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VOLUME III

AIRCRAFT SIMULATOR DATA REQUIREMENTS STUDY

SYSTEMS RESEARCH LABORATORIES, INC.
2800 INDIAN RIPPLE ROAD
DAYTON, OHIO 45440

JANUARY 1977

TECHNICAL REPORT ASD-TR-77-25, VOLUME III

AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Air Force had encountered difficulties involving the availability, quality, and format of air weapon system design data required for the acquisition of simulators. In view of the increasing importance of modern digital computer-driven flight simulators in providing the required training, both for initial qualification and for the maintenance of readiness, it was determined that an up-to-date standard to identify the data required by simulator manufacturers was needed. This standard would then be included in the development

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and acquisition contracts for future weapon systems to provide for the timely supply of the requisite data.

Systems Research Laboratories, Inc. was selected to perform a study of the simulator data requirements, resolve any difficulties incident to the timely supply of that data, and prepare a General Requirement for the acquisition of that data in future contracts. The study was conducted by surveying simulator manufacturers and simulator acquisition activities to determine the problems and requirements, then surveying aircraft, avionic systems, and engine manufacturers to determine data availability, problems in satisfying the requirements, and suggestions for alternate approaches.

As a result of this study, a proposed General Requirement was prepared which could be included in future weapon system procurement contracts to provide for the timely supply of the data required for simulator development. In addition to this "Data Specification," certain other actions are required to make the system work.

1. Order the data when the aircraft is ordered.
2. Place simulator data at a high enough precedence to ensure compliance
3. Make certain that simulator data requirements are included in the procurement contracts for GFE items.
4. Have simulator data delivered to the Government.
5. Have an initial data package based on the best data available, probably wind tunnel, bench test, and engine test-stand supported estimations delivered after the aircraft design freeze and before announcing the simulator development competition.
6. Have the initial data package updated at specific block intervals until all data is based on flight test results or equivalent "hot bench" data.
7. Task the Air Force Flight Test Center to make engineering simulations of each new aircraft development program and to derive the handling qualities and performance parameters from flight test data for the use of the simulator manufacturer. Make this an early item in the flight test program so that the simulator can be in operation at the operational command in time to support the receipt of the first aircraft.
8. Task AFFTC to supply a qualified test pilot current in type and a flight test engineer to assist in the simulator development from the initial contract award through acceptance testing.

Other recommendations for further studies to resolve certain simulation technical problems and to reduce the cost of simulators are included in the report.

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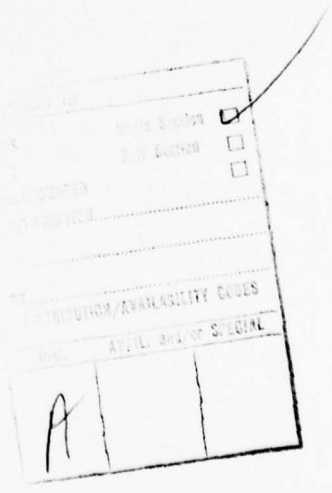

GENERAL DATA REQUIREMENTS FOR DESIGN OF AIRCRAFT TRAINING EQUIPMENT

1.0 SCOPE

This specification establishes the requirements for the preparation of aircraft design data for use in the design of aircraft training devices. The configuration data supplied herein will be used to fabricate and assemble crew stations which are physically equivalent to those used in the aircraft. The performance data will be used to develop transfer functions which will be programmed on a computer to accept inputs from pilot and crew stations and generate outputs to activate instruments, displays, indicators, etc. in a realistic manner.

2.0 DESIGN DATA FORM

Design data shall be provided in the form specified in the aircraft manufacturer's development contract with the Government.

3.0 CONFIGURATION DATA

The following data shall be provided by the aircraft contractor:

(a) General arrangement drawing of aircraft showing fuselage stations, water lines, and butt lines of crew stations from forward to aft bulkheads, floor line to top of canopy, and from maximum left to maximum right butt lines of crew stations.

(b) Drawings showing general arrangement of crew stations interiors and identifying all instruments, indicators, displays, controls and furnishings.

(c) Loft line drawings of fuselage from bulkhead forward of crew station to bulkhead aft of crew station.

(d) Structural assembly, subassembly, and detail drawings of cockpit and crew stations showing instrument panels and control consoles, along with panel, crew station floor, and fuselage internal structure.

(e) Drawings showing fields-of-view from crew stations and showing any obstructions to vision. Include data on the location of the air refueling receptacle.

(f) Drawings showing the landing gear position, center-of-gravity, fuselage angle-of attack, etc.

