AC NO: AC 121-14A

DATE: 2/9/76

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRCRAFT SIMULATOR EVALUATION AND APPROVAL

1. PURPOSE. This circular sets forth one means that would be acceptable to the Administrator for approval of aircraft simulators or other training devices requiring approval under FAR 121.407.

2. CANCELLATION. AC 121-14, Aircraft Simulator Evaluation and Approval, dated December 19, 1969, is canceled.

3. BACKGROUND. As the state-of-the-art in simulator technology advances, more effective use can be made of the aircraft simulator in both training and checking of flight crewmembers. The increasing size, complexity, and operating costs of the modern turbojet transport and its operating environment point to greater use of the advanced technology now available in aircraft simulators. Simulators can provide more indepth training on emergency procedures than can be accomplished in the aircraft. This, in turn, results in more effective training on emergency procedures than can be accomplished in the aircraft. There is a very high percentage of transfer of learning from the simulator to the aircraft. The ultimate goal for this transfer is 100% at which time all training and checking could be accomplished in the simulator. The additional use of simulators in lieu of the aircraft results in great cost reductions for the operator. Additional benefits are fuel conservation and a decrease in noise and exhaust pollution.

4. SCOPE OF APPROVAL. Approval procedures which follow apply to specific maneuvers, procedures, and crewmember functions for which the user requests approval.

5. DEFINITIONS.

   a. Simulator Data includes the various types of data used by the simulator manufacturer and the applicant to design, manufacture, and test the flight simulator. Normally, the aircraft manufacturer will provide the aircraft data to the simulator manufacturer, which in

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the case of aircraft not yet flying will be predicted data. In the case of aircraft already flying, data obtained from the Airplane Flight Manual, Aircraft Type Inspection Report, or flight tests in the applicant's aircraft may be used. The data must be applicable to the specific aircraft and must be acceptable to the Administrator. In the event predicted data is used in programming the simulator, it will be updated as soon as practicable when actual aircraft data becomes available.

b. The Functional Test Guide used to obtain FAA approval for the use of the aircraft simulator for training and checking activities should be made up of operational tests designed to verify the performance characteristics, both static and dynamic, of the simulator relative to the aircraft.

c. The Customer Acceptance Test Guide is a test guide used to verify the simulator's performance to the customer's flight simulator specifications as refined by final aircraft performance.

6. AIRCRAFT SIMULATOR GENERAL - FAA REQUIREMENTS. When the applicant determines the aircraft simulator will meet his acceptance criteria, the FAA should be notified with sufficient lead time to assure a mutually satisfactory date for FAA evaluation. As appropriate, the following general requirements should be evaluated during the FAA aircraft simulator evaluation and approval process:

a. The cockpit should represent a full-scale mockup of the aircraft simulated. Where movement of controls and switches is involved, the direction of movement should be identical to that in the applicant's aircraft.

b. Circuit breakers that affect procedures and functions resulting in observable cockpit indications should be checked for functional accuracy.

c. The effect of aerodynamic changes for various combinations of drag and thrust normally encountered in flight should reasonably correspond to actual flight conditions. The effect of change in aircraft attitude, thrust, drag, altitude, temperature, gross weight, center of gravity location, and configuration should be included.

d. In response to control movement by a crewmember, all relevant instrument indications involved in the simulation of the applicable aircraft should be entirely automatic.

e. The rate of change of simulator instrument readings and of control forces should correspond to the rate of change which would occur on the applicable aircraft under actual flight conditions for any given change in forces applied to the controls, in the applied power, or in aircraft configurations.

f. Control forces and degree of actuation control travel should correspond to that which would occur in the aircraft under actual flight conditions.

g. Communications and navigation equipment should correspond to that installed in the applicant's aircraft and should reasonably operate within the tolerances prescribed for the actual airborne equipment.

