear were as follows:

Axis	Main Gear	Nose Gear
Longitudinal	25 Hz	25 Hz
Vertical	1.41 Hz	1.19 Hz

13. The rough terrain tests were initially conducted with a tire pressure of 95 psi. The aircraft was first operated over single raised obstacles (1 x 4 boards and then 2 x 4 boards, layout A, fig. B) at speeds from 5 knots ground speed to 40 knots in 5-knot increments, and from 40 to 80 knots in 10-knot increments. Operations were then conducted in the same sequence and at the same speeds over the multiple obstacles (layout B, fig. B). A total of 37 passes were accomplished with light braking on three of the passes over the multiple 2 x 4 obstacles. The limit loads established by BAC were not reached on any of the passes.

Photo A. Maximum Rut Depth.

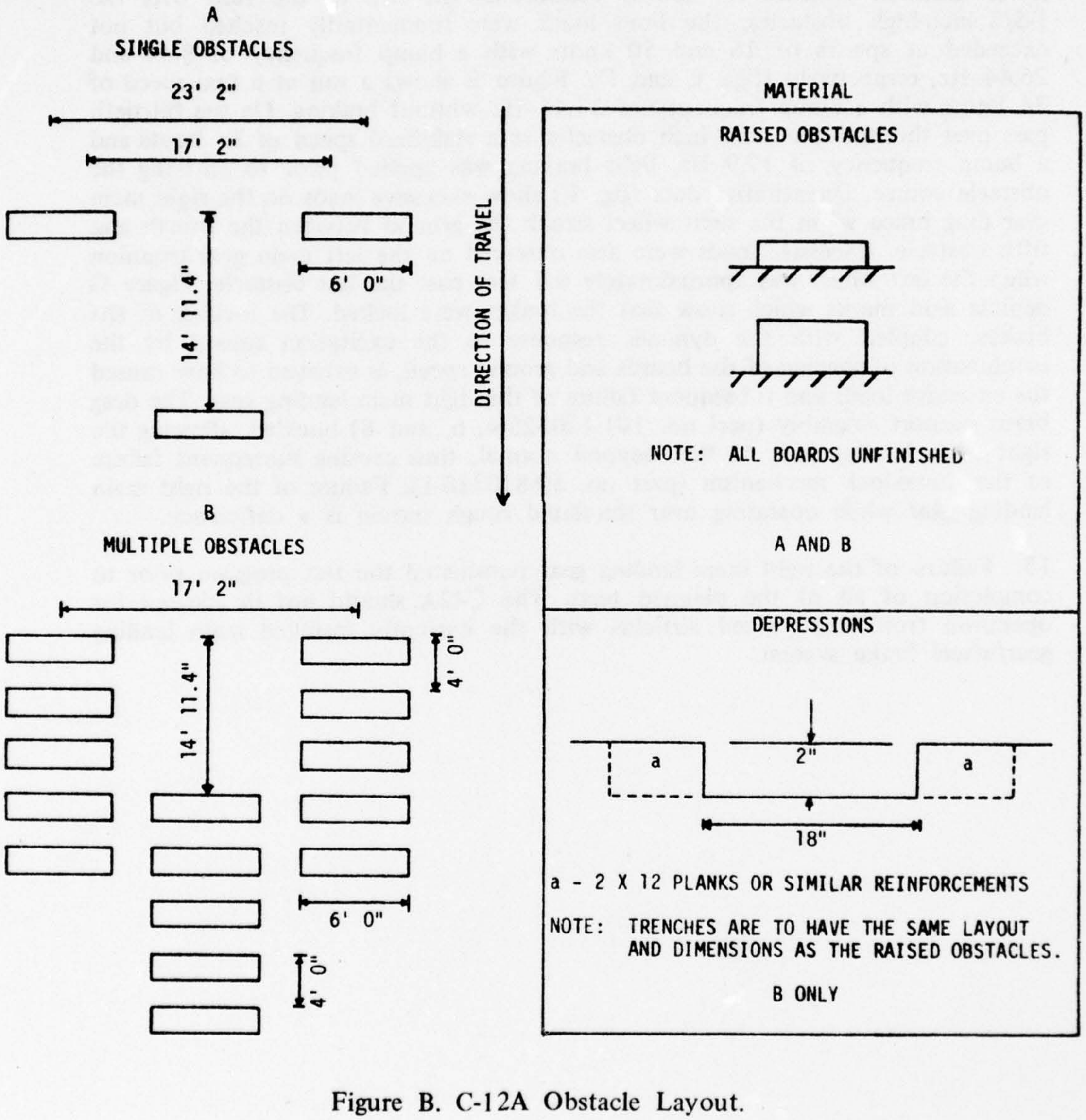


Figure B. C-12A Obstacle Layout.

14. The main landing gear inflation pressure was increased to normal (102 psi) and the tests repeated. Twenty-nine passes were successfully completed, with 17 being over the 1-5/8 inch-high multiple obstacles (2 x 4 boards). The landing gear loads with the higher inflation pressure were observed to be higher than at the lower inflation pressure for similar conditions. On two of the runs over the 1-5/8 inch-high obstacles, the limit loads were momentarily reached but not exceeded at speeds of 16 and 50 knots with a bump frequency of 8.44 and 26.44 Hz, respectively (figs. C and D). Figure E shows a run at a taxi speed of 34 knots with a bump frequency of 17.41 Hz without braking. On the thirtieth pass over the multiple 1-5/8-inch obstacles at a stabilized speed of 33 knots and a bump frequency of 17.9 Hz, light braking was applied prior to entering the obstacle course. Quantitative data (fig. F) show excessive loads on the right main gear drag brace when the right wheel struck the ground between the fourth and fifth obstacle. Excessive loads were also observed on the left main gear trunnion when the left wheel was approximately 4.5 feet past the last obstacle. Figure G depicts skid marks which show that the brakes were locked. The locking of the brakes, coupled with the dynamic response to the excitation caused by the combination of spacing of the boards and ground speed, is believed to have caused the excessive loads and subsequent failure of the right main landing gear. The drag brace support assembly (part no. 101-120025-4, 6, and 8) buckled, allowing the right main landing gear to flex beyond normal, thus causing subsequent failure of the down-lock mechanism (part no. 50-810338-1). Failure of the right main landing gear while operating over simulated rough terrain is a deficiency.

15. Failure of the right main landing gear terminated the test program prior to completion of all of the planned tests. The C-12A should not be cleared for operation from unimproved airfields with the currently installed main landing gear/wheel brake system.

FIGURE C
LANDING GEAR LOADS
C-12A USA S/N 73-22250

GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	DENSITY ALTITUDE (FT)	OAT (C)	GROUND SPEED (KNOTS)	CONFIGURATION
12500	185.0 (FWD)	2220	10.2	16	NO BRAKING