(g) Installation, assembly and detail drawings of windshields, canopy, crew seats, throttles, indicators, hand controls, and panels.

(h) Copies of engineering orders and engineering change proposals shall be submitted.

4.0 WEIGHT, BALANCE AND MOMENTS OF INERTIA DATA

The following weight, balance, and moments of inertia data shall be furnished by the aircraft contractor.

(a) The three first moments and six second moments of the empty aircraft plus normally fixed articles shall be furnished.

(b) The three first moments, and six second moments of each article and external store capable of being moved, consumed, jettisoned, or released in flight shall be furnished.

(c) The weight of the empty aircraft along with the individual weights of each article consumed, jettisoned, or released shall be furnished.

(d) Reference axes and planes shall be explicitly identified.

5.0 AERODYAMIC DATA

The specified aerodynamic data shall be consistent with the data used in preparing the flying qualities and demonstration reports submitted by the aircraft contractor. When data are available from more than a single source, the order of preference shall be:

(a) Flight test data

(b) Wind tunnel data

(c) Theoretical data

Stability derivatives derived from flight test (a) are preferred. When data of a higher preference becomes available, the original data shall be replaced or updated as needed. The aerodynamic data shall be sufficient to cover the operational flight envelope and initial departure in both the clean configuration and with external stores.

5.1 Aerodynamic Functions

Functions showing the dependence of the aerodynamic coefficients on each of the variables as listed below shall be presented. The representation of functions may be graphical, analytic, or tabular. Axis systems shall be defined and the maximum ranges of the following coefficients and variables indicated:

(a) Coefficients

(1) Airplane lift

(2) Airplane drag

(3) Airplane longitudinal force

(4) Airplane side force

(5) Airplane vertical force

(6) Airplane rolling moment

(7) Airplane pitching moment

(8) Airplane yawing moment

(9) Aileron hinge moment

(10) Stabilizer hinge moment

(11) Rudder hinge moment

(12) Other applicable control surface moments

(b) Variables

(1) Angle of attack (including post stall angles)

(2) Angle of sideslip (including post stall angles)

(3) Time rate of change of angle of attack

(4) Time rate of change of angle of sideslip

(5) Rolling velocity

(6) Pitching velocity

(7) Yawing velocity

(8) Mach number

(9) Control surface deflections including asymmetrical operation (elevators, ailerons, rudders, taps, flaps, speed brakes, spoilers, wing sweep, leading and trailing edge devices, etc.)

(10) Time rate of change of control surface deflections

(11) Aeroelastic effects as a function of altitude and dynamic pressure

(12) External stores including incremental data for each store type and station, including pylons and racks with interference effects

(13) Landing gear and door excursions

(14) Inoperative engine

(15) Feathered propellers

(16) Center of gravity

(17) Ground effects

(18) Thrust coefficient

(19) Ground handling including the effects of nose wheel steering, braking, etc.

(20) Other significant factors such as structural mode data

5.2 Dynamic Characteristics

Time histories of the longitudinal-and lateral-directional characteristics of the aircraft for the entire flight envelope shall be provided. The data shall be annotated to indicate aircraft weight, center-of-gravity, inertia, and other pertinent data necessary to clearly denote test conditions. The time histories shall include:

(a) Short period longitudinal oscillation

(b) Phugoid

(c) Dutch roll

(d) Roll

(e) Longitudinal trim changes resulting from

(1) Landing gear position change

(2) Flap, slat, spoiler, and speed brake position change

(3) Wing sweep change in position

(4) Power setting changes

(f) Spiral stability

5.3 Maximum Values

Maximum values based on the flight envelope shall be tabulated or plotted for the following:

(a) True airspeed

(b) Placard and red line speeds for each configuration

(c) Linear accelerations and velocities along the wind, stability, or body axes of the airplane

(d) Angular accelerations and velocities about the wind, stability, or body axes of the airplane

(e) Rates of climb and dive

(f) Altitude

(g) Mach number

(h) Maximum range and rates of change of angle of attack and sideslip

(i) Limits of potential growth envelope

5.4 Buffeting

Buffeting characteristics shall be described in terms of the following:

(a) Boundary conditions in terms of variables

(b) Frequency and amplitude of vibrations as a function of the pertinent variable. Measurements shall be made at the crew stations.

5.5 Stall

Stall warning and recovery characteristics of the airplane shall be described. If available, a time history of stall entry and recovery shall be presented. All pertinent parameters such as altitude, gross weight, center-of-gravity and configuration shall be specified.