h. In addition to the flight crew stations, there should be two suitable seat accommodations for the Instructor/Check Airman and FAA Inspector. Operators who have the Check Airman/Instructor occupy a crew position seat need only provide one additional observer seat. These seats should provide adequate vision to the pilot's panel and forward windows in visual system models. "Grandfather" rights prevail on previously approved simulators; however, efforts should be made to improve surveillance visibility. These observer seats need not represent the aircraft seats.

i. Simulator systems should simulate the applicable aircraft system operation, both on the ground and in flight. Major systems should be operative to the extent that normal operating procedures, abnormal and emergency procedures included in the applicant's programs can be accomplished.

j. An Instructor Control Console should be installed to enable the Instructor/Check Airman or FAA Inspector (when applicable) to control the visual attachment (if installed) and insert abnormal or emergency conditions into the aircraft systems.

7. AIRCRAFT SIMULATOR OPERATIONAL EVALUATION PROCEDURES. The FAA evaluation will cover each maneuver and procedure for which the applicant has requested specific approval. The Functional Test Guide will be used in evaluating Flight Controllability (i.e., static stability, longitudinal stability - including configuration changes, roll rates, etc.). As applicable, performance and system operation will be evaluated in accordance with the following typical sequence of ground and flight maneuvers including cockpit check, system operation, normal, abnormal and emergency procedures. The Operator's Manual and Checklists will be used in this evaluation.

a. Visual and Nonvisual Simulators.

(1) Preflight. Accomplish a thorough preflight of all switches, indicators, and systems at all crewmembers' stations.

(2) Engine Start.

(a) Normal start.

(b) Alternate start procedures.

(c) Abnormal and emergency procedures during start.

(3) Taxi.

(a) Thrust response.

(b) Ground handling.

(c) Brake operation (normal and alternate emergency).

(d) Abnormal and emergency procedures associated with ground operations.

(4) Takeoff and Climb.

(a) Powerplant checks (engine parameter relationships).

(b) Acceleration characteristics.

(c) Nose wheel and rudder steering.

(d) Aborted takeoff.

(e) Normal takeoff.

(f) Takeoff with engine failure at V_1.

(g) Instrument takeoff.

(h) Landing gear, flap, slat operation (gear and flap retraction times).

(i) Area departure.

(j) Climb performance - normal and engine/engines out.

(k) Abnormal and emergency procedures associated with takeoff and climb.

NOTE: During the above checks particular attention should be paid to rotation characteristics, handling characteristics, and rudder forces required with engine inoperative.

(l) Minimum control speed (one and two engines inoperative).

(5) Cruise.

(a) Performance characteristics (speed vs power).

(b) Turns with/without spoilers.

(c) High speed buffet/mach tuck, overspeed warning.

(d) Normal and steep turns.

(e) Approach to stalls (stall warning, buffet and "G" break).

(f) Unusual attitudes.

(g) Specific flight characteristics.

(h) All systems operations associated with normal in-flight functions.

(i) Abnormal and emergency procedures associated with cruise configuration.

(6) Descent.

(a) Normal descent.

(b) Abnormal and emergency procedures associated with descents.

(7) Approach and Landing.

(a) Maneuvering with all engines operating and with engine(s) inoperative.

(b) Landing gear and flap operation (time to extend), normal and abnormal extension.

(c) All engines approach and landing.

(d) Engine(s) out approach and landing (in the case of three and four-engine aircraft, two engines inoperative).

(e) ILS approaches and landings:

1 Normal.

2 Engine inoperative.

3 Category I.

4 Category II.

5 Category III (if applicable).

(f) Nonprecision approaches.

(g) Circling approach.

(h) No flap approach.

(i) Auto-coupler, auto-throttle, auto-land approaches.

(j) Manually controlled ILS, with and without flight director.

(k) All engines operating missed approach.

(l) Engine out missed approach.

(m) Rejected landing.

(n) Crosswind approach and landing.

(o) Navigation and communications.

(p) Abnormal and emergency procedures associated with approach and landing.

(8) Landing Roll and Taxi In.

(a) Spoiler operation.

(b) Reverse thrust operation.

(c) Directional control and ground handling.

