DATA ITEM DESCRIPTION

Title: AIR VEHICLE FLIGHT PERFORMANCE DESCRIPTION REPORT FOR ROTORCRAFT AND PROPELLER-DRIVEN FIXED-WING AIRCRAFT

Number: DI-SESS-82321
AMSC Number: 10185
DTIC Applicable: No
Preparing Activity: AV
Applicable Forms: N/A

Approval Date: 20200610
Limitation: N/A
GIDEP Applicable: No
Project Number: SESS-2019-022

Use/relationship: The Air Vehicle Flight Performance Description Report for Rotorcraft and Propeller-driven Fixed-wing Aircraft provides engineering design, test and analysis information quantifying the flight performance characteristics, capabilities and limitations of air vehicles. The information contained in the report and supporting documentation will be used to support development of a flight performance model of the air vehicle. This model will be used to calculate performance characteristics and mission capabilities throughout the flight envelope. The data provided will also be used to calibrate conceptual design tools for future acquisition programs and design trade studies. It is the purpose of this Data Item Description (DID) to ensure complete documentation of the air vehicle flight performance at a level of data quality and substantiation consistent with the current design stage of the air vehicle.

The Air Vehicle Flight Performance Description Report for Rotorcraft and Propeller-driven Fixed-wing Aircraft data item is intended to be used in conjunction with the air vehicle's corresponding weight report (DI-MGMT-81501) and the Air Vehicle Technical Description (DI-SESS-82291) report. The engineering data in these reports form the basis of a digital representation of the performance of the air vehicle.

a. This DID contains the format, content, and intended use information for the data deliverable resulting from the work task described in the contract.

b. This DID is applicable to acquisitions of air vehicles, from conceptual design through Operations and Sustainment of a fielded system.

Requirements:

1. Reference documents. The applicable issue of the documents cited herein, including their approval dates and dates of any applicable amendments, notices, and revisions, shall be as specified in the contract.

2. Format. The Air Vehicle Flight Performance Description Report for Rotorcraft and Propeller-driven Fixed-wing Aircraft and supporting documentation shall be in contractor's format. Multiple format possibilities are anticipated, and permitted, as stipulated by the requiring activity in its contract. The following sections provide specific format requirements associated with the air vehicle system lifecycle phase.

2.1 Graphs and Tables. This report shall present graphs and tables embedded in the report in a manner that depicts and delineates the documented data as follows:

a. If a graph has been constructed based on experimental information, it shall show the data points in symbol format. If a graph has been constructed based on an analytical model, show the data in curve format.

b. The scales and grids used on graphs shall facilitate interpolation and reading of data directly from the graphs.

c. The layout of graphs shall facilitate comparisons between graphs. In general, this means that all graphs which show a particular parameter shall use the exact same scale for that parameter. As a specific example, all graphs with airspeed on the x-axis and power on the y-axis shall use the same ranges and physical lengths for each axis so that graphs can be physically overlaid to compare data.

d. The report shall provide all data and formulas used to generate the graphs included in this report either as tables in the body of the report or included in the delivered data file. If the data are provided in a table in the body of the report, it shall be formatted such that the data can be selected, copied, and pasted to a word processing or spreadsheet software program (e.g. American Standard Code for Information Interchange (ASCII) text format with comma delimiters).

e. The report shall provide a discussion justifying use of curves fitted to experimental data. The discussion shall describe any use of conservatism or optimism compared to the experimental data.

f. The report shall provide detailed descriptions of interpolation and extrapolation methods intended for use with data provided in a table or shown in graphs.

2.2 System of Measurement. The units for data documented shall conform to the following guidelines: all data typically or historically presented to the pilot in English or nautical units (e.g. altitude, rate of climb, airspeed) shall be presented in English or nautical units. The report shall provide all other dimensions and design parameters in units as specified in the contract.

2.3 Air Vehicle Configurations. Baseline data provided shall correspond to the primary mission configuration as specified in the air vehicle system specification (if available) for developmental program phases. For fielded air vehicles (i.e., Level III), this configuration shall be the same as defined in the flight performance section of the Operator's Manual In Accordance With (IAW) MIL-PRF 63029, 3.5.11, Chapter 7 – Performance Data. The reported configuration definitions shall include rotor and thruster positions and control schedules used for normal operation. This mission configuration definition shall correspond to a delivered Weight and Balance Report, Air Vehicle Technical Description, and acquisition phase IAW Table 1. The citation of the applicable reference documents shall be included in the report.