SOLID LINE   SHORT DASH   LONG DASH

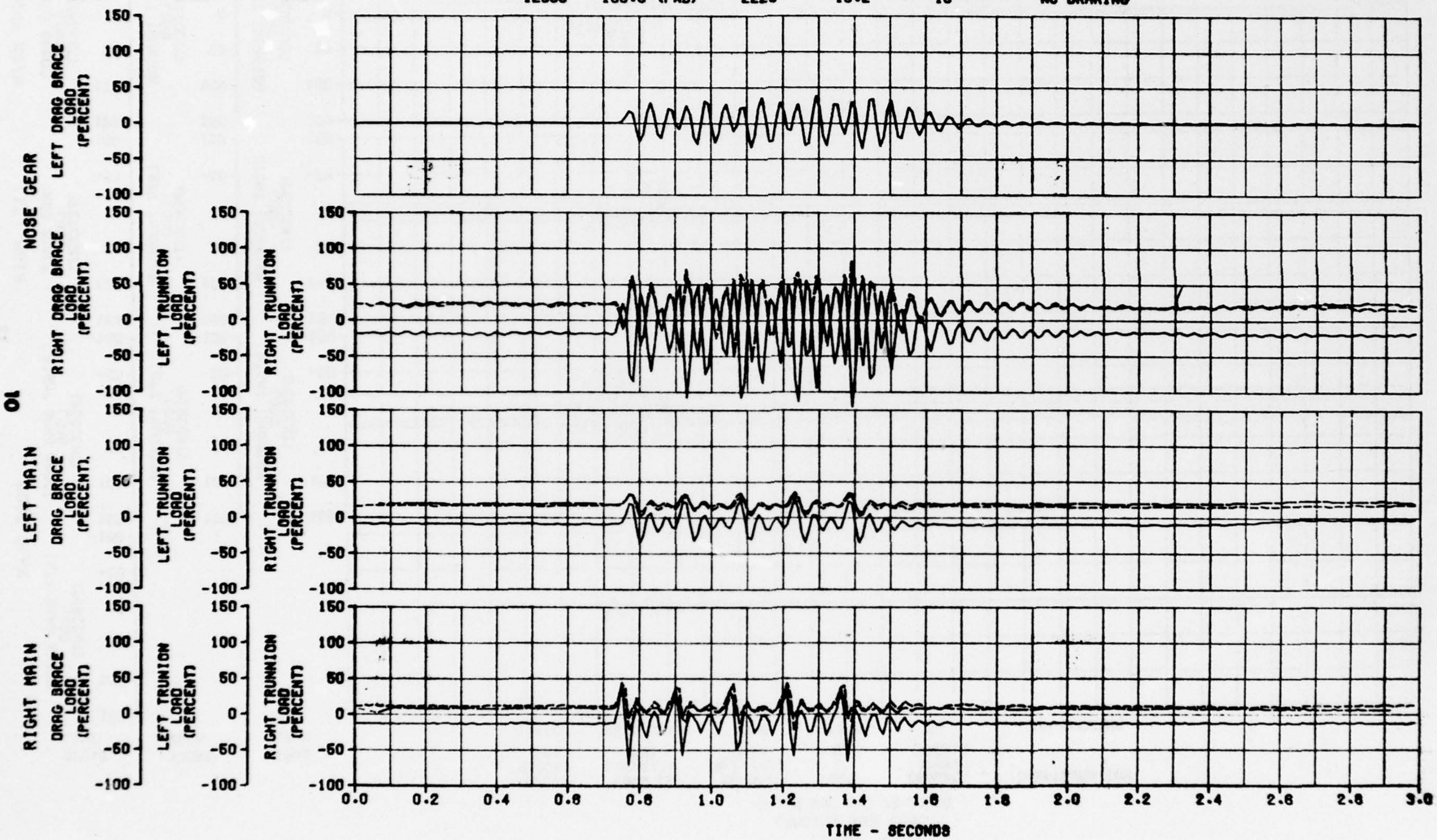


FIGURE D
LANDING GEAR LOADS
C-12A USA S/N 73-22250

GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	DENSITY ALTITUDE (FT)	OAT (C)	GROUND SPEED (KNOTS)	CONFIGURATION
12500	185.0 (FWD)	2220	10.2	50	NO BRAKING

SOLID LINE — SHORT DASH — LONG DASH

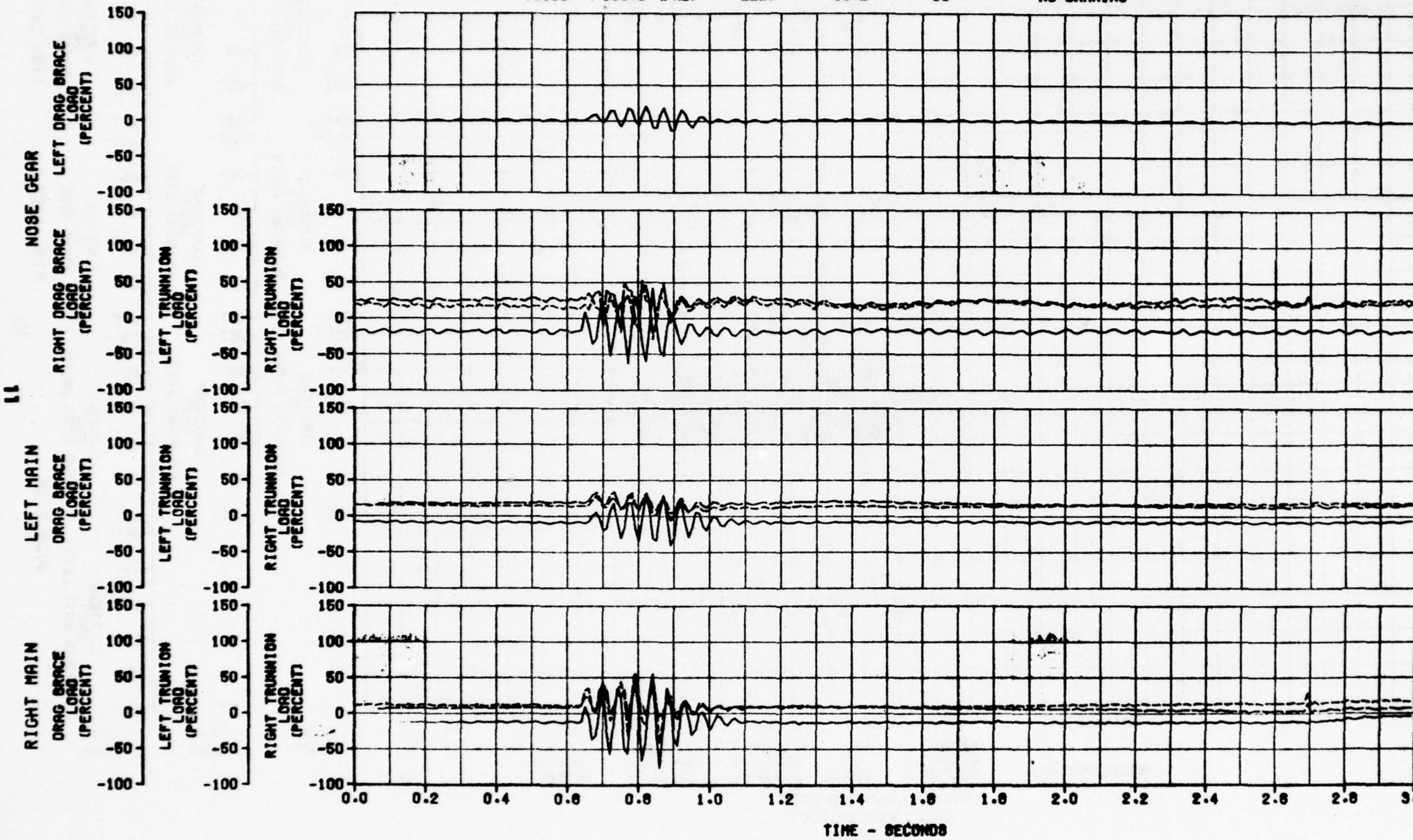


FIGURE E
LANDING GEAR LOADS
C-12A USA S/N 73-22250

GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	DENSITY ALTITUDE (FT)	OAT (C)	GROUND SPEED (KNOTS)	CONFIGURATION
12500	185.0 (FWD)	2220	10.2	34	NO BRAKING

