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14. ABSTRACT
This TOP provides an overarching compilation of flight test techniques used in the conduct of both fixed- and rotary-wing aircraft. These techniques include procedures for conducting handling qualities and performance flight tests. Classical flight test techniques are taught at the recognized test pilot schools. Many Flight Test Manuals are available to document these tests and test techniques and are referenced in this TOP to provide a single source for currently approved procedures within the Army flight test community. Additional tests and test procedures are included for those tests not recognized as classical techniques.

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TEST OPERATIONS PROCEDURE

Test Operations Procedure 7-4-020 01 July 2009
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FLIGHT TEST TECHNIQUES

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1. SCOPE.

This Test Operations Procedure (TOP) documents the sources of information available to the tester relating to flight test techniques. It is essential during the planning and execution phase of a flight test program that everyone involved has access to reference material that has been developed by the flight test community over many years. The experience contained within such documentation is vital for the safe, efficient, and effective execution of flight tests. The references include flight test manuals that document the classical flight test techniques as taught at the major test pilot schools throughout the world and sources of additional material covering tests and test procedures not recognized as classical techniques.

2. FACILITIES AND INSTRUMENTATION.

This Flight Test Techniques TOP covers a wide range of flight test methods and tests. The facilities and instrumentation necessary to conduct the procedures documented in this TOP vary widely for the ranges of tests covered. For many tests, the facility and data requirements are detailed in the specified references or test plans. Where references are not provided or are inadequate, specific data requirements are identified within that section of this TOP.

2.1 Facilities.

Facilities required for tests covered in this TOP vary widely, and may include the following:

a. Government, contractor, and civilian airfields.

b. Various restricted and general-use airspace.

c. ADS-33E[1*] Handling Qualities Course.

d. Various aerial gunnery ranges.

e. Various aircraft simulators.

2.2 Instrumentation.

Instrumentation devices and their permissible measurement uncertainty required for tests covered in this TOP vary widely, and may include the following:

a. Temperature transducers and devices.

b. Sensitive strain, force, torsional measurement devices.

c. Accelerometers for vibration assessment.

[*] Superscript numbers correspond to those in Appendix E, References.

d. Aircraft flight control position measurement.

e. Sensitive engine and rotor instrumentation.

f. MIL-STD-1553[2] Data Bus recorders.

3. REQUIRED TEST CONDITIONS.

3.1 Air Vehicle Flight Test Techniques.

Many different flight test techniques are in existence. As technology evolves, flight test techniques are developed to meet the challenge of assessing new developments in aircraft and aircraft systems. Classical flight test techniques for the aircraft itself can be placed in two general categories: stability and control, and performance.

3.1.1 Stability and Control.

Stability and control encompasses air vehicle stability, air vehicle control, and air vehicle flying qualities.

a. Air Vehicle Stability. Air vehicle stability testing determines the air vehicle reaction to perturbations in the air vehicle flight condition.

b. Air Vehicle Control. Air vehicle control testing determines the air vehicle reaction to changes to the air vehicle flight control system and covers both pilot control inputs and automatic control inputs.

c. Air Vehicle Flying Qualities. Air vehicle flying qualities testing determines the level of difficulty for a pilot to execute a particular maneuver or establish a steady state flight condition. Air vehicle flying qualities result from the summation of stability and control characteristics and all pilot interfaces, flight controls, flight instruments, crewstation design, and all other man-machine interfaces.

3.1.2 Air Vehicle Performance.

Air vehicle performance testing determines mission effectiveness, specification compliance, and provides handbook data for operators.

a. Mission Effectiveness. An air vehicle is designed to accomplish specific missions. Air vehicle performance testing determines whether the various air vehicle elements combine to permit acceptable mission accomplishment.

b. Specification Compliance. Specification compliance determines whether an air vehicle is constructed to the contractual standards established between the customer and the manufacturer.

c. Handbook Data. Handbook data are developed from performance testing to provide operators with information to conduct pre-mission performance planning, confirm in-mission performance, and provide advice to operators on how to maximize performance under various conditions.