Table 1: Complete Mission Configuration Definition Matrix

Data Maturity Levels (See 3.3)	Air Vehicle Technical Description Levels, DI-SESS-82291	Weight and Balance Report, DI-MGMT-81501	Design Milestones
I	I	Estimated	Analysis of Alternatives
II	II	Calculated	Critical Design Review
III	III	Calculated	Production and Fielding

2.4 Configuration Changes. The report shall provide data and methods to calculate flight performance for other configurations defined in 3.3 in each applicable Content section. This shall be accomplished by providing either additional complete data sets, or corrections to the baseline flight performance data for each configuration change. For a program of record, the report shall address all Class I, Government-approved, engineering changes IAW MIL-HDBK-61, 6.1.1.2, Change Classification, and any corrections to the system technical data which impact the air vehicle flight performance.

Examples include:

a. installation of alternate rotor systems
b. removal or addition of lifting surfaces for specific missions
c. lift and drag changes due to lifting device settings
d. changes to thruster orientation to be flown operationally as a mission leg
e. alternate control schedules or manual control available to the pilot that affects flight performance
f. landing gear position – retracted or extended
g. center of gravity changes due to loading, and
h. addition or removal of external stores or externally mounted equipment which changes the vertical or horizontal drag

Sample calculations shall fully describe how performance characteristics are calculated for any corrections to the air vehicle baseline data for all configurations defined in 3.3.

2.5 Trim States. For air vehicles that use multiple control effectors to achieve trimmed flight, performance data shall correspond to those trim states necessary to achieve the specified operational conditions. The report shall provide all data and methods to correct the baseline for each alternate trim state available to operators.

2.6 Rotor Speed. For designs that use rotor speed variation throughout the flight performance envelope, the report shall provide data and methods that describe the rotor speed schedule and effects of rotor speed on power and torque required, fuel flow, power and torque available, and maneuver performance.

2.7 Data Maturity Levels.

2.7.1 General. The three data maturity levels defined below are intended to classify the types of data and methods appropriate to the air vehicle design maturity. These definitions provide some example analysis and testing for each level but are not considered a complete or mandatory list.

The level definitions in this document are intended to be consistent with the corresponding level data described in MIL-STD-31000.

The report shall declare which data maturity level applies to the provided data. The accompanying data and substantiation are provided to support the maturity level determination.

2.7.2 Level I: Conceptual. Level I addresses the types of inputs and methods which would be available in the conceptual design phase to support initial assessments for decision making. These include, use of "rules-of-thumb," parametric equations, engineering first principles, aerodynamic theory, and subject matter expertise.

2.7.3 Level II: Developmental. Level II addresses the types of inputs and methods that would be available in the preliminary or early detailed design phases. These include individual engineering assessments of key subsystems such as isolated rotor or fuselage aerodynamic modeling, subsystem wind tunnel tests, comprehensive physics-based modeling and simulation, detailed engineering drawings, air vehicle wind tunnel tests, and preliminary flight demonstrations and tests.

2.7.4 Level III: Production. Level III addresses the types of inputs and methods necessary to sufficiently describe a final validated design. These shall include production-representative air vehicle flight test data as a primary basis. Production level drawings, data derived from subsystem testing, data derived from flight test or Level II data calibrated to flight test data may be used to supplement the primary test data in order to fully describe the flight performance envelope and alternate configurations.

2.8 Confidence Assessment. For each substantiation subparagraph contained in 3.8, the report shall provide confidence in the final data set in accordance with Table 2. As an example, hover power required for a medium class helicopter may be described as a nominal value +/- 200 shaft horsepower for a critical subset of the flight performance envelope such as at the design performance conditions, while all other points in the flight performance envelope may be as much as +/- 500 shaft horsepower (these values are for example only and do not prescribe tolerance bands). Along with presentation of these bands, the report shall provide a discussion and analysis that provides substantiation of the error quantities used. The report shall include identification of all uncertainty sources such as observational uncertainty, model inadequacy, or expert opinion, if any. In addition to data uncertainties described in Table 2, the prescribed uncertainties for any model or algorithm inputs shall be provided. Table 2 lists acceptable representations of uncertainty in order of increasing specificity, along with the data maturity level considered appropriate for each type.