SOLID LINE　SHORT DASH　LONG DASH

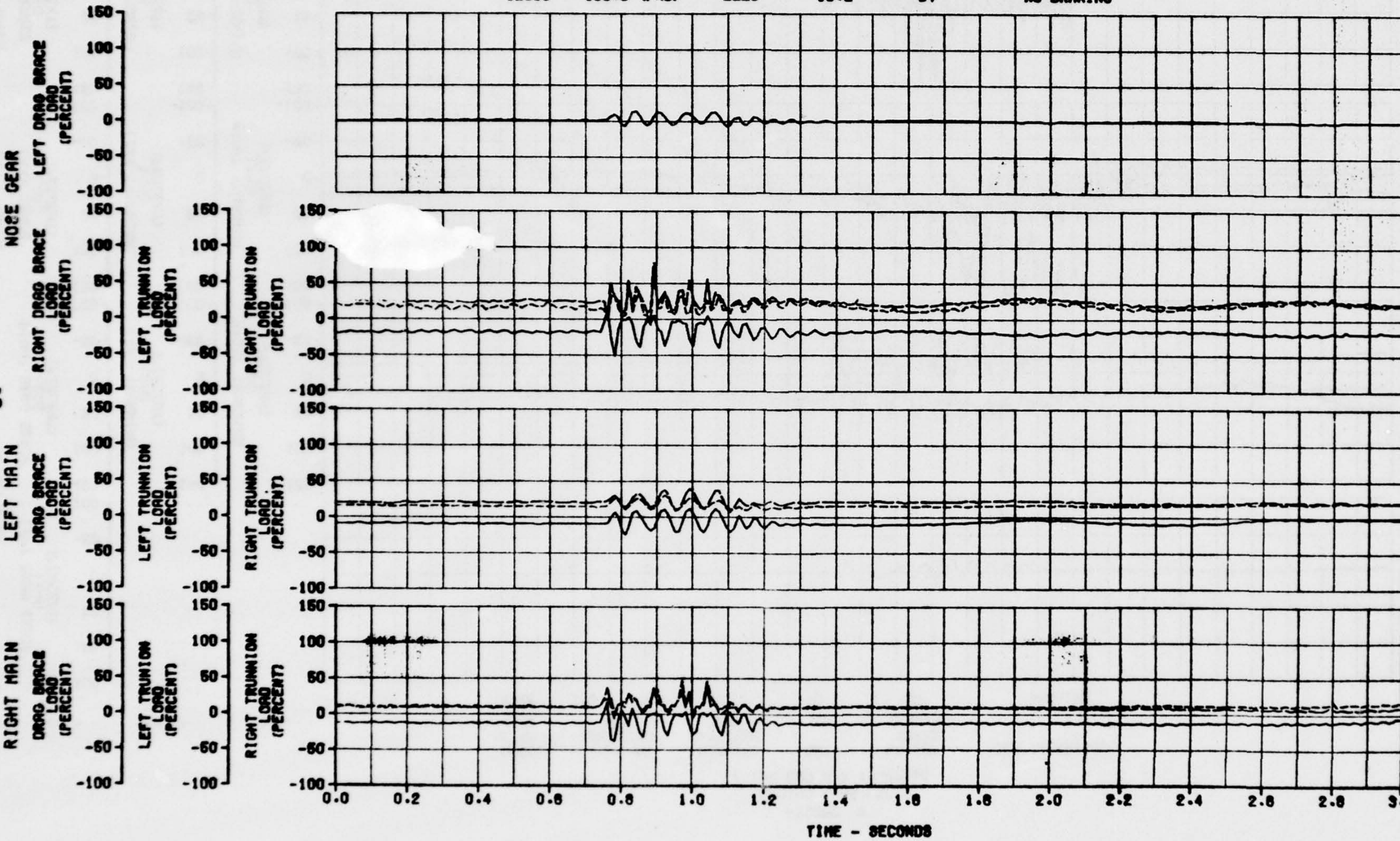
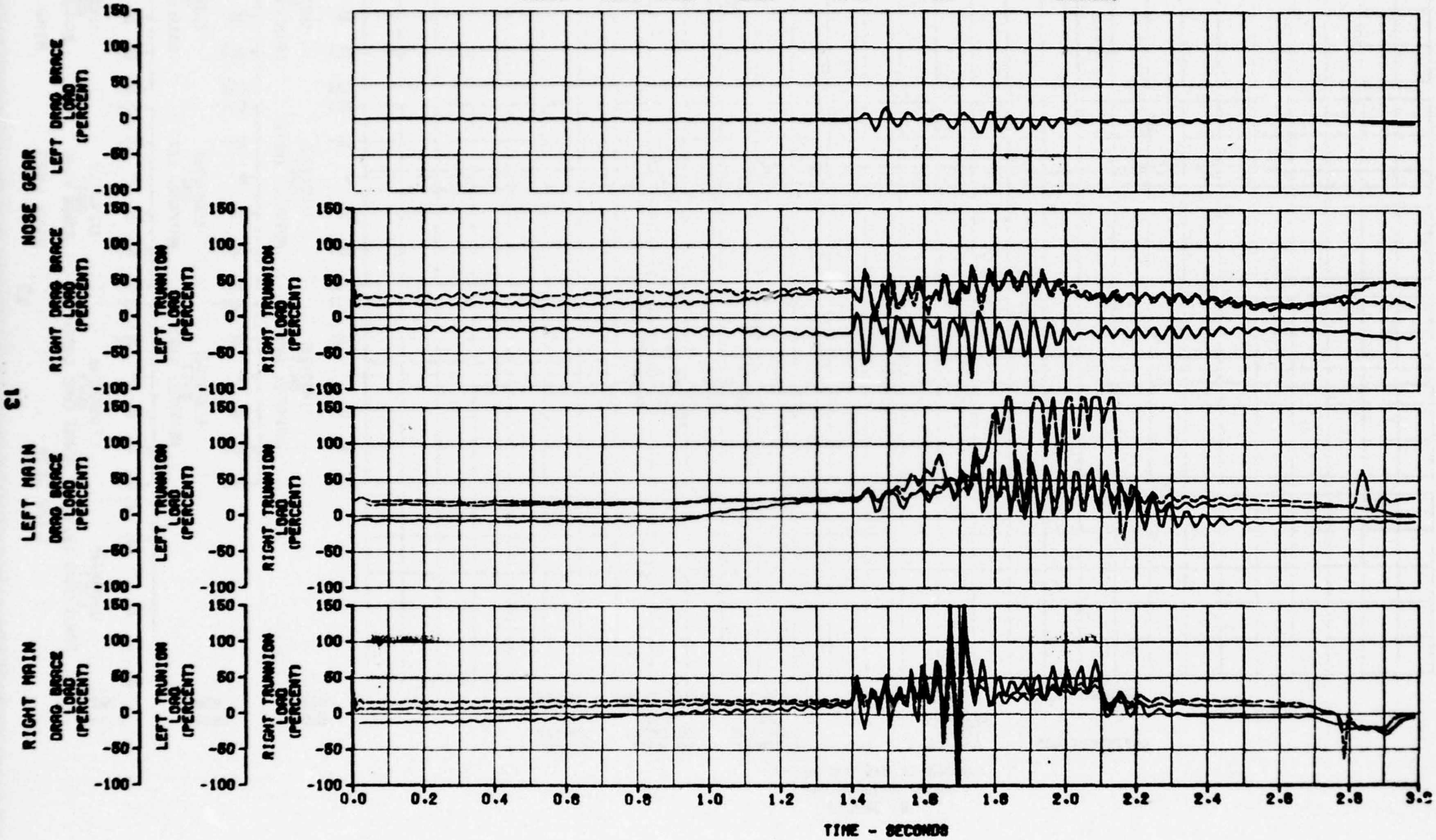


FIGURE F
LANDING GEAR LOADS
C-12A USA S/N 73-22250

GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	DENSITY ALTITUDE (FT)	OAT (C)	GROUND SPEED (KNOTS)	CONFIGURATION
12500	185.0 (FWD)	2220	10.2	33	BRAKING