5.6 Spin

The conditions for entry and recovery from spins as well as the characteristics of the spin shall be described in terms of pertinent variables and instrument indications. The results of flight tests including time histories and motion pictures/video tapes are required.

5.7 Ground Handling

Data shall be provided which describes taxiing behavior including the operation of the brakes and nose wheel steering systems. Data shall include:

(a) Landing strut compression data
(b) Deceleration due to foot brakes as a function of pedal position and airplane velocity
(c) Pedal forces versus pedal position for braking
(d) Yaw moment due to asymmetric braking
(e) Turn angle of nosewheel as a function of cockpit control deflection
(f) Rudder effectiveness and oleo data

5.8 Notation of Axis Systems

All axis systems shall be defined to provide projections of forces and moments from one coordinate system to another. Coefficients shall be defined in terms of a non-vanishing dynamic pressure point.

6.0 PROPULSION SYSTEM DATA

Installed engine performance data shall be furnished by the aircraft contractor in accordance with the following requirements where applicable.

6.1 Turbojet and Turbofan

(a) Installed engine performance shall consist of the following:

(1) Curves showing the performance of the engine at sea level and at 10,000 feet increments up to the maximum rated altitude of the engine shall be furnished. At each specified altitude the variation of the net jet thrust, fuel flow, exhaust temperature, and airflow shall be shown as a function of the pertinent parameters.

(2) Data showing the installation losses shall be provided and the methodology used for computing the losses shall be indicated.

(3) Data for correcting net jet thrust, fuel flow, and airflow for nonstandard temperature conditions for various altitudes over the full operating range of the engine shall be provided.

(4) Curves for engine operating limits shall be provided.

(5) Curves showing correction of net jet thrust and fuel flow for power extraction and bleed air flow shall be provided for the altitudes specified.

(6) Description, characteristics and schematics for the control system used in manipulating variable geometry devices associated with power plant installation shall be provided.

(b) An engine calibration summary shall be included which provides:

(1) Pilot's power lever position versus the controlled engine variable, thrust, engine speed, turbine outlet, temperature and fuel flow for the complete operating range.

(2) Elapsed time versus power lever position, engine pressure ratio, and thrust during a controlled start, acceleration and deceleration.

(3) Where emergency controls are used, completely describe the characteristics of the emergency control and transients which occur during the transfer of primary control.

(4) Where variable area jet nozzle controls or other surface controls are provided, additional curves shall be furnished to show proper positioning of these controls for best performance and also the variation in performance, such as thrust, fuel consumption and gas temperature with position of the controls.

(5) Oil volume flows and pressures as a function of variables when external oil system is used.

(c) A system operation summary shall provide the following data:

(1) Characteristics and schematics of engine controls including fuel scheduling.

(2) Description of the control system with the angular relationship between the throttle lever position and the control mechanism. The description shall include a functional block diagram of the engine and control system. Each block

shall be identified and contain a transfer function which relates the input to the output under normal, emergency, and transient conditions.

(3) Characteristics of engine performance during operation with the emergency fuel system.

(4) Cooling and deicing system data including sources, outlets and requirements.

(d) A power plant operation summary shall be included which provides:

(1) Specific engine operating instructions for normal and emergency conditions including starting, stopping procedures, etc.

(2) A time history for normal and air starts.

(3) Data showing start and warmup as a function of time including related instrument indications.

(4) Air-start data (windmilling speeds versus Mach number) and procedures for all operating altitudes.

(5) Time histories for the operating range of the power plant including acceleration to take-off r/min from idle and for deceleration from take-off r/min to idle. All variables, such as tailpipe temperature, oil pressure, fuel pressure, pressure ratio, etc. for both normal and emergency fuel control shall be presented. These data shall include the effects of small changes in throttle position, particularly in the 80 to 95 percent r/min region.

(6) Exhaust gas temperature and pressure ratios versus true airspeed for various altitudes, engine speeds, and true airspeed.

(7) Exhaust gas temperature versus r/min for ground operation.

(8) Minimum idling r/min fuel flow, and thrust versus altitudes and airspeeds for normal and emergency control.

(9) Indicators versus control parameters for all engine instruments.

(10) Run down time from idle r/min for both ground and in-flight conditions, the latter to be at different altitudes.

(11) If procedures can be executed in more than one sequence, provide data to define results of following incorrect procedures (e.g., hot start, engine overspeed, compressor stall, etc.).

(e) Data describing engine malfunctions shall be presented for various types of engine or accessory failures. The data shall include the indications of failure, the corrective action required, the results of the applied corrective action and the results to the engine, aircraft or related system if appropriate action is not taken. The following list is representative of failures for which data will be required.