Table 2: Specificity of Output Uncertainty for Data Maturity Levels

Uncertainty Quantification	Description	Data Maturity Level
Bounded Interval	Expected lower and upper bounds of data.	Level I
Supported Interval with mean	Lower and upper bounds of data with estimate of mean.	Levels I and II
Quartile Intervals	Bounds (quartiles) for lower, lower-middle, upper-middle, and upper 25 % of data range.	Levels I and II
95% 95% Tolerance Intervals	95% confidence in the 95% Tolerance Interval.	Levels II and III
99% 99% Tolerance Intervals	99% confidence in the 99% Tolerance Interval.	Level III

2.9 Acceptable Data Formats.

2.9.1 General. Characterization of the overall flight performance of the air vehicle contained in 3.4 shall be provided in one of three ways as supporting documentation: a nondimensional or referred database, a delivered flight performance software model, or an exhaustive dimensional database. These options are addressed in the following sections.

2.9.2 Nondimensional or Referred Data. Traditionally, Air vehicle flight performance data has been be nondimensionalized or referred to a reference condition. This is the preferred method for rotorcraft power required data derived from flight test. However, this method may not be possible or convenient for all air vehicle types or design stages. The general format of this information shall be a baseline nondimensional or referred power required data set. This baseline database shall correspond to a set of conditions that represent a reference level of compressibility effects on power required. The range of independent variables included in the database shall be sufficient to derive dimensional or unreferred values that cover the air vehicle flight performance envelope. All methods and data needed to derive dimensional flight performance data from the nondimensional or referred database shall be included and described in the relevant section, along with inclusion of sample calculations.

Variations in power required due to compressibility shall be provided in the form of additional data sets to cover the flight performance envelope. These additional data sets shall be in terms of total air vehicle power required or changes in power required to be applied to the baseline database.

2.9.3 Performance Model. Delivery of a performance software model is an acceptable alternative to performance data described in 2.9.2, provided that the model outputs the full scope of data described in the Content section below. The model shall be executable on a host application acceptable by the Government. The full input data set, software version definition, and user documentation shall be provided. Sample data output from the model shall be provided for all missions and flight conditions needed to obtain the technical performance metrics required by the procuring agency. The performance model output data shall be subject to meeting the data substantiation requirements of 3.8, including correlation with flight test or wind tunnel data as appropriate for the corresponding Data Maturity Level. Performance models are subject to the requirements in Army Regulation 5-11 (https://armypubs.army.mil/) regarding verification, validation, and accreditation.

2.9.4 Dimensional Data. An alternative to the nondimensional database or performance model is submission of a baseline database of dimensional data. For fielded air vehicles, this is the same data used to create Operator's Manual flight performance charts. For this format option, the report shall provide data, methods, and sample calculations in order to correct the baseline data for alternate configurations.

2.10 Sample Calculations. For sections that require sample calculations, the atmospheric conditions included in Table 3 shall be used, in addition to atmospheric conditions included in the flight performance requirements of the air vehicle system specification.

Table 3: Atmospheric Conditions for Performance Calculations

Pressure Altitude (feet)	Ambient Temperature (Celsius)	Notes
0	15	International Standard Atmosphere (ISA), MIL-STD-3013
0	39.4	Hot Atmosphere, MIL-STD-3013
2000	21.1	Intermediate Condition
4000	35	A Study of the Army Hot Day Design Hover Criterion; Bellaire, Bousman, 1970 (www.dtic.mil)
0	-26.5	Polar Atmosphere, MIL-STD-3013
7122	0.9	Equivalent density altitude for 4000 feet/35 Celsius
6000	35	A Study of the Army Hot Day Design Hover Criterion; Bellaire, Bousman, 1970 (www.dtic.mil)
9532	-3.9	Density altitude for 6000 feet/35 Celsius
0	35	Navy Operational Day, ISA + 20 Celsius

3. CONTENT

General Instructions: Total system flight performance data requirements are included in 3.1 through 3.7. For data delivered in accordance with 2.9.2 or 2.9.4, the report shall include data analysis ensuring appropriate interpolation and usage of the data. The report shall include plots of the data showing general smoothness in all dimensions to allow for nonlinear or spline interpolation. If linear interpolation is preferred, the data set shall be sufficiently dense in order to reduce error for interpolated points. In either case, data matrices shall be sufficiently dense to capture the defining characteristics of the data trends such as inflections. The report shall note any points of discontinuity in the documentation. These points shall be explicitly included in the data matrix.