3.2 Air Vehicle Systems Testing.

Air vehicle systems testing determines the utility of air vehicle systems to assist the operator to accomplish the mission. Air vehicle systems include, but are not limited to, communication systems, navigation systems, weapon systems, and survivability systems.

4. TEST PROCEDURES.

4.1 Rotary-Wing Performance.

The following flight test techniques and methods for rotary-wing performance testing are described in detail in the U.S. Naval Test Pilot School (USNTPS) Flight Test Manual (FTM) No. 106 (USNTPS FTM-106[3].)

4.1.1 Pitot/Static System Performance.

The purpose of this flight test is to investigate thoroughly the flight characteristics of the aircraft pressure sensing systems to achieve the following objectives:

a. Determine the airspeed and altimeter correction data required for performance data processing.

b. Determine mission suitability.

c. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.1.2 Engine Assessment.

The purpose of these tests is to evaluate the engine/rotor compatibility and suitability for the mission of the host helicopter. Specific tests that are conducted include an evaluation of the engine controls and displays; engine operating procedures, both normal and emergency; engine start and shutdown characteristics; engine acceleration characteristics; engine trim response; engine/rotor stability, both static droop and transient droop; engine torque matching; engine limiting characteristics; and engine power contribution during minimum power descents. USNTPS FTM-106 describes several engine assessment test techniques. Additionally, a technique for evaluating drivetrain torsional stability is described in Appendix A.

4.1.3 Engine Performance.

The primary purpose of these tests is to determine power available. USNTPS FTM-106 describes test methods for inlet performance and engine performance. An additional test technique, Running Lines, is frequently used to assess extreme engine performance and power available. This technique is described in Appendix B.

4.1.4 Hover Performance.

The purpose of this test is to evaluate aircraft hover performance characteristics. Airframe power required to hover will be determined and combined with engine power available to establish aircraft hover performance.

4.1.5 Vertical Climb Performance.

The purpose of this test is to investigate aircraft vertical climb performance characteristics to achieve the following objectives:

a. Determine the vertical climb correction factor for use in computing vertical climb performance.

b. Determine mission suitability.

c. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.1.6 Level Flight Performance.

The purpose of this test is to investigate aircraft performance characteristics in level flight to achieve the following objectives:

a. Determine significant performance parameters: maximum level flight airspeed (V_H), maximum range airspeed (Vmax range), cruise airspeed (Vcruise), maximum endurance airspeed (Vmax end), combat radius, maximum endurance, and maximum range.

b. Determine mission suitability.

c. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.1.7 Climb and Descent Performance.

The purpose of this test is to examine the forward flight climb and descent performance characteristics to achieve the following objectives:

a. Determine the airspeed for maximum rate of climb, Vmax R/C.

b. Determine the airspeed for best angle of climb, Vx.

c. Determine mission suitability.

d. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.1.8 Autorotation Performance.

The purpose of this test is to examine the autorotative performance characteristics to achieve the following objectives:

a. Determine the recommended autorotative airspeed.

(1) Determine the airspeed for minimum rate of descent, Vmin R/D.

(2) Determine the airspeed for maximum autorotation glide range, Vmax glide.

b. Determine the rotor speed effects on descent rate.

c. Determine mission suitability.

d. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2 Fixed-Wing Performance.

The following flight test techniques and methods for fixed-wing performance testing are described in detail in the USNTPS FTM-108[4].

4.2.1 Pitot Static System Performance.

The purpose of pitot static system testing is to investigate the characteristics of the aircraft pressure sensing systems to achieve the following objectives:

a. Determine the airspeed and altimeter correction data required for flight test data reduction.

b. Determine the temperature recovery factor, KT.

c. Determine mission suitability.

d. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.2 Stall Speed Determination.

The purpose of this test is to determine the stall airspeed of the airplane in the takeoff and landing configuration with the following objectives:

a. Determine the 1 g stall speed for an airplane at altitude and at sea level.

b. Apply corrections to obtain the stall speed for standard conditions to check compliance with performance guarantees.

c. Determine mission suitability.

d. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.3 Level Flight Performance.