SOLID LINE — SHORT DASH — LONG DASH



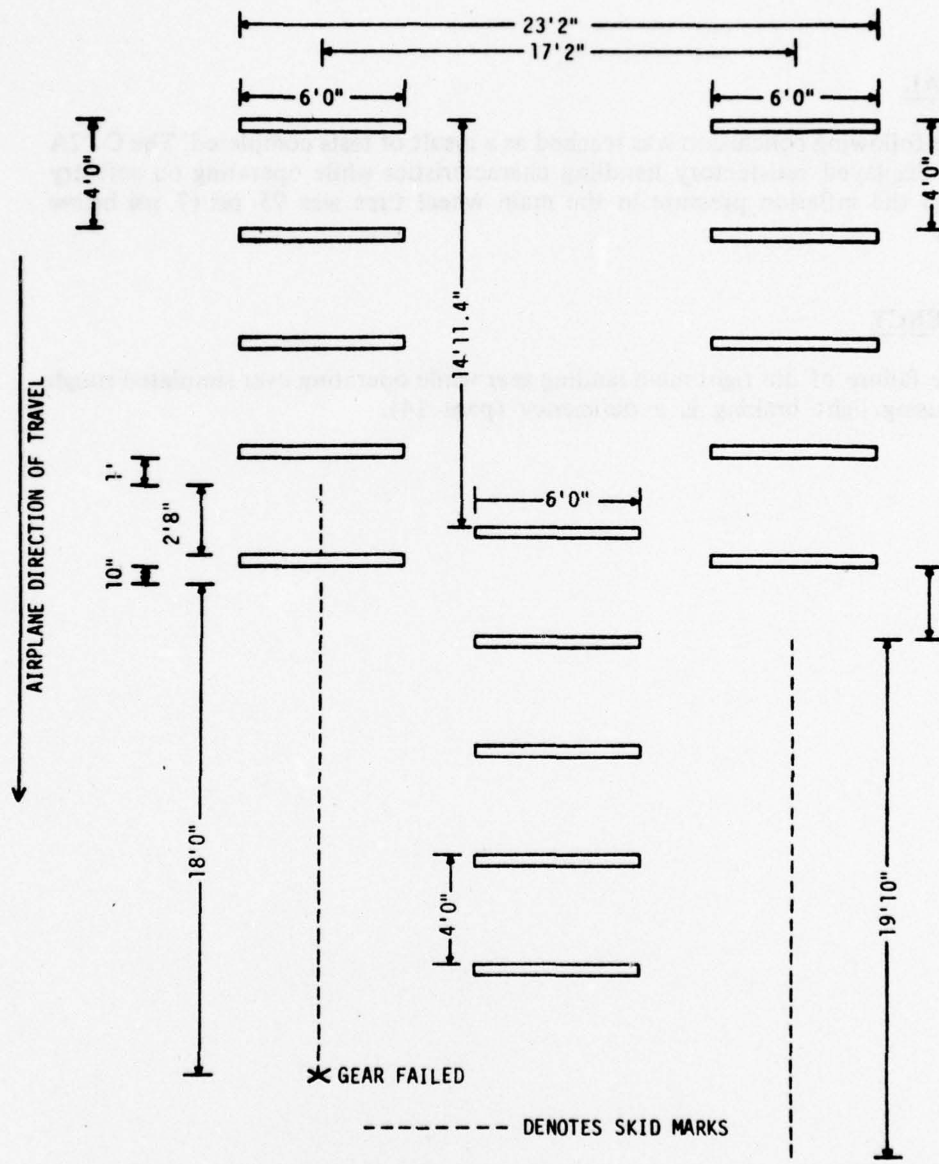


Figure G. Landing Gear Failure.

CONCLUSION

GENERAL

16. The following conclusion was r[illegible] result of tests completed. The C-12A airplane displayed satisfactory hand[illegible]ics while operating on soft dry soil when the inflation pressure in [illegible] tires was 95 psi (7 psi below normal).

DEFICIENCY

17. The failure of the right main landing gear while operating over simulated rough terrain using light braking is a deficiency (para 14).

RECOMMENDATIONS

18. The deficiency identified during this program must be corrected if the C-12A is to be operated on other than smooth improved airfields (para 14).

19. The C-12A should not be cleared for operation from unimproved airfields with the currently installed main landing gear/wheel braking system (para 15).

APPENDIX A. REFERENCES

1. Final Report, USAAEFA, Project No. 75-08, *Airworthiness and Flight Characteristics Evaluation, C-12A Aircraft*, October 1976.

2. Prime Item Development Specification, Beech Aircraft Corporation, BS 22483D, "Army Model U-X and Air Force Model CX-X," 26 April 1974, revised 30 September 1974.

3. Regulation, Federal Aviation Administration, Federal Air Regulation FAR Part 23, *Airworthiness Standards; Normal, Utility, and Acrobatic Category Airplanes*, 13 March 1975.

4. Military Specification, MIL-F-8785B(ASG), *Flying Qualities of Piloted Airplanes*, 7 August 1969, with Interim Amendment 1, 31 March 1971.

5. Letter, AVSCOM, DRSAV-EQI, 18 March 1976, subject: Test Directive, C-12A Landing Gear Capability Tests.

6. Message, AVSCOM, DRSAV-EQI, 192220Z March 1976, subject: Safety of Flight Release for C-12A Soft and Rough Field Tests.

7. Report, Beech Aircraft Corporation, No. 101E777 DL, *Engineering Structural Dynamics Report, Landing Gear Calibration - US Army Rough Field Test, Model C-12*, 22 March 1976.

8. Report, US Army Engineer Waterways Experiment Station, Miscellaneous Paper M-76-18, *Preliminary Evaluation of the Ability of the C-12A Aircraft to Operate Safely on Substandard Airstrips*, October 1976.

APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The C-12A aircraft has the general structure and space arrangements of the BAC Super KingAir Model 200 aircraft. Three views of the test aircraft are shown in photos 1, 2, and 3. General specifications are listed below.

Dimensions

Wing span	54 ft, 6 in.
Horizontal stabilizer span	18 ft, 5 in.
Length	43 ft, 10 in.
Height to top of vertical stabilizer	15 ft, 0.5 in.
Propeller diameter	8 ft, 2.5 in.
Propeller/fuselage clearance	29.6 in.
Propeller/ground clearance	14.5 in.
Distance between main gear	17 ft, 2 in.
Distance between main and nose gear	14 ft, 11 in.

Cabin Dimensions

Total pressurized length	264 in.
Cabin length, partition to partition	128 in.
Cabin height	57 in.
Cabin width	54 in.
Entrance door	51.5 in. by 26.7 in.

Wing Area and Loading

Wing area	303 ft^2
Wing loading	41.3 lb/ft^2
Power loading	7.4 lb/hp

Weights

Maximum takeoff weight	12,500 lb
Maximum ramp weight	12,585 lb
Maximum landing weight	12,500 lb
Maximum zero fuel weight	10,400 lb

Photo 1. Right Quarter View.

Photo 2. Front View.

Photo 3. Left Three-Quarter View.

Ground Turning Clearance

Radius for inside gear	4 ft
Radius for nose wheel	19 ft, 6 in.
Radius for outside gear	21 ft, 1 in.
Radius for wing tip	39 ft, 10 in.

FLIGHT CONTROL SYSTEM

2. The C-12A aircraft is provided with conventional dual controls for the pilot and copilot. The flight control system is reversible. The elevator and rudder control surfaces are of conventional design. The aileron control surface has a 28-inch by 1-1/2-inch metal sandwich added to the trailing edge adjacent to the trim tab to aid lateral control effectiveness. The elevators and ailerons are operated by conventional control wheels interconnected by a T-column. The rudder pedals are interconnected by a linkage below the floor. These systems are connected to the control surfaces through closed cable bell crank systems. Rudder, elevator, and aileron trim are adjustable, with controls mounted on the center pedestal. Position indicators for each of the trim tabs are integrated with their respective controls. An elevator bob weight and downspring has been incorporated to lighten longitudinal control forces in flight. A control lock is provided which permits positive locking of the control column, rudder pedals, and engine power controls.