(1) Total engine failure

(2) Partial loss of power

(3) Abnormal oil temperature or pressure

(4) Abnormal tailpipe or exhaust gas temperature

(5) Engine driven fuel pump failure or failure of the primary engine fuel system.

(6) Engine flameout as a function of altitude, airspeed, and power setting.

(7) Hot start.

(8) Unstable operation of compressor, burners and control systems.

(9) Misposition of the variable geometry components, such as variable area nozzle, inlets, and auxiliary doors.

(10) Engine fire.

(11) Abnormal pressure ratio and r/min.

(12) Abnormal fuel pressure.

(13) Failure of each transfer pump.

(14) Failure of each main fuel booster pump.

(15) Failure of each fuel control valve.

(16) The engine manufacturer shall provide a list of the most likely malfunctions or failures determined by a failure analysis or experience with this or similar engines.

(f) Polar moments of inertia of the turbine and compressors, including accessories.

6.2 Turboprop Engines

(a) Installed engine performance shall consist of the following:

(1) Curves showing the performance of the engine for the following ratings: take-off, military, normal, 80 percent normal, 60 percent normal and 40 percent normal. The curves shall show the variation of propeller shaft horsepower, airflow, equivalent shaft horsepower, specific oil consumption, and equivalent specific fuel consumption versus altitude for constant true aircraft speeds. The propeller efficiency used for calculating equivalent performance shall be presented.

(2) Data showing all installation losses and method of calculation.

(3) Engine operating limits curves.

(4) Description, characteristics and schematics for the control system utilized for variable geometry features of power plant installations.

(b) A summary of engine calibration shall consist of:

(1) Power lever and governor position versus thrust, engine speed, turbine outlet temperature, and fuel flow for the full Mach number and altitude range.

(2) Elapsed time versus power lever position, engine speed, exhaust gas temperature, fuel flow, pressure ratio and thrust during a controlled start, acceleration, deceleration.

(3) Where emergency controls are used, time histories of engine r/min, gas temperature, thrust and fuel pressure (emergency pump) during an automatic change from the primary control to the emergency control, shall be provided.

(4) Where variable area jet nozzle controls or other sub-controls are provided, curves showing variation in performance such as thrust, fuel consumption, gas temperature with position of the controls.

(5) Oil volume flows and operating pressure when external oil system is used.

(6) Definition of actual values of r/min for various percent r/min values.

(c) System operation

(1) Characteristics and schematics of engine controls including fuel scheduling.

(2) Description of the control system with the angular relationship between the throttle level position and the positions of the control mechanism.

(3) Characteristics of engine performance during operation with emergency fuel system.

(4) Cooling and deicing system data including sources, outlets and requirements.

(d) A power plant operation summary shall be included which provides:

(1) Specific engine operating instructions for normal and emergency conditions including starting, stopping procedures, etc.

(2) A time history for normal and emergency starts.

(3) Data showing start and warmup as a function of time, including related instrument indications.

(4) Air-start data and procedures for all operating altitudes.

(5) Time histories for entire operating range of the power plant including acceleration to take-off r/min from idle and for deceleration from take-off r/min to idle. All variables, such as temperature, oil pressure, fuel pressure, pressure ratio, etc. for both normal and emergency fuel control shall be presented.

(6) Exhaust gas temperatures and pressure ratios versus true airspeed for various altitudes and engine speeds.

(7) Exhaust gas temperature versus r/min for ground operation.

(8) Minimum idling r/min, fuel flow, and thrust versus altitudes and airspeeds for normal and emergency control.

(9) Normal operating values for all engine instruments.

(10) Run-down time from idle r/min.

(e) Engine malfunctioning data shall be presented for various types of engine or accessory failure. The data shall include the indications

of failure, the corrective action required, the results of the applied corrective action and the results to the engine, aircraft or related system if appropriate action is not taken. These data shall be presented in tabular form. The following list is typical of such failures:

(1) Total engine failure.

(2) Partial loss of power.

(3) Abnormal oil temperature or pressure.

(4) Abnormal exhaust gas temperature.

(5) Engine driven fuel pump failure or failure of the primary engine fuel system.

(6) Flameout as a function of altitude, airspeed and power.

(7) Hot start.

(8) Unstable operation of compressor, burners, control systems, and governor.

(9) Engine fire.

(10) Abnormal pressure ratio and r/min.

(11) Abnormal fuel pressure.

(12) Failure of each transfer pump.

(13) Failure of each main fuel booster pump.

(14) Total failure of each fuel control valve.

(f) Propeller data:

(1) Propeller designation.

(2) Blade angle setting.