For any option chosen in 2.9, the data shall cover the flight performance envelope of the air vehicle. The report shall include the data for the baseline configuration defined in 3.3, along with methods and data to address changes to performance due to changes in configuration as described in 2.4.

The Air Vehicle Flight Performance Description Report shall include the following:

3.1 Introduction. The Introduction shall include a brief summary of the design status of the aircraft, recent activity that has caused a change to flight performance, and any assumptions that affect the data contained in the body of the report.

3.2 Definitions of Constants, Variables, and Reference Frame. Include any symbolic notation and unit designations in the definitions. Values and precision of constants shall be consistent with any data used from the Air Vehicle Technical Description delivered in accordance with (IAW) DI-SESS-82291, and shall be consistent throughout the delivered report. A symbol shall be assigned to a specific variable or constant and not reused to represent other quantities. Use of subscripts is permissible. The air vehicle reference frame and sign conventions shall be defined and illustrated.

3.3 Configuration Definition. The Configuration Definition shall include a description of the system configuration used for baseline flight performance data and each mission alternate configuration defined by the applicable air vehicle system specification. This description shall include all information affecting power available, fuel flow and power required. Examples of relevant information include items affecting aerodynamic lift and drag, electrical power, engine installation effects (inlet and exhaust), hydraulic system losses, and weight.

3.4 Air Vehicle Power, Fuel Flow, and Mass Flow Required. The intent of this section is to obtain total air vehicle power required at the engine output shaft and the fuel and mass flow required to produce that power. If power data is measured at some point other than the engine output shaft, include all efficiencies and losses incurred from the engine output shaft to the point at which the power data is provided, to include sample calculations.

3.4.1 Air Vehicle Hover Power Required. This baseline data set shall include total engine power required, formatted as described in 2.9, for incremental wheel or skid heights above ground. If operational hover flight is conducted in multiple configurations or trimmed attitudes, data shall be provided for each planned setting. This section shall include data for a number of heights to fully describe the ground effect on hover power required, including the minimum operationally relevant wheel or skid height, incremental In-Ground Effect (IGE) heights, and the Out-of-Ground effect (OGE) height explicitly.

For nondimensional or referred data, compressibility effects on power required shall be formatted as described in 2.9.2 at each wheel or skid height included in the baseline hover power required data set. Compressibility effects for Level III data submission shall be supported by flight test data.

This section shall include sample calculations using the above data for hover power required at the primary mission gross weight, or the most demanding hover segment occurring anywhere in the mission profile for both OGE conditions and at the lowest operational wheel or skid height.

3.4.2 Air Vehicle Forward Level Flight Power Required. This section shall include a data set of total engine power required as a function of airspeed, covering the flight performance envelope. If operational cruise flight is conducted in multiple configurations, such as intermediate rotor or nacelle angles or trim schemes, data for each configuration setting shall be included. If hovering flight is possible in cruise configuration(s), zero airspeed (hover) data points shall correspond to the associated out-of-ground-effect data described in 3.4.1.

For nondimensional or referred data, variations in power required due to compressibility shall be provided as described in 2.9.2 at all airspeeds included in the baseline power required data set. Compressibility effects for Level III data submission shall be supported by flight test.

Sample calculations using the above data shall be included for cruise power required at the primary mission gross weight for the entire speed envelope in 5 knot increments.

3.4.3 Air Vehicle Climb and Descent Power Required. This section shall include data and methods to calculate climb and descent power required at any point in the flight performance envelope. The preferred method is to base climb and descent rate capability on the change in power to climb from the power required to maintain constant altitude described in 3.4.1 and 3.4.2. The airspeeds for minimum rate of descent and maximum glide angle for a nominal flight condition shall be specified.

Sample calculations shall be provided using the above data that show maximum rate of climb capability at zero horizontal airspeed and at best rate of climb speed at the primary mission gross weight.

Power-off steady-state autorotative rate of descent as a function of rotor speed, airspeed, density altitude, and gross weight shall be provided for air vehicle configurations using rotors for lift.