3. A rudder boost system is provided to assist in maintaining directional control during asymmetrical thrust conditions, such as engine failure or a large variation of power between the engines. Incorporated in the rudder cable system are two pneumatic rudder boosting servos that actuate the cables to provide rudder pressure to help compensate for asymmetrical thrust. The system is operated by sensing differential pressure between each of the engine bleed air systems. The system is operated by a toggle switch located on the pedestal below the rudder trim wheel. A functional check of the system may be obtained during the conduct of normal engine run-up procedures.

4. A yaw damper system is provided to assist in maintaining directional stability. The system components include a yaw sensor, amplifier, and control valve. Regulated air pressure from the control valve is directed to the same pneumatic servos used for the rudder boost system. The system is controlled by a toggle switch adjacent to the rudder boost switch on the pedestal. The circuit of the yaw damping system is interrupted by the landing gear safety switch while the airplane is on the ground and will not operate in this condition. The system may be used at any altitude; however, it is required for flight above 17,000 feet.

ELECTRICAL SYSTEM

5. The airplane electrical system is a 28-volt direct current (VDC) (nominal) system with the negative lead of each power source grounded to the main airplane structure. DC electrical power is provided by one 34 ampere-hour, 20-cell nickel-cadmium battery and two 250-ampere starter/generators connected in parallel. The system is capable of supplying power to all subsystems that are necessary for normal operation of the airplane. A hot battery bus is provided for emergency operation of certain essential equipment and the cabin entry threshold light circuit. Power to the main bus from the battery is through the battery relay, controlled by a security keylock switch (Army only), and a master switch, placarded BATT ON - OFF. Both are located on the overhead control panel. Power to the bus system from the generators is through generator line contactors. The voltage regulators prevent the generators from absorbing power from the bus when the generator voltage is less than the bus voltage by opening the line contactors. The generators are controlled by master switches placarded #1 GEN and #2 GEN, located on the overhead control panel.

6. Starter power to each individual starter/generator is provided from the main bus through a starter relay. The start cycle is controlled by a three-position switch for each starter, placarded IGNITION AND ENGINE START, on the overhead control panel. The starter/generator drives the compressor section of the engine through the accessory gearing. The starter/generator initially draws approximately 1100 amperes and then drops rapidly to about 300 amperes as the engine reaches 20 percent of the gas generator speed.

7. The Army aircraft has a security keylock switch, placarded OFF - ON, installed on the overhead control panel. The switch is connected into the battery relay circuit and must be ON when energizing the battery master power switch. The key cannot be removed from the lock when in the ON position.

8. For ground operation, an external power socket, located under the right wing outboard of the nacelle, is provided for the use of auxiliary power units. A relay in the external power circuit will close only if the external source polarity is correct. The security keylock switch and battery switch must be ON when applying external power. For starting, external power sources capable of up to 1000 amperes (400 amperes maximum continuous) should be used. A green advisory light on the caution/advisory annunciator panel, EXTERNAL POWER, is provided to alert the operator when the external DC power plug is connected to the airplane. Placing the avionics master power switch in the EXT PWR position will allow the use of an auxiliary power unit for avionics checkout.

ENVIRONMENTAL SYSTEM

9. The environmental system consists of the bleed air pressurization, heating and cooling system, and their associated controls. The cabin pressure vessel is designed for a normal working pressure differential of 6 psi, which will provide a cabin

pressure altitude of 3870 feet at an airplane altitude of 20,000 feet. It will provide a nominal cabin altitude of 9840 feet at an airplane altitude of 31,000 feet. A mixture of bleed air from the engines and ambient air is available for cabin pressurization at a rate of approximately 10 to 15 pounds per minute. This air mixture also passes through a heating flow control unit in each nacelle and is ducted into the cabin to provide heating. An air-to-air heat exchanger helps regulate the temperature of the bleed air. Cabin air conditioning is provided by a refrigerant gas vapor-cycle refrigeration system consisting of a belt-driven engine-mounted compressor installed in the right engine. An environmental control section on the overhead control panel provides for automatic or manual control of the environmental system.

PROPULSION SYSTEM

10. The PT6A-38 engine, manufactured by UACL, has a three-stage axial, single-stage centrifugal compressor driven by a single-stage reaction turbine. The power turbine, counterrotating with the compressor turbine, drives the output shaft. These engines are derated to produce 750 shp each under standard-day, sea-level, uninstalled conditions. Maximum continuous speed of the engine is 38,100 rpm, which equals 101.5 percent N_1. Prior to gear reduction, the turbine speed on the power side of the engine is 30,000 rpm at 2000 rpm propeller speed.

11. The Hartzell propeller is a full-feathering, constant speed, counterweighted reversing type, controlled by engine oil pressure through a single-action, engine-driven propeller governor. The propeller is three-bladed and flange-mounted to the engine shaft. Centrifugal counterweights, assisted by a feathering spring, move the blades toward the low rpm (high pitch) position and into the feathered position. Governor-boosted engine oil pressure moves the propeller to the high rpm (low pitch) hydraulic stop and reversing position.

12. The propulsion system is operated by three sets of controls: the power levers, propeller levers, and condition levers. The power levers provide control of engine power from idle through takeoff power by operation of the gas generator (N_1) governor in the fuel control unit. When the power levers are lifted over the idle detent they control engine power through the beta and reverse ranges. The propeller levers are operated conventionally and control the constant-speed propellers through the primary governor. Normal operating range is 1600 to 2000 rpm. The condition levers control the flow of fuel at the fuel control outlet and select fuel cutoff, low-idle (52 percent N_1), and high-idle (70 percent N_1) functions.

FUEL SYSTEM

13. The fuel system consists of two separate systems connected by a valve-controlled cross-feed line. Each system consists of a nacelle tank, two wing

leading edge tanks, two box section bladder tanks, and an integral (wet cell) tank, all interconnected to flow into the nacelle tank by gravity. This system of tanks is filled from the filler located near the wing tip.

14. An antisiphon valve is installed at each filler port which prevents loss of fuel or collapse of a fuel cell bladder in the event of improper securing or loss of the filler cap.

15. Each fuel system is vented through two ram vents located on the underside of the wing adjacent to the nacelle. To prevent icing of the vent system, one vent is recessed into the wing and the backup vent protrudes from the wing and contains a heating element. The vent line at the nacelle contains an in-line flame arrestor.

LANDING GEAR

16. A 28-volt split field motor, located on the forward side of the center section main spar, extends and retracts the landing gear. The landing gear motor is controlled by a switch located on the pilot subpanel which must be pulled out of detent to initiate extension or retraction. The motor incorporates a dynamic braking system, through the use of two motor windings, which prevents overtravel of the gear.

17. Torque shafts drive the main gear actuators and duplex chains drive the nose gear actuator. A spring-loaded friction-type overload clutch incorporated in the gearbox prevents damage to the structure and to the torque shafts in the event of mechanical malfunction. A 200-ampere remote circuit breaker, located on the landing gear panel forward of the main spar under the center floorboard, protects the system from electrical overload.

18. The Beech air-oil type shock struts are filled with compressed air and hydraulic fluid. Spring-loaded linkage from the rudder pedals permits nose wheel steering. When the rudder control is augmented by a main wheel brake, the nose wheel deflection can be considerably increased. As the nose wheel retracts after lift-off, it is automatically centered and the steering linkage becomes inoperative.

ANNUNCIATOR SYSTEM

19. The annunciator system consists of a warning annunciator panel (with red readout) centrally located in the glare shield and a caution/advisory annunciator panel (CAUTION yellow, ADVISORY green) located on the center subpanel. Individual function lights are of the word readout type. In the event of a fault, a signal is generated and applied to the respective channel in the appropriate annunciator panel. If the fault requires the immediate attention of the pilot, the fault warning lights on the glare shield will flash. The flashing fault warning lights may be extinguished by pressing the face of the light to reset the circuit. The

illuminated fault indication on the warning annunciator panel will remain on if the fault is not, or cannot be, corrected. If an additional fault occurs, the appropriate light on the annunciator panel will illuminate and the warning flashing light will again illuminate.

