AC NO: AC 121-14

DATE: 12/19/69

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRCRAFT SIMULATOR EVALUATION AND APPROVAL

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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 121.407.

2. BACKGROUND. Factors such as safety and aircraft traffic congestion strongly point to the increased use of simulation. The increasing size, complexity and operating cost of the modern turbojet transport and its operating environment point to greater use of the highly sophisticated technology now available in aircraft simulators and aircraft simulation devices.

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

4. 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 aircraft simulator manufacturer, which in 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.

   b. Customer Acceptance Test Guide is a test guide used by the applicant to verify that the simulator complies with contractual specifications. This is an extensive engineering flight test of all areas of performance and systems operation.

Initiated by: FS-426

5. AIRCRAFT SIMULATOR GENERAL-FAA REQUIREMENTS. When the applicant determines that 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. Circuit breakers that affect procedures and functions resulting in observable cockpit indications should be checked for functional accuracy.

b. 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 required in the aircraft.

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 unless otherwise specified.

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 configuration.

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 aircraft and should reasonably operate within the tolerances prescribed for the actual airborne equipment.

h. The cockpit should include flight crew stations and seat accomodations for the instructor/check airman and FAA inspector.

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 procedures and emergency procedures included in the applicant's programs can be accomplished.

6. AIRCRAFT SIMULATOR OPERATIONAL EVALUATION PROCEDURES. The FAA evaluation will cover each maneuver and system operation for which the applicant has requested specific approval. As applicable, performance and system operation will be evaluated in accordance with the following typical sequence of ground and flight maneuvers including cockpit check, systems operation, normal procedures, abnormal procedures and emergency procedures.

a. Preflight and Prestart.

(1) Cockpit check in accordance with prestart checklist. Items to be checked will include: electrical power, external power, APU, lighting, crew oxygen, passenger oxygen, cockpit interphone, flight recorder, etc.

(2) Set up operating conditions. Included will be: gross weight, fuel load, oil quantity, hydraulic quantity, ground power, etc.

(3) Determine environmental conditions such as: temperature, barometric pressure, field elevation, wind, etc.

(4) Execute prestart checklist.

b. Engine Start and After-Start Checklist in Accordance with the Applicant's Operating Manual.

(1) Normal start procedures.

(2) Alternate start procedures.

(3) Cross-bleed starts.

(4) Abnormal and emergency procedures during start.

(5) Systems operations transfer to engine support, ground equipment and external power removed.

(6) After-start checklist.

c. Taxi for Takeoff.

(1) Taxi checklist.

(2) Thrust necessary for taxi

(3) Rudder - nose wheel steering - ground handling.

(4) Yaw damper operation.

(5) Anti-skid operation.

(6) Brake operation.

(7) Operation of all systems required for taxi.

(8) Simulator visual system evaluation.

(9) Abnormal and emergency procedures associated with ground operation.

d. Pre-Takeoff.

(1) All systems set for takeoff.

(2) Pre-takeoff checklist.

(3) All runup procedures.

e. Takeoff and Climb.

(1) Engine parameter relationships.

(2) Ground acceleration.

(3) Nose wheel and rudder steering.

(4) Aborted takeoff.

(5) Takeoff with engine failure at V_1.

(6) Normal takeoff.

(7) Rotation characteristics.

(8) Handling characteristics on takeoff, all engines operating and engine-out.

(9) Systems operation transfer from on ground to flight and systems operation for climb configuration.

(10) Gear, flap, slat, slot operation.

(11) Communications and navigation facilities used for departure.

(12) Normal climb and engine-out climb.

(13) After takeoff checklist.

(14) Abnormal and emergency procedures associated with climb configuration.

(15) Evaluation of visual system.

f. Cruise.

(1) Cruise checklist.

(2) Speed vs. power with associated engine parameters.

(3) Overspeed warning.

(4) Mach tuck and tuck compensator.

(5) Buffet onset at high mach numbers.

(6) Steep turns, other turns.

(7) Approach to stalls.

(8) Unusual attitudes.

(9) Dutch roll, specific flight characteristics.

(10) Abnormal and emergency procedures associated with cruise configuration; i.e., powerplant failures, fire in flight, smoke control, rapid decompression, hydraulic and electrical system failures and malfunctions, and landing gear and flap system failure or malfunction.

(11) Systems operation associated with cruise configuration.

g. Descent.

(1) Descent checklist.

(2) Emergency descents.

(3) Reverse thrust.

(4) Speed brake operation.

(5) System operation associated with descent.

(6) Abnormal and emergency procedures associated with descent.

(7) Navigation and communication.

h. Approach and Landing.

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

(2) Gear, flap, slat, slot operation.

(3) Approach and landing checklist.

(4) All engine approach and landing.

(5) Engine(s) out approach and landing.

(6) No flap approach.

(7) Approach with jammed stabilizer.

(8) Approach with unboosted controls.

(9) Flight director approach.

(10) Raw data approach.

(11) Auto coupler approach, auto throttle and auto land.

(12) Visual reference approach and landing, if visual system installed.

(13) Missed approach all engines.

(14) Missed approach with engine(s) inoperative.

(15) Navigation and communications.

(16) System operation associated with approach.

(17) Abnormal and emergency procedures associated with approach.

i. Landing Roll and Taxi In.

(1) Spoiler operation.

(2) Reverse operation.

(3) Directional control and ground handling.

(4) Normal brake and anti-skid operation.

(5) Emergency brake operation.

(6) Nose wheel steering.

(7) System operation associated with landing and taxi.

(9) After-landing checklist.

j. Engine Shutdown and Parking.

(1) Transfer of systems and operation to ground power, APU or battery.

(2) Systems operation.

(3) Parking brake operation.

(4) Parking checklist.

k. All Other Items For Which Operational Approval Has Been Requested.

NOTE: At the discretion of the applicant, the FAA acceptance and approval process may be conducted at the aircraft simulator manufacturer's factory or at the applicant's training facility. When the simulator has been approved by the FAA at the simulator manufacturer's factory, the simulator will receive an FAA functional check when it has been relocated at the applicant's training facility to assure continued fidelity.

7. 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.

8. 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.

9. AIRCRAFT SIMULATOR MOTION. Visual and non-visual simulators to be approved for any of the maneuvers authorized in FAR 61, Appendix A and FAR 121, Appendix E, to be performed in a simulator in lieu of the aircraft, must have motion.

10. PERFORMANCE STANDARDS. The following list of performance standards are 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 if a maneuver, procedure, or function fails to meet the operational test criteria.

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: +/-10%.

(4) Calibration of Gyrocompass, and turn and bank indicator in standard rate turns and 30° banked turns: +/-10%.

(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.

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

(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 +/-10%.

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 +/-8 lbs., or 25% of the forces encountered in the airplane, except in regard to rudder forces, +/-10 lbs., or +/-20%.

(1) Configuration changes.

(2) Stick force per "G".

d. Roll Rate in the simulator in operational configuration should be within +/-2 seconds or 25%.

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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