3.4.4 Air Vehicle Fuel Consumption. This section shall include data and methods to calculate total fuel flow for all operational conditions in the flight performance envelope and for ground operations that consume air vehicle fuel prior to takeoff (e.g. engine flight and ground idle, and alternative power unit operation). Data and methods to address fuel flow dependency on engine bleed air settings, to include operational options and combinations shall be included.

If the air vehicle can be operated with degraded engines, data and methods to calculate fuel flow in these conditions shall be included.

3.4.5 Engine Mass Flow Required. This section shall include data and methods to calculate engine mass flow for all operational conditions in the flight performance envelope and for ground operations prior to takeoff (e.g. engine flight and ground idle, and alternative power unit operation). Data and methods to address mass flow dependency on engine bleed air settings, to include operational options and combinations shall be included.

3.5 Limitations to Air Vehicle Flight Performance.

3.5.1 Engine Power Available. This section shall include maximum installed power available for all operational engine ratings with all engines operating and at contingency power with one engine inoperative for hover and forward level flight conditions throughout the flight performance envelope. This section shall also include a description of the state of the data provided in terms of manufacturing variations and engine health assumptions. Some examples include minimum specification, average new, minimum new, fully degraded, etc. For air vehicles that operate at a range of engine output shaft speeds, data shall be included for the range of operational shaft speeds. This section shall include pressure altitude, ambient temperature, and airspeed variations in the data. A breakdown of the engine installation losses from each source (e.g. engine inlet, engine bleed air, accessory pad, particle separator, exhaust system) shall be included. For air vehicles that benefit from residual thrust from the exhaust system, data and methods to calculate the residual thrust for the flight performance envelope shall be included. Data shall include the points at which the engine is limited by different phenomena, such as gas-generator speed limits or turbine gas temperature limits. Other inflections and discontinuities shall be noted and included in the data such as engine mechanical or fuel flow limits. Effects of exhaust gas recirculation on power available when in ground effect shall be included in the data as a function of wind azimuth if applicable. Data and methods to calculate the power available dependency on engine bleed air settings shall be included, to include operational options and combinations.

Sample calculations shall be included for hover and the same speed increments used in 3.4.2.

3.5.2 Drive System Torque. This section shall include maximum continuous and time-limited torque limits for all air vehicle performance-limiting drivetrain component such as gearboxes and shafts.

3.5.3 Gross Weight and Center of Gravity (C.G.). This section shall include all gross weight and C.G. limits applicable to the primary and alternate mission configurations in the air vehicle systems specification, along with any other operational configurations (e.g., external load, ferry). References to documents that provide authoritative limit definition are appropriate.

3.5.4 Airspeed. This section shall include maximum and minimum operational airspeed limits as a function of the applicable independent variables (e.g. density altitude, temperature, gross weight, etc.) for all specified configurations. Speed limits may be due to blade stall or tip compressibility effects, wing stall, structural loads, weapons loading, etc.

3.5.5 Rotational Speed. This section shall include maximum and minimum limits for engine, rotor, and thruster rotational speeds for power-on and power-off flight conditions.

3.5.6 Environmental Conditions. This section shall include maximum and minimum environmental conditions approved for flight, to include temperature, pressure altitude, density altitude, humidity, wind (including cross-wind landing limits, if applicable), icing conditions, etc.

3.5.7 Flight Control Limits on Performance. Level flight and maneuvering performance may be limited by advanced control laws for the purpose of protecting certain components from damage due to load exceedance. This section shall describe any control system effects (e.g. load-limiting control laws) on flight performance.

3.5.8 Height-Velocity Envelope. This section shall include data and methods required to calculate the conditions required for a safe landing or flyaway due to a single engine failure as a function of height above ground and velocity for the flight performance envelope.

3.6 Takeoff and Landing Performance.

3.6.1 General. This section shall include Takeoff and Landing Performance data for the full flight performance envelope. Data and methods shall be included to account for the following effects on performance:

a. headwind or tailwind,
b. runway slope,
c. flap settings,
d. ice vanes,
e. engine settings,
f. propeller reversing.

3.6.2 Takeoff. This section shall include information sufficient to determine air vehicle takeoff performance, including the distance and speeds to clear a 50 feet obstacle at the end of the runway, as well as methods to calculate decision speeds and distances (accelerate-go and accelerate-stop), and the resulting climb capabilities (climb gradient, distance to climb calculations), and fuel use during climb.