FIRE DETECTION SYSTEM

20. A fire detection system is installed to provide immediate warning in the event of fire in the engine compartments. The system consists of three photoconductive cells in each engine nacelle, control amplifiers in the center section leading edge, red warning lights in the fire control T-handles placarded #1 FIRE PULL and #2 FIRE PULL, a rotary fire protection test switch on the copilot subpanel, and a 5-ampere FIRE DETR circuit breaker panel. Flame detectors, sensitive to infrared rays, are positioned in the engine compartments to receive direct and reflected rays, thus covering the entire compartment with three cells. Heat level and rate of heat rise are not factors in the sensing method. The cell emits an electrical signal proportional to the infrared intensity and ratio of the radiation striking the cell. To prevent stray light rays from signaling a false alarm, the control amplifier activates only when the signal reaches a preset alarm level, which illuminates the appropriate warning lights in the fire control T-handles and the master fault warning light on the glare shield. When the fire has been extinguished, the cell output voltage drops below the alarm level and the control amplifier resets. No manual resetting is required to reactivate the detection system.

EMERGENCY LIGHTING SYSTEM

22. An independent battery-operated emergency lighting system is installed in the airplane. The system is actuated automatically by shock, such as a forced landing, providing adequate lighting inside and outside the fuselage to permit crew and passengers to read instruction placards and locate exits. An inertia switch, when subjected to a 2 to 3g shock, will illuminate interior lights in the cockpit, forward and aft cabin areas, and exterior lights at the overwing emergency exit and the cabin door. The battery power source is automatically recharged by the aircraft electrical system.

EMERGENCY EXIT

23. The emergency exit door, placarded EXIT-PULL, is located on the right cabin side wall just aft of the copilot seat. From the inside, the door is released with a pull-down handle and on the outside the door may be released with a flush-mounted pull-out handle. The door is of the nonhinged plug type which removes completely from the frame when the latches are released. From the inside, the door can be keylocked to prevent opening from the outside. The inside handle

will unlatch the door, whether or not it is locked, by overriding the locking mechanism. The keylock should be unlocked prior to flight to allow removal of the door from the outside in the event of an emergency. The key remains in the lock when the door is locked and can be removed only when the door is unlocked. Removal of the key from the lock before flight assures the pilot that the door can be removed from the outside if necessary.

APPENDIX C. INSTRUMENTATION

1. Instrumentation was installed in the test aircraft and maintained by USAAEFA personnel. A magnetic tape system was used as the primary means of obtaining engineering flight data. The main instrumentation package was located in the passenger cabin area at FS 198 (photo 1). An engineer flight instrument panel was also located in the passenger cabin between the crew compartment and the instrumentation package (photo 2). A pitot-static boom which incorporated angle-of-attack and angle-of-sideslip vanes was mounted on the right wing at buttline 224 (photo 3).

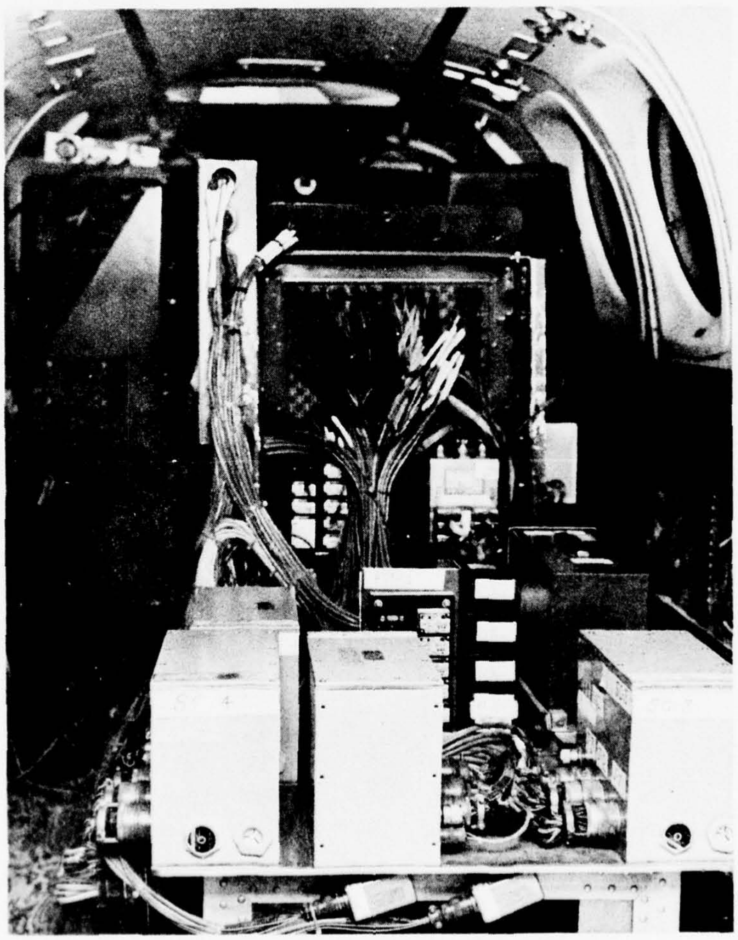


Photo 1. Instrumentation Package.

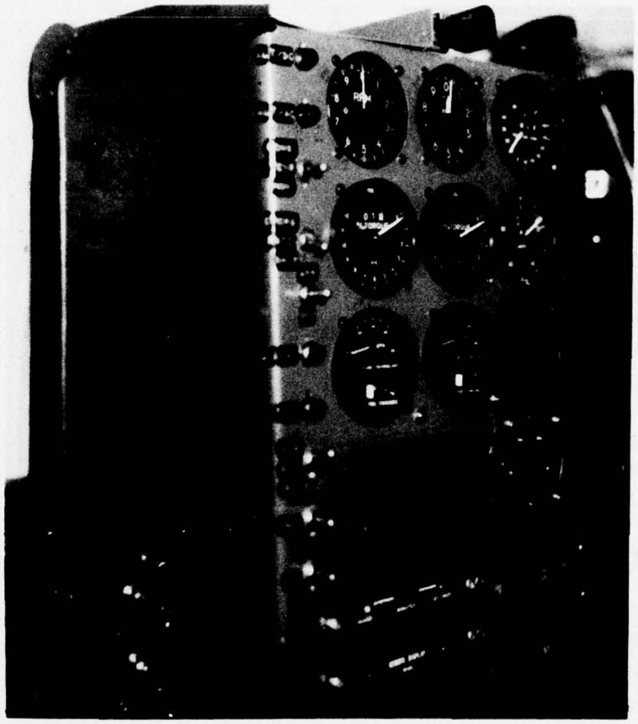


Photo 2. Engineer Panel.

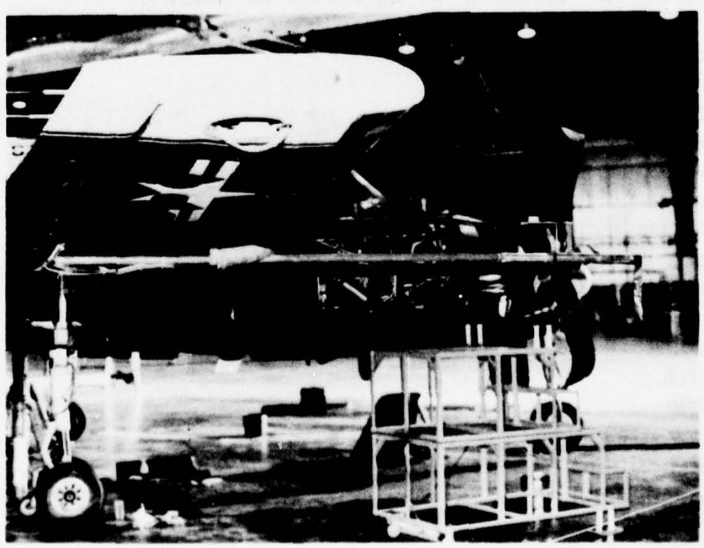


Photo 3. Pitot-Static Boom.