(3) Blade activity factor.

(4) Correction factor due to installation.

(5) Propeller governor and control system operating characteristics regions attainable within operating airplane envelope as follows:

a. C_Q against J for constant blade angles.

b. Q_C against 1/J for constant blade angles.

c. C_t against J for constant blade angles.

d. T_C against 1/J for constant blade angles.

e. Tip Mach number correction.

7.0 AIRCRAFT SYSTEM DATA

Data for these systems shall be provided by the aircraft contractor in such a form as to completely describe the system operation. Static, dynamic, and transient conditions shall be defined in sufficient detail to permit accurate duplication of system response, characteristics, and indications. Where component specifications, specification control drawings, or demonstration reports are prepared, such data shall be furnished for the respective component or system. The normal and emergency operation shall be given for each system. These data shall include the indications of failure, the corrective actions required, the results of the applied corrective action, and the results to the system and aircraft if the appropriate action is not taken. These data shall be presented in tabular form for each system. The requirements stated herein are examples of the types of data needed for typical aircraft systems.

7.1 Surface Control Systems

(a) Drawings of all surface control systems from controls to surfaces.

(b) Control deflections versus surface deflections at no load. Control forces versus accelerations.

(c) Boost tab (or other load relieving device) characteristics.

(d) Power boost system characteristics.

(e) Artificial feel characteristics and forces.

(f) Friction characteristics.

(g) Deformation characteristics.

(h) Ratio of torque at stick and pedal axes to angular accelerations of respective controls.

(i) Trim tab (or other trim device) deflections versus tab indicator readings, and control forces for given settings.

(j) Rates of movement of trim devices, flaps, and speed brakes under normal and emergency conditions.

(k) Blowback characteristics of flaps.

(l) Slat position as a function of all pertinent variables.

(m) Transfer functions of control surface servos.

7.2 Ground Braking and Steering System

(a) Deceleration due to foot brakes as a function of brake pedal position and speed.

(b) Pedal force versus pedal position for braking.

(c) Yawing moment due to asymmetric braking.

(d) Turn angle of nosewheel as a function of cockpit control deflection.

(e) Coefficients of tire friction for typical runway surfaces.

(f) Anti-skid system characteristics.

7.3 Landing Gear System

(a) Rates of extension and retraction including the effects of airspeed and reduced hydraulic pressures.

(b) Forces for control handle operation.

(c) Tire rolling friction and drag coefficient as a function of tire angle.

7.4 Hydraulic and Pneumatic Systems

(a) System schematic of hydraulic and pneumatic systems.

(b) Operating values of bypass valves, volume flow of pumps, volume flow through hydraulic motors, and hydraulic ram displacements.

(c) Hydraulic and pneumatic pressure readings as a function of system operation including time histories of variations.

(d) Amplitude and rate of transient response of indicated hydraulic pressure for system loads, individually and in combination.

(e) Accumulator decay rates.

7.5 Electrical Systems

(a) Circuits and schematics of electrical systems and electronic system installations.

(b) Electrical load analysis.

(c) Voltmeter, ammeter, power meter and frequency meter readings as a function of electrical system operation.

(d) Detail of system management including normal and emergency procedures.

(e) Details of the constant speed drive unit.

7.6 Anti-icing System

(a) Description of operation, including schematic diagrams.

(b) Time of operation for various climatic conditions.

7.7 Fuel System

(a) Description of installation and operation, including schematic diagrams, operation pressures of valves, and volume flow of pumps as a function of r/min and pressure differences.

(b) Fuel pressure readings for each combination of boost pumps and engine pumps as a function of pump r/min and pressure differences.

(c) Maximum and minimum rates of consumption and rates of transfer and dump.

(d) Details of fuel system management.

7.8 Oil System

(a) Description of operation, including schematic diagrams.

(b) Details of oil system management.

7.9 Fire Warning and Control System

(a) Description of operation, including schematic diagrams.

(b) Time of operation.

(c) Temperatures and conditions that cause warning lights to illuminate.

7.10 Cabin Pressurization System and Pilot Equipment Support

(a) Description, including schematic diagrams, of pressurization system, cabin air conditioning system, G suit, oxygen, and full pressure suit systems.

(b) Cabin altitude and its relation to aircraft altitude, cabin pressure control setting and engine shutdown.

(c) Emergency cabin pressurization dump procedure for smoke and fumes elimination or ejection and including rates of pressurization and dump.

7.11 Emergency Escape System

(a) Description of operation of all emergency escape equipment, including schematics.

(b) Procedure for use of emergency escape equipment.