Most test techniques are described in USNTPS FTM-108. Additionally, a technique for determining baseline aircraft parasitic drag (without contribution by powered propellers) is described in Appendix C. The level flight performance tests are used to:

a. Determine significant performance parameters: maximum range and optimum range, maximum endurance and optimum endurance, and long range or ferry range.

b. Determine the aircraft excess power characteristics.

c. Derive climb schedules to optimize time to height, energy gain, or to minimize fuel consumption.

d. Predict sustained turn performance envelopes.

e. Determine mission suitability and enable operational comparisons to be made among different aircraft.

f. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.4 Turn Performance and Agility.

The purpose of these tests is to determine the turning performance and maneuvering characteristics of the airplane with the following objectives:

a. Measure sustained and instantaneous turn performance.

b. Measure maneuvering excess energy characteristics.

c. Present agility measures and airplane comparison methods.

d. Determine mission suitability.

e. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.5 Climb Performance.

The purpose of this test is to determine the following climb performance characteristics:

a. Conditions for best climb angle.

b. Conditions for best climb rate.

c. Conditions for the shortest time to climb.

d. Conditions for minimum fuel used to climb.

e. Climb schedules for the above conditions.

f. Determine mission suitability and enable operational comparisons to be made among different aircraft.

g. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.6 Descent Performance.

The purpose of this test is to investigate aircraft descent performance characteristics to determine time, fuel used, and distance traveled. The tests are performed at different airspeeds and in different configurations to obtain data for the Operator's Manual including:

a. Optimum descent airspeed or Mach number/airspeed schedules.

b. Penetration descent schedules.

c. Precautionary approach patterns.

d. Flameout approach patterns.

e. Determine mission suitability.

f. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.2.7 Takeoff And Landing Performance.

The purpose of this test is to investigate aircraft takeoff and landing performance characteristics to determine data for the Operator's Manual including:

a. Normal ground roll takeoff distance (time/fuel/distance).

b. Distance, time, and fuel from liftoff to climb intercept.

c. Minimum (short field) ground roll takeoff distance (time/fuel/distance).

d. Obstacle clearance takeoff distance (time/fuel/distance).

e. Takeoff speed.

f. Speed/distances for checking takeoff acceleration.

g. Maximum refusal speed.

h. Emergency braking velocity.

i. Effects of runway condition.

j. Approach and landing speeds.

k. Landing ground roll distance.

l. Limit braking velocity for landing.

m. Determine mission suitability and enable operational comparisons to be made among different aircraft.

n. Assess compliance with pertinent Military Specifications and/or detailed model specification.

4.3 Rotary-Wing Stability and Control.

There are two primary reference documents for rotary-wing stability and control flight testing. The USNTPS FTM-107[5] is the primary guide for "classic" stability and control flight test theory, test techniques, and data reduction. The Airworthiness Design Standard, Performance Specification, Handling Qualities Requirements for Military Rotorcraft (ADS-33E-PRF) is the current handling qualities performance specification. The initial purpose of the ADS-33E-PRF was to specify design parameters for helicopter handling qualities that would result in desired pilot performance across mission types and in different visual environments. ADS-33E-PRF is technically a performance specification rather than a flight test techniques manual. However, ADS-33E-PRF in conjunction with the Test Guide for ADS-33E-PRF (RDECOM Special Report

AMR-AF-08-07[6]) and the Background Information and User's Guide for Handling Qualities Requirements for Military Rotorcraft (USAAVSCOM Technical Report 89 A 008[7]) provide significant guidance for handling qualities testing methods and techniques. Generally, Section II Test Guide for ADS-33E-PRF provides the specific data requirements, input types necessary, and test techniques for each test. Overall, there is significant overlap between the USNTPS FTM-107 and the ADS-33E-PRF documents and neither document completely covers all handling qualities tests of the other. In some cases, the system specification may explicitly state the test system must meet the requirements of the ADS-33E-PRF. When this is the case, the ADS-33E-PRF will be the guide for planning and executing the handling qualities testing; but, if the guidance is not explicit, tests from both documents are often conducted.