(d) Normal brake and anti-skid operation.

(e) Alternate/emergency brake operation.

(9) Engine Shutdown and Parking.

(a) Systems operation.

(b) Parking brake operation.

(10) All Other Items for which Operational Approval has been requested.

NOTE: The above procedures, maneuvers, and systems operations will be evaluated from each flight crewmember position as applicable. There is a need to identify any shortcomings in the equipment that would preclude realistic simulation of the maneuver, procedure, or system operation.

8. EVALUATION AND APPROVAL OF PROCEDURAL TRAINERS AND SIMULATION DEVICES. The operational evaluation philosophy contained in this circular is applicable to all training devices for which the applicant seeks FAA approval as provided in FAR 121.407.

9. VISUAL ATTACHMENTS. Visual systems may be approved for the applicant by and for the specific maneuver, procedure, or function involved provided the attachment adequately demonstrates its capability to accomplish the training and checking objective. A means of reducing visibility to reasonably simulate appropriate weather conditions must be provided for visual systems approved for instrument takeoffs and/or instrument approach procedures.

10. AIRCRAFT SIMULATOR MOTION. Visual and nonvisual simulators to be approved for any of the maneuvers authorized in FAR 61, Appendix A, and FAR 121, Appendices E and F to be performed in a simulator in lieu of the aircraft must have motion. To provide the maximum degree of realism, a six (6) axis freedom of motion system is desirable. This system would be more adaptable to modifications and changes that may occur as a result of advancements in the state of the art of simulation.

11. RECURRENT EVALUATIONS. To insure the continuing fidelity of the simulator, all simulators requiring approval under FAR 121.407 will be evaluated on a quarterly basis after the initial approval.

12. PERFORMANCE STANDARDS. The following list of performance standards is provided for use as a guide in evaluating the aircraft simulator's functional accuracy specifications. The specific performance standards contained in the customer's acceptance test guide should be used as a basis for determining that the simulator is performing to desired performance standards.

a. Performance Characteristics. (Weight and Center of Gravity Optional).

(1) Landing gear operating time: + /-3 seconds.

(2) Wing flap operating time: + /-3 seconds.

(3) Takeoff Acceleration Time to V_1: + /-5%.

(4) Calibration of Gyrocompass, and turn and bank indicator in standard rate turns and 30° banked turns: + /-5%.

(5) Minimum control speed in flight: + /-5 knots.

(6) Stall warning speeds, stick shaker and buffet onset: + /-5 knots.

(7) Propeller feathering time: + /-3 seconds (where applicable).

(8) Manifold pressure for a given BMEP and RPM: + /-1 inch (where applicable).

(9) Critical altitude piston engine simulators: + /-800 feet or + /-10%.

(10) $N_1 - N_2$ relationship, turbine engine, for a given EPR: + /-2%.

(11) Speed vs thrust in level flight at cruise altitude: + /-5 knots, or 3%, or .03 mach.

(12) Climb performance: + /-100 feet or + /-5%.

b. Flight Characteristics. (Aircraft Weight and Center of Gravity Optional).

(1) Static Longitudinal Stability. Control forces during climb, cruise, approach, and landing should reasonably represent the applicable aircraft. The simulator should return to trim within + /-5 knots from a speed within 15% of trim speed. The direction of the elevator force, pull or push, must be in the same direction as the applicable aircraft elevator force.

c. Control Forces. Aircraft simulator control forces in the following areas should be within + /-3 pounds, or 10% of the forces encountered in the airplane, except in regard to rudder forces, + /-5 pounds, or + /-10 %.

(1) Configuration changes.

(2) Stick force per "G".

d. Roll Rate in the simulator in operational configuration should be within + /-2 seconds or 10%.

e. Limited Data Area. In the following areas of performance where a minimum of data exists, adequacy of simulation should be based on training and checking requirements.

(1) Compressibility trim changes.

(2) Buffet at high mach numbers.

(3) Dutch roll.

(4) Emergency descent.

(5) Any other items that logically fall in this category.

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