Data shall be included for takeoff emergency situations, such as one-engine inoperative climb.

3.6.3 Landing. This section shall include sufficient data to determine appropriate landing distance and speeds, as well as emergency situations such as a balked landing climb.

3.7 Maneuvers.

3.7.1 Specification Maneuvers. For the maneuvers included in the air vehicle system specification, the following parameters shall be included as functions of time:

a. flight path airspeed,
b. air vehicle X, Y, and Z position with respect to the ground,
c. air vehicle pitch, roll, and heading angles,
d. air vehicle pitch, roll, and yaw rates,
e. translational and rotational accelerations,
f. rotor or propeller control inputs and control surface positions,
g. rotor speed,
h. rotor shaft power
i. engine power required and available,
j. power available from speed or altitude loss,
k. and air vehicle normal load factor at center of gravity.

This section shall also include a written description of the maneuvers, how the air vehicle is controlled to achieve the desired performance, and notification of any maneuvers that have not been performed under flight test conditions.

3.7.2 Longitudinal Acceleration. This section shall include maximum longitudinal acceleration and deceleration capability and corresponding fuselage attitude for conditions of constant altitude using the maximum rated engine power as a function of forward velocity at a low, medium, primary mission, and max gross weight. See Table 3 for the required atmospheric conditions. The section shall also fully describe how the maneuver is flown, including thrust and air vehicle control schemes at different forward velocity regimes. If longitudinal acceleration is conducted in multiple configurations, data shall be provided for each planned configuration setting.

3.7.3 Decelerating Turn. This section shall include flight path deceleration in a constant-altitude turn due to maximum transient normal load factor as a function of forward velocity for a light, primary, and maximum alternate weight configuration. The corresponding turn rate and radius plus fuselage pitch and roll attitudes shall be included. See Table 3 for the required atmospheric conditions. The section shall fully describe how the maneuver is flown, including thrust and air vehicle control schemes at different forward velocity regimes.

3.7.4 Lateral Acceleration. This section shall include lateral acceleration capability versus vertical climb rate for a primary mission weight configuration and maximum alternate weight configuration using maximum rated engine power or drive system limit.

See Table 3 for the required atmospheric conditions. The section shall fully describe how the maneuver is flown, including thrust and air vehicle control schemes at different forward velocity regimes.

3.7.5 Directional Control. This section shall include the maximum wind velocity as a function of azimuth for the applicable margin or limit for a representative primary and maximum alternate weight configuration in hover. See Table 3 for the required atmospheric conditions. The section shall fully describe how the maneuver is flown, including thrust or air vehicle control schemes.

3.7.6 Sustained Load Factor. This section shall include normal load factor, turn rate and turn radius as a function of velocity for a light, primary, and maximum alternate mission configuration at maximum rated power or drive system power limit. See Table 3 for the required atmospheric conditions.

3.7.6.1 Rotor-borne flight: This section shall include maximum blade loading capability versus forward velocity at both a representative primary and maximum alternate gross weight configuration for a sustained flight condition where no change of airspeed or altitude is used as additional energy for the maneuver. All limits encountered, such as rotor control system endurance loads, sustained maneuver tip path plane pitch rate, vibration levels and stability shall be stated.

3.7.6.2 Wing-borne flight: This section shall include maximum load factor as a function of forward velocity at primary and maximum alternate gross weight configurations for sustained flight conditions. All aerodynamic and structural limitations shall be included.

3.7.7 Transient Load Factor. This section shall include the maximum transient normal load factor as a function of forward airspeed for a light, primary, and maximum alternate weight configuration for maximum rated engine power or drive system power levels. This section shall include airspeed and altitude loss or gain required, as well as entry airspeed and rotor tip path plane pitch rate.

3.7.7.1 Rotor-borne flight: This section shall include maximum blade loading as a function of forward velocity for a primary and maximum alternate weight configuration for a transient maneuver condition. The air vehicle transient capability is defined as that level which can be maintained or sustained for 3 seconds. If this level of blade loading is different than that for the sustained condition, the limiting factors assumed shall be declared.

3.7.7.2 Wing-borne flight: This section shall include maximum load factor as a function of forward velocity for a primary and maximum alternate weight configuration for a transient maneuver condition. If this level of loading is different than that for the sustained condition, the limiting factors assumed shall be declared.