7.12 Automatic Stabilization and Control System

(a) Description and operation of autopilot and damper systems for each axis, including schematics.

(b) A functional block diagram with appropriate transfer functions of autopilot and yaw damper systems shall be provided.

(c) Time histories of aircraft transient response with autopilot on and off and with dampers on and off.

(d) Description and operation of auto-throttle system with all transfer functions.

8.0 AIRCRAFT INSTRUMENTS DATA

The aircraft contractor shall supply the following for all contractor-furnished aircraft instruments. For aircraft GFE items, the aircraft contractor shall supply installation information covering operating pressures, activation voltages, or other activating devices for instrument operation.

(a) Description of normal and emergency operation of instruments.

(b) Dependencies of accurate instrument outputs upon proper aircraft systems operation.

(c) Instrument malfunction data presented for various cases of instrument failure or resulting from associated system failure.

(d) Instrument reading time histories of instrument or instrument system, variation and fluctuations.

(e) Position of instrument pointers with power removed.

(f) Static and dynamic performance data shall include the effects of installation on instrument performance.

(g) Indications of instrument or system malfunctions, e.g., flags, barber pole, etc.

9.0 AVIONICS SYSTEM DATA

The aircraft contractor shall supply the following for all contractor-furnished equipment on the aircraft and for contractor-modified equipment provided as Government-furnished equipment. The design data shall be furnished which describes in detail the characteristics of the installed equipment. For GFE, the aircraft contractor shall supply equipment interfaces with other systems and installation information covering operating pressures, activation voltages or other activation devices for equipment operation.

(a) Input/output properties for each equipment module such as power requirements, signal characteristics (e.g., pulse duration, levels, parallel or serial) and timing diagrams showing timing relationships of signals and other pertinent data.

(b) Test and alignment procedures.

(c) External wiring diagrams showing interfaces between equipment modules, interface with other systems, and installation instructions.

(d) Internal schematics or functional equivalent diagrams with transfer functions or Boolean equations for each block.

(e) Design data supplied with preproduction or design approved model.

(f) Reports on contractor's test results.

(g) Detail equipment specification.

(h) Interim and final engineering reports, including narrative descriptions of each function and module.

(i) Detailed mechanical drawings of all control units, controls, indicators, and displays.

(j) Engineering change notices.

(k) Video recordings of display signals or movie films of operating display systems with annotations of aircraft status.

(l) Descriptions of the behavior and status of a system when the controls are activated in sequences other than those specified or recommended by the manufacturer.

(m) Mathematical models and program developed by the airframe manufacturer and an estimate of their utility.

(n) Known or suspected malfunctions (abnc alities) with cause and effect.

9.1 Communication, Navigation and Identification System

(a) A detailed description of all types used in the aircraft and including the type number, modification letters, operation, operating frequencies, manufacturer, and control box type and associated indicators.

(b) System diagrams of intercabling between receivers, transmitter, control, and power sources.

(c) Type, number, layout and manufacturer of each control panel.

9.2 Navigation Equipment System

(a) Description of operation of navigation computer and display systems. Description of operation and interaction with other systems, and displays of each knob, button and switch.

(b) Schematic diagrams and functional diagrams and transfer functions of the complete system.

(c) System failures, anomalies and malfunctions based on system analysis or experienced in operation.

9.3 Radar System

(a) Type (pulse, doppler, attack, terrain following, etc.)

(b) Number of modes and description of each.

(c) Antenna

(1) Scan pattern generator equations.
(2) Tracking equations.
(3) Radiation pattern for all modes.
(4) Stabilization platform transfer function with respect to aircraft and ground references.
(5) Scan rate(s).

(d) Transmitter

(1) PRF in each mode.
(2) Pulse width in each mode.
(3) Peak and mean power.
(4) Frequency(ies).
(5) Special capabilities--jitter, pulse compression, stagger, etc.

(e) Receiver (each item as a function of mode)

(1) AGC characteristics, MGC characteristics.
(2) Lin/log characteristics.
(3) Minimum detectable level (i.e., detection capability).
(4) Special processing for displays (e.g., doppler filtering).

(5) Interface signals and signal strength for tracking system and display system.

(6) Noise figures.

(7) Special effects such as response to jamming, etc.

(8) Video bandwidth.

(9) Dynamic range.

(f) Tracking system (each item as a function of radar mode)

(1) Ranging capability max./min. ranges, range rate.

(2) Velocity capability.

(3) Lock-on characteristics in terms of signal strength and range rate.

(4) Resistance to jamming (e.g., range gate stealer).

(5) Break lock criteria such as signal strength, manual control, etc.