2. Data parameters are listed below.

<u>Pilot/Copilot Panel</u>

Airspeed
Altitude
Vertical speed
Propeller speed, each engine
Turbine gas temperature, each engine
Center-of-gravity normal acceleration
Angle of attack

<u>Engineer Panel</u>

Airspeed (boom)
Altitude (boom)
Vertical speed
Outside air temperature
Propeller speed, each engine
Engine torque, each engine

3. Data parameters recorded on tape were as follows:

Airspeed (boom)
Altitude (boom)
Propeller speed, each engine
Engine torque, each engine
Turbine gas temperature, each engine
Outside air temperature
Angle of attack
Attitude:
- Pitch
- Roll
- Yaw

Control position:
- Longitudinal
- Lateral
- Rudder (pedal)

Control force:
- Longitudinal
- Lateral
- Rudder (pedal)

Nose gear left drag brace load
Nose gear right drag brace load
Nose gear left trunnion load
Nose gear right trunnion load
Left main gear drag brace load
Left main gear right trunnion load
Left main gear left trunnion load
Right main gear drag brace load
Right main gear right trunnion load
Right main gear left trunnion load

4. A complete description of the landing gear loads instrumentation can be obtained from reference 7, appendix A.

APPENDIX D. SOIL SURVEY

MATERIEL TEST DIRECTORATE
YUMA PROVING GROUND
YUMA, ARIZONA

LABORATORY SERVICES BRANCH TEST REPORT

Item C-12A Unprepared Runway Soil Data **Date** 6 February 1976

Project Engineer Messrs. Bell and Pond **Project No.** 75-08

Comments

Test Results

Introduction:

Personnel from Material Analysis Section, at Yuma Proving Ground, Yuma Arizona, were requested to find a suitable area at Harper Lake for an unprepared runway for tests with the C-12A aircraft.

Detailed inspection of broad areas of the dry lake were made with the use of a cone penetrometer. A suitable area was delineated and in-place California Bearing Ratio (CBR) readings to at least 8 inch depth were made and reported. CBR readings were also supported by frequent cone penetrometer readings. Soil samples for moisture determination were taken at 2 inch intervals from surface to 12 inch depth and reported. Tire imprints of the aircraft in course of test were measured and reported.

Inspected By [signature] **Approved By** [signature]

STEYP-MTD Form 35, 23 Sep 71. **(MTD SOPs A&C 11-70 & LS-7-70)**

Site Selection

Site selection of a fine-grained soil at Harper Lake, CA was in line with the specifications outlined in page 11 of the UX/CX IFB, paragraph 3.5.1 (attached) which states:

> ". . . the capability of making a minimum of 40 passes on a soil field of CBR-4 at the gross weight defined by the range requirements of paragraph 3.1.2.1 is required (reference ASD-TR-68-34). . ."

Preliminary survey of the Harper Lake area was made with the use of a helicopter followed by an intensive ground survey of possible areas using the cone penetrometer. When a site was found, which afforded the approximate CBR and possible runway for the tests, detailed measurements of California Bearing Ratio (CBR) were made at depths of surface, 2", 4", 6", 8", 10" and 12".

Moisture samples were taken of each depth to provide supportive data for the CBR readings reported.

The test area was established in the NW portion of Harper Lake and laid in a general east-west direction. It was comprised of a central section of approximately 2000 feet of white salt-encrusted surface. On the east and west ends of this salty area were areas of harder surfaced soil each extending for approximately 1000 feet.

Equipment and Calibration

The equipment used for the accumulation of this data is the Field In-place California Bearing Ratio apparatus as listed in the Instructions for Use of Field In-Place California Bearing Ratio Apparatus.[1]

The penetrometer used for general site location was a trafficability cone penetrometer with a dial-type load indicator (0-300 range) equipped with a 0.8 inch diameter cone having a cross-sectional area of 0.5 square inch.

All of the above equipment was calibrated by the U.S. Army Calibration Branch, Yuma Proving Ground, Yuma, AZ.

Procedure

The procedure used in running the California Bearing Ratio (CBR) test was taken from the U.S. Army, Instructions for Use of Field In-Place California Bearing Ratio Apparatus.

All CBR values given in this report were taken using the above procedure and its prescribed equipment. The use of the cone penetrometer was restricted to finding the general area to be used. All cone penetrometer readings were divided by 50 to give the results in terms of airfield index.[2] No penetrometer data is given due to the fact that correlation from the airfield index given by the penetrometer to CBR requires extensive testing for each soil type and moisture content and then gives only approximations of the CBR.

Description of Typical Salty Soil Profile - Harper Lake

The surface of this soil consists of an uneven crust of white crystalline soluble salts to a depth of approximately one-eighth inch. This is underlaid with one-quarter of an inch of light brown crumb-structured loose salty soil which when moistened is identified as clayey very fine sand. Beneath this to a depth of 1 1/2 to 2 inches is reddish-brown sponge - structured very fine sandy clay. Below this to 30 inches or more is reddish-brown compacted very fine sandy clay.

The supportive strength of this soil is dependent upon how much moisture it is holding. At the time of this writing severe drouth conditions prevailed and the soil below a depth of 12 inches was firm with relatively low moisture. A 5-ton truck with a 2500 lb. load left tire tracks on this soil only one inch deep.

Other soil areas adjacent to the salty soil described above, are much drier in the surface and much firmer. The clay content of the surface 2 to 2 1/2 inches is much higher than in the salty soil and when dried out it cracks into saucer-sized chunks. These soils are firm from 6 inches down to levels where more moisture is present.

<u>CBR Data</u>

All values given below are actual CBR values rounded off to the nearest tenth. The average CBR value given for each location is the average of the CBR values from the 2" through 8" depth.[3]

The location of each CBR run is shown on the diagram of the airstrip with this report.

Location	A	B	C	D	E	F	G
Surface	3.0	1.8	1.3	2.3	7.6	4.4	11.3
2"	2.9	2.2	1.5	2.5		5.8	
3"					5.1		5.8
4"	5.5	4.0	2.2			7.3	
6"	5.7	5.9	4.8	2.5	6.2	7.6	9.8
8"	5.9	7.0	4.7	3.0		7.7	
10"		5.1	5.2	2.8			
12"		5.5	5.3	5.0			
Average	5.0	4.8	3.3	2.6	5.7	7.1	7.8

Due to the severe drouth conditions at the time of the test this is the only area on the lake of sufficient size to run the test. As can be seen from the above data it is not of CBR 4 as requested, but was the only area on the lake close to this requirement.