3.8 Substantiation General Instructions: Substantiation for the data described in 3.1 through 3.7 shall be provided in 3.8. This section shall clearly state the associated level classification of the data (IAW Table 1) and methods used in each subparagraph. For

Data Maturity Levels I and II, a component building-block approach is taken for substantiation. Substantiation of the model provides confidence in its outputs. In cases where the final data are produced from a model of an air vehicle which has been calibrated to flight test data, both the Level II and III sections are required. All aerodynamic data and thorough descriptions of methods used in the calculation of the air vehicle performance shall be included. All assumptions that affect performance predictions shall also be clearly and fully documented. The substantiation shall include applicable references. The boundaries of the data shall be clearly defined to distinguish between data with high confidence (e.g. within a flight test database range or validated engine deck output range), and data that was estimated or extrapolated in order to cover the flight performance envelope (See Table 2).

3.8.1 Levels I – II Data Substantiation.

3.8.1.1 Isolated Rotor or Propeller. The following information shall be provided for all rotors, propellers, proprotors, and fans:

3.8.1.1.1 Hover. This section shall include rotor figure of merit (efficiency) and coefficient of power versus coefficient of thrust at incremental values of tip Mach numbers for each individual isolated rotor. For configurations that use multiple rotors as the primary source for lift or thrust (e.g., coaxial, tandem, synchropters), total rotor system coefficient of power versus coefficient of thrust shall be included in addition to each isolated rotor. The range of values for coefficient of thrust provided shall encompass the rotor design envelope. Data shall reflect rotor heights corresponding to the heights provided in the response to 3.4.1. If the air vehicle system specification includes a vertical rate of climb requirement, the same parameters shall be reported at the required climb state.

3.8.1.1.2 Forward Flight. For propellers and proprotors operating in primarily axial flow conditions in forward flight, propeller efficiency data shall be included using classical propeller performance definitions, such as defined in Airplane Aerodynamics and Performance, Dr. Chuan-Tau, Edward Lan, and Dr. Jan Roskam; Design, Analysis, and Research Corporation (DARcorporation), 2003 (Design, Analysis, and Research Corporation, 1440 Wakarusa Drive, Suite 500, Lawrence, Kansas 66049).

For rotors in edgewise flight, lift-to-equivalent drag ratio and coefficients of power, lift, and propulsive force as a function of advance ratio shall be included. This information shall include a range of shaft angles. The range of values for advance ratio provided shall encompass the rotor design envelope. Rotor lift and details of the equivalent main rotor drag calculation shall be included.

3.8.1.2 Integrated Model. This section shall include the following data for the operationally trimmed flight state for the atmospheric conditions listed in Table 3. The data listed in 3.8.1.2.1 shall be included for all combinations of the flight conditions and air vehicle configurations listed in 3.8.1.2.2 and 3.8.1.2.3. A detailed description of the methods used to acquire the data shall be provided. This section shall fully describe how to build up the integrated model from isolated component performance, including all installation and aerodynamic interference effects.

3.8.1.2.1 Data. The following data shall be included:

a. Rotor or propeller total, profile, parasite, and induced power required

b. Rotor or propeller forces and moments and control inputs

c. All major outer-mold-line structures' (e.g., nacelles, fuselage, tailboom, pylons, sponsons, landing gear, hub, etc.) forces and moments. These shall be combined into subsets of aerodynamic effects where applicable

d. Wing forces and moments

e. Control surface forces and moments and control positions

3.8.1.2.2 Flight Conditions. The following shall be included:

a. Hover: OGE and IGE at the same heights included in the response to 3.4.1

b. Steady, level flight from minimum airspeed (zero airspeed if capable of hover) to maximum level flight airspeed in even increments

c. Maximum vertical climb rate capability from zero airspeed to maximum level flight airspeed