(6) A/G ranging criteria.

(7) Details of interface with other displays (provide photographs, diagrams), fire control system, and on-board computer.

(g) Display system (each item for each radar mode)

(1) Photographs and movies of displays to illustrate effects of radar modes and noise, jamming, and target returns. For each photograph and throughout each movie, provide detailed information on environmental conditions (weather, etc.) and on aircraft and equipment status.

(2) Sensitivity to input signal--indicate shades of gray versus video signal strength.

(3) Description of use of display tracking with controls.

(4) Photographs to show display type such as A-scope, B-scope, pulse doppler, etc.

(5) Photographs of ground maps and descriptions of use of system to perform navigation fixing using cursors or other interactive devices.

(6) Response times of display changes to changes in control and radar mode change inputs.

(h) Cooperating Systems

(1) Description and functional diagram showing the interfaces of the radar system with all other cooperating systems.

(2) Interface specifications showing all external interfaces.

(3) Scan converter characteristics.

9.4 Head Up Display

(a) Detailed description of modes versus symbolic displays.

(b) Photographs of displays showing all symbology in all modes.

(c) Field of view relative to eye point (provide detailed drawing).

(d) Standby reticle--provide detailed drawing.

(e) Mirror deflections.

(f) Cooperating systems.

(1) Descriptions and functional diagram showing interfaces of HUD with all other systems and equipment.

(2) Interface specifications showing all external interface signals.

(g) HUD alignment procedures.

9.5 Central Configured Avionics System

The following data on the Central Computer Complex is required.

(a) Hardware

(1) Memory description including word size, cycle time.

(2) CPU description including speed (number of instructions per second).

(3) Input/output description and transmission rates and data formats.

(4) A complete description of the hardware is required.

(b) Software

(1) Operating system description including program control.

(2) Programming manual.

(3) Programming data for all modules.

a. Mathematical model

b. Flow charts and narrative description

c. Interaction rate or interrupt conditions

d. Worst-case cycle time and conditions for worst case.

e. Detail listing of source code with descriptions.

f. Symbol dictionary

g. Tactical tapes

(4) Data structure.

(5) A copy of the software documentation and user's manuals.

(c) Interface with cooperating systems

(1) Digital discrete I/O

a. Description of signal, symbol name and source

b. Destination hardware or software

c. Transfer rates

(2) Analog I/O

a. Description of signal, symbol name and source or destination in hardware

b. Transfer rates

(3) Descriptions for all digital, discrete, and analog I/O signals.

a. Signal timing

b. Pulse magnitudes

c. Pulse lengths

d. Other pertinent signal parameters

9.6 Weapon Control System

(a) System description

(1) Detailed circuit diagrams and narrative descriptions of theory of operation.

(2) Detailed interface signal descriptions indicating effects of transmitted and received signals.

(3) Detailed specification of weapon release computations, envelope computations and computed information such as steering, blast and ground clobber avoidance.

(4) Detailed interface signals and descriptions of the armament system with other systems, e.g., navigation, flight control, central computer, search sensors, etc.

(b) Stores management system

(1) Description of controls and procedures for arming weapons.

(2) Procedures for firing guns, launching rockets, missiles and dropping bombs.

(3) Detailed wiring and electrical schematics for procedures outlined in (1) and (2) for all launch, fire and release logic including jettison of weapons or pods.

(c) Cockpit displays

(1) Detailed descriptions of all status and steering displays associated with armament system.

(2) Schematics which show how the indicators, lights, and other status devices are driven by the armament system.

(3) Schematics and transfer functions showing dynamic relationship of release computations to the pilot's steering display for each operational mode such as dive, dive toss, predicted impact, etc.

9.7 Weapon Description

Basic data weapon type shall be provided as follows:

(a) Nomenclature (e.g., AIM-9B, MK-82)

(b) Weight, center of gravity, moment of inertia.

(c) Quantity per station and sequence of weapon release.

(d) Pertinent ballistic coefficient and characteristics to predict accurate trajectory and impact point after release of weapon from aircraft.

For each of the weapons the following data is required.

(a) Missiles

(1) IR homing

a. Prelaunch procedures to prepare a missile for launch.

b. Interface signals of missile with on-board systems such as radar antenna.

c. Missile antenna characteristics such as beamwidth, scan rate and stabilization transfer function.

d. Launch criteria such as gimbal limits, body rates, etc.

e. Lock-on tone frequency and indicators.

f. Search tone frequency and indicators.

g. Fusing and arming criteria and lethal envelope.

h. Thrust characteristics and in-flight control capability.