Moisture Data

Moisture samples were taken from location C which is 1100 feet mark of the airstrip and the area closest to the CBR 4 value requested. The results of the samples are:

Surface = 10.7%

2 inch = 23.3%

4 inch = 24.1%

6 inch = 24.0%

8 inch = 23.9%

10 inch = 24.6%

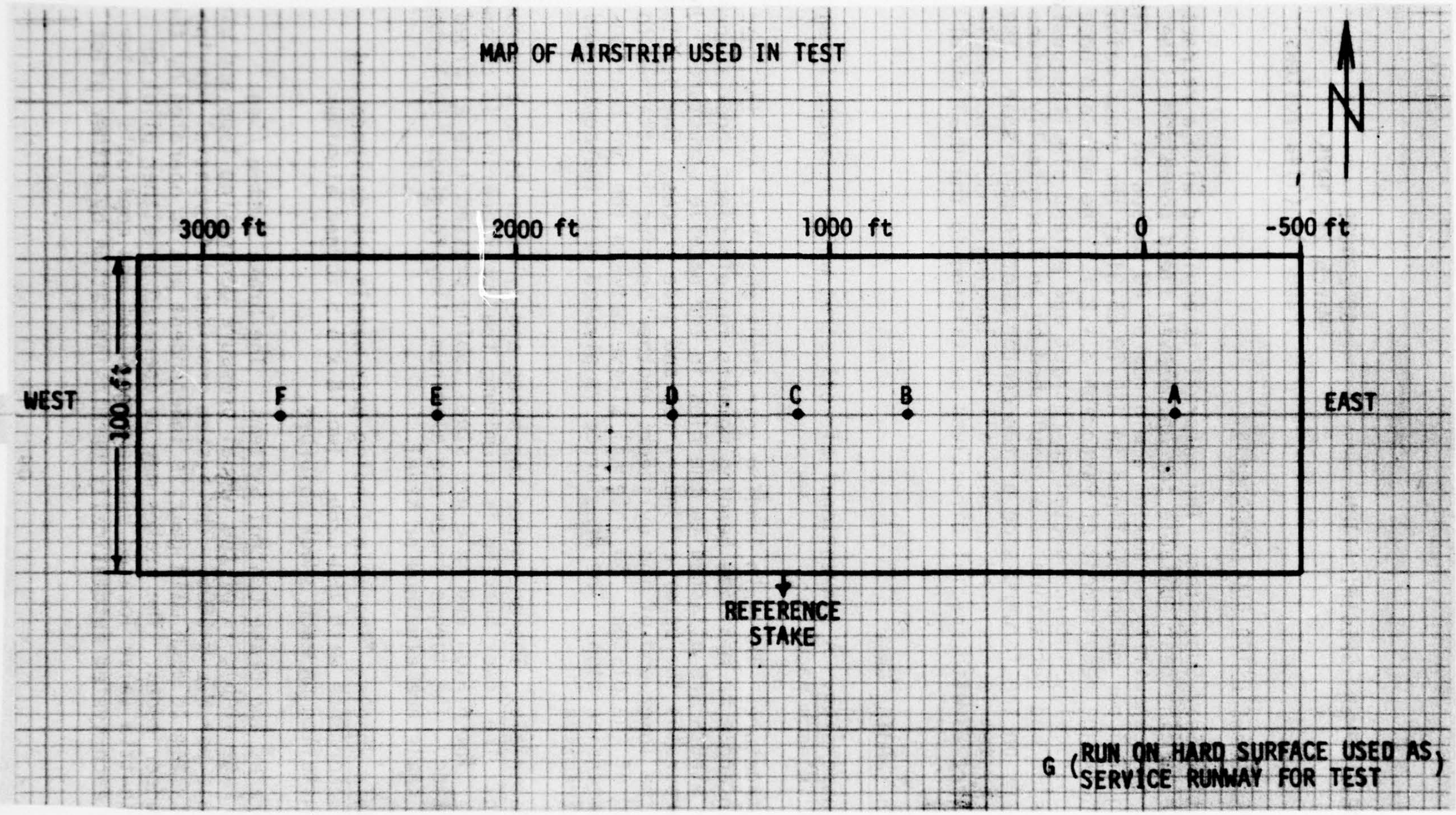
12 inch = 23.4%

DEPTH OF WHEELPRINT

ACTIVITY	WHEEL	DEPTH OF RUT	PHOTO NO.	LOCATION
4 FEB 76				
First Power Run	Right Main Gear	2 1/4"	1	1100'
First Taxi Run	Right Main Gear	1 5/8"	2	1100'
First Power Run	Nose	1 1/2"	3	1100'
First Taxi Run	Nose	1 5/8"	4	1100'
Second Power Run w/flaps	Right Main Gear	1 3/4"		1100'
Second Power Run w/flaps	Nose	1 1/2"	5	1100'
Turn At West End	Left Main Gear	1 7/8"	6	2250'
First Landing in Existing Tracks	Right Main Gear	1 3/4"	7	1100'
First Landing in Existing Tracks	Left Main Gear	1 7/8"		1100'
360° Turn	Left Main Gear	1 3/4 to 2 1/4"	8	1200'
360° Turn	Nose	1 3/4"		1200'
360° Turn	Right Main Gear	2"		1200'
Second Landing	Right Main Gear	1 3/4"		1100'
Second Landing Braking Area	Left Main Gear	2 1/4"		1000'

DEPTH OF WHEELPRINT (CONTINUED)

ACTIVITY	WHEEL	DEPTH OF RUT	PHOTO NO.	LOCATION
5 FEB 76				
First Take-off	General View Left Main Gear	1 3/4"	1,2,3	1100'
First Take-off	Right Main Gear	2 1/8"	4	1000'
First Landing	Left Main Gear	2"	5	1100'
First Landing	Nose	2 3/8"	6	1100'
Second Take-off	Right Main Gear	2 1/4"	7	1100'
Second Take-off	Nose	1 7/8"	8	1100'
A200 Take-off	Left Main Gear	1 5/8"	9	1100'
A200 Take-off	Nose	1 1/4"	10	1100'


MAP OF AIRSTRIP USED IN TEST
N
3000 ft
2000 ft
1000 ft
0
-500 ft
WEST
EAST
100 ft
F
E
D
C
B
A
REFERENCE STAKE
G (RUN ON HARD SURFACE USED AS SERVICE RUNWAY FOR TEST)

3.5 Airframe, Description and Components.

3.5.1 Alighting Gear Subsystem. The aircraft is equipped with a retractable tricycle landing gear suitable for unimproved field operation. The aircraft has the capability of making a minimum of 40 passes on a soil field of CBR rating of 4 per method outlined in ASD-TR-68-34 at the gross weight defined by the range requirement of Paragraph 3.1.2.1. The main and nose gears are mechanically interconnected to retract and extend simultaneously. Normal extension and retraction is accomplished by an electrically driven gearbox mounted on the forward side of the center section main spar. The landing gear system is designed to meet all the landing conditions specified by FAR Part 23 with special directives pertaining to the dual wheel installation.

3.5.1.1 Main Landing Gear.

3.5.1.1.1 Suspension. A conventional air-oil strut which retracts forward is installed in each nacelle.

3.5.1.1.2 Structure. The main landing gear shock absorbers are inclined forward at an angle to minimize bending moments for efficient shock absorber action. The struts are attached to the ribs in the nacelle structure. One forging incorporates the upper cylinder, top and side braces. One bearing is fixed in the lower end of the cylinder; another bearing is attached to the upper end of the piston. An internal sleeve between the two bearings acts as an extension stop. The drag brace is pivoted near the center and folds for retraction.

3.5.1.1.3 Materials. The one-piece top brace and cylinder is an aluminum alloy forging. The lower bearing is aluminum; the upper bearing is chrome plated steel. The piston and axle are steel tubing pressed into a forged aluminum fitting. The torque knees are aluminum alloy forgings. All other parts except seals are aluminum or steel.

3.5.1.1.4 Main Wheels. The main landing gear wheels are designed and approved in accordance with TSO-C26b. Two 18 x 5.5 forged aluminum wheels are installed on each shock absorber.

3.5.1.1.5 Brakes and Brake Control Systems. The brake system (See Schematic on Page 114b), is of the manual pressure generating type and uses hydraulic fluid per MIL-H-5606. The system provides differential braking, in that the system to each main gear is independent and is operated by the respective rudder pedal. The brakes may be operated by either pilot or copilot. A shuttle valve located between the pilot and copilot's master cylinders in each system automatically permits operation by either pilot or copilot.

References

1. Technical Instructions, *Use of Field In-Place California Bearing Ratio Apparatus*, Corps of Engineers, U.S. Army Waterways Experiment Station, Vicksburg, Mississippi, September, 1952.

2. Technical Manual, TM-5-366, P.49-51, U.S. Army.

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