3.8.1.2.3 Air Vehicle Configuration. Air vehicle configuration shall be included as follows:

a. Primary mission design gross weight, minimum gross weight, maximum structural gross weight

b. Primary mission design, most forward, and most aft centers of gravity

c. Drag state for all configurations defined in 3.3

3.8.2 Level II Data Substantiation. For reports and data delivered at Level II, total system power required and fuel flow substantiation shall be provided, clearly documenting the relationship of the final data to flight test data. This section shall reference the approved flight test reports as the basis for data used to represent the performance of the test air vehicle. Correlation of the performance model or curves used to generate the final data discussed in 3.4 to the applicable flight test shall be included. This section shall show derivation of final data in 3.4 from the correlated curve or model, showing all calculations needed to perform the derivation. These shall include:

a. Adjustments for the difference between the test air vehicle and the baseline air vehicle configuration, to include test instrumentation drag and electrical power requirements.

b. Any propulsive efficiency data needed to accurately produce changes in engine power required for changes in drag configuration from the tested air vehicle. Data shall be provided as a function of the same independent variables used in the baseline forward flight power required data set from 3.4.2.

c. Any equations or calculations required to nondimensionalize or refer the finalized dimensional test data.

d. Any interpolation methods used to create data between flight test data regimes and extrapolation methods used to cover the flight performance envelope.

e. Airspeed and altimeter calibrations of the ship and test instrumentation systems required for use in data reduction or operational flight planning data utilizing indicated airspeed.

f. A graphical or tabular data representation of the flight performance envelope required by the Operator's Manual compared to the range and limits of the actual test conditions shall be provided.

g. Confidence assessments for specific regions within the flight performance envelope. This section shall include the data boundaries that differentiate between data that are within the flight test data region (high confidence), data regions beyond test data but substantiated by other analysis (medium confidence) and those outside the test region that have minimal substantiation (low confidence). See 2.8. These confidence assessments shall include references to tests and analysis that help define the confidence boundaries.

Any data and methods required to supplement the flight test data in order to produce the final data shall be included. Some examples are: comprehensive rotor models, wind tunnel tests, basic aerodynamic calculations, and empirical trends based on similar air vehicles.

Power available and fuel flow data shall be based on the delivered engine cycle deck with installation effects included as required by the procuring agency. This section shall reference individual reports documenting all other limits to flight performance provided in 3.5 for that engineering discipline.

Data and methods to convert true airspeed to calibrated airspeed and the position error correction to provide indicated airspeed as presented in the cockpit displays shall be included. The data shall include position error corrections for level flight, low and high rates of climb, low rate of descent and full autorotation. The corresponding pitot static and independent static altimeter error shall be provided as a function of airspeed in level flight. These requirements shall apply to both the ship's primary pilot and copilot systems, if independent. Data and methods for airspeed calibration of alternate configurations shall be included if those configuration changes affect the performance of the airspeed system. The required accuracy and dynamic response of the airspeed and altimeter systems approved by the procuring agency shall be documented in this section as well.

A description of the calibration method used to determine the ship system position errors from a standard system shall be included, along with any required documentation or calibrations of the standard system.

3.9 Mission Performance. This section shall include a mission description for each mission in the air vehicle system specification, along with an illustrative profile figure. See MIL-STD-3013 for examples. This mission description shall include a corresponding detail profile description of the aircraft design configuration and the following conditional factors for each of the air vehicle's assigned, required mission legs which apply:

a. Type of mission activity (hover OGE, IGE, Running Takeoff, Cruise, Reserve, Warm-up, etc.)

b. Atmospheric conditions (pressure altitude and free air temperature)

c. Wind conditions

d. Gross Weight at mission leg start and associated vertical climb capability (if vertical climb in hover is required)

e. Forward flight velocity (e.g. best range, best endurance, best climb rate, 100% maximum continuous power speed, etc.)

f. Duration

g. Rate and angle of climb or descent

h. Range credit to and from another leg

i. Ordnance load or cargo load

j. Payload drag and download

k. Rotor or propeller speeds

l. Fuel flow, mission leg fuel and specific range

m. Any fuel flow conservatism applied

n. Engine power setting

o. Engine and drive system torque or power margin

p. Engine inlet and exhaust options

q. Accessory power load in engine shaft power

r. Aerial refueling parameters

s. Total power required and power available.

t. One engine inoperative rate of climb at best climb speed for cruise legs of self-deployment mission, if applicable.

u. Takeoff requirements (e.g., obstacle clearance, climb rate, balance field length, etc.)

v. Fuel reserve requirements, to include Minimum Fuel on Deck (MFOD) and fuel reserve required at the end of the specified mission.

End of DI-SESS-82321 .