(2) TV homing or command controlled

a. Prelaunch requirements such as acquisition using on-board displays.

b. Camera characteristics such as bandwidth and slew capability as a function of on-board controls.

c. Launch criteria such as gimbal limits, body rates, etc.

d. Manual control inputs during cruise.

e. Thrust and guidance characteristics.

(3) Radar homing

a. Fire control interface details.

b. Interface signals with on-board radar.

c. Description of effects of missile radar on the on-board systems.

d. Antenna systems characteristics (e.g., tracking, lock-on criteria, antenna steering criteria).

e. Inflight performance, control capability and guidance characteristics.

(b) Guns

(1) Fire rates (number of rounds/sec).

(2) Weight loss per second during firing and rate of center of gravity shift.

(3) Effects of recoil on aircraft.

(4) Boresight and bullet dispersion for guns.

(c) Rockets

(1) Fire rates.

(2) Number of rockets per pod.

(3) Reaction of rocket motor on aircraft.

(4) Effect of rocket motor on airflow.

9.8 Penetration Aids

(a) Radar homing and warning system (RHAWS)

(1) Nomenclature.

(2) Description of controls for all types of threats.

(3) System schematics or equations showing decision logic and system operation with narrative description.

(4) Interaction of system with other systems such as radar, audio and countermeasures.

(5) Audio tone characteristics and criteria.

(6) Receiver sensitivity.

(b) Countermeasures receiver system (CMRS)

Refer to RHAWS (para. 9.8)

(c) Electronic countermeasures (ECM)

(1) Controls/system response.

(2) Interface with other penetration aids.

(d) Countermeasures dispenser system (CMDS)

(1) Controls/indicators description.

(2) Break track characteristics.

(3) Interaction with other penetration aids.

(e) Jammers

(1) Transmitted power.

(2) Nomenclature.

(3) Description.

(4) Interactions with other systems.

(5) Frequency, bandwidth, etc.

10.0 AIRCRAFT SOUND RECORDING DATA

The aircraft contractor shall supply sound recordings on tape as follows:

(a) Tape characteristics

(1) Standard sound recording magnetic tape.

(2) Recorded at 7-1/2 or 15 inches per second.

(3) Recorded through a system with a minimum frequency reponse of 80 to 15,000 Hz with plus or minus 5 decibels.

(4) Recording shall be stereo with known microphone positions.

(b) Recording content

(1) Narrated sounds recorded at the pilot's and crew stations of the aircraft.

(2) Sounds shall include engine starting, taxiing, take-off, climb, cruise, windmilling, buffet, descent, landing, tire screech, and engine shut down. The sounds associated with the operation of flaps, landing gears, actuators, etc. audible at crew stations shall be recorded and identified. Afterburner sounds shall be included.

(3) Sounds of accessory equipment during normal and emergency operation which are audible to the aircraft personnel shall be recorded and identified. Warning sounds associated with emergency flight conditions or the operation of avionics systems shall be provided.

(4) EW equipment.

(5) Sounds shall be provided for weapons release and launch and gunfire.

11.0 VIBRATION DATA

Data showing the levels, frequencies, and orientation of vibrations present at the pilot and crew stations shall be presented. If data is dependent on engine and flight conditions, these conditions shall be identified.

12.0 CHARACTERISTICS AND PERFORMANCE DATA

Preliminary copies of standard aircraft characteristics charts and substantiating performance data shall be submitted.

13.0 ESTIMATED FLYING QUALITIES

Estimated flying qualities and performance data shall be submitted by the aircraft contractor. Test results shall contain details on procedures, aircraft configuration, test and ambient conditions.

14.0 DEMONSTRATION DATA

The following reports shall be submitted:

(a) Aerodynamic Demonstration Report
(b) Power Plant Demonstration Report
(c) Equipment Demonstration Report
(d) Demonstration Progress Report
(e) Electronic Demonstration Report
(f) Armament Demonstration Report
(g) Hydraulic and Pneumatic Demonstration Report
(h) Weight and Balance Reports
(i) Spin Test Report
(j) Flight Test Report

To aid in the identification of engineering reports, the aircraft contractor shall submit an accession list showing the names and a brief description of all reports related to the aircraft, engine, systems, avionics, instruments, displays, etc. This list shall include published reports, informal documents, and memorandums.

15.0 HANDBOOKS

Copies of the Pilot's Flight Handbook and the Aircraft Handbook of Maintenance Instruction and Parts Catalog shall be submitted along with all revisions.

16.0 PHOTOGRAPHS

Photographs of the aircraft mockup, cockpit and crew stations shall be submitted.