4.3.1 The following flight test techniques and methods for rotary-wing stability and control testing are described in detail in the USNTPS FTM-107.

a. Pilot Flying Qualities Evaluations. The purpose of flying qualities testing is to evaluate the mission suitability of an aircraft's piloted flying qualities in a real or simulated mission environment.

b. Open Loop Testing. The purpose of open loop testing is to quantify stability and control evaluations. Specific objectives of open loop testing are:

(1) Substantiate the pilot's qualitative opinion.

(2) Document characteristics of the aircraft-control system combination.

(3) Provide data for comparing the aircraft characteristics with others and for formulating future designs.

(4) Provide baseline data for expansion of flight and center of gravity envelope.

(5) Provide data for predictive closed loop analysis.

(6) Provide data for simulator applications.

(7) Assess compliance with pertinent Military Specifications and/or detailed model specification.

c. Flight Control System Characteristics. The purpose of the flight control system characteristics evaluation is to document the control system characteristics in support of stability, control, and flying qualities evaluations, as well as specification compliance.

d. Forward Flight Longitudinal Stability, Control, and Flying Qualities. The purpose of these tests is to evaluate the forward flight longitudinal stability, control, and flying qualities of the helicopter. The engineering tests included in the evaluation are:

(1) Trimmed flight control positions.

(2) Static stability.

(3) Maneuvering stability.

(4) Long-term dynamic stability.

(5) Short-term dynamic stability.

(6) Control response.

(7) Gust response.

e. Forward Flight Lateral-Directional Stability, Control, and Flying Qualities. The purpose of these tests is to evaluate the helicopter forward flight lateral-directional stability, control, and flying qualities. The tests included in the evaluation are:

(1) Trimmed control positions.

(2) Static stability.

(3) Dynamic stability.

(4) Spiral stability.

(5) Control response.

(6) Gust response.

f. Hover and Low Airspeed Stability, Control, and Flying Qualities. The purpose of these tests is to evaluate the hover and low airspeed stability, control, and flying qualities of the helicopter. The tests included in the evaluation are:

(1) Trim control positions.

(2) Critical azimuth.

(3) Turn on a spot.

(4) Static stability.

(5) Long-term dynamic stability.

(6) Control response.

(7) Mission maneuvers.

g. Coupled Longitudinal and Lateral-Directional Stability, Control, and Flying Qualities. The purpose of these tests is to evaluate pilot requirements to compensate for coupling in trimmed steady flight and to suppress coupling in short- and long-term dynamic situations. As a minimum, coupling evaluations include:

(1) Trim control positions for equilibrium in hover, low airspeed, and forward flight.

(2) Trim control positions to maintain steady non-rectilinear flight such as forward flight turns.

(3) Control positions required to perform long-term flight condition changes such as level accelerations, transition to climb, and diving accelerations for ordnance delivery.

(4) Short term, off axis aircraft responses to rapid control inputs.

h. Sudden Engine Failures, Autorotative Flight, and Autorotative Landings. The purpose of these tests is to evaluate the handling qualities of the helicopter from engine failure to completion of the landing. Tests are conducted to evaluate the following characteristics:

(1) Engine failure and autorotation entry.

(2) Steady autorotative flight.

(3) Autorotative landings.

4.3.2 ADS-33E-PRF testing is divided into two major methods of assessment: predictive handling qualities levels and assigned handling qualities levels. Paragraphs 3.1 through 3.10 (quantitative criterion measurements) cover predictive assessment methods while paragraph 3.11 (Mission Task Elements) covers the assigned handling qualities level methodology. ADS-33E-PRF is designed to test rotorcraft with advanced flight control systems capable of multiple flight control response types, and also provides tests designed to characterize various rotorcraft configurations including conventional helicopters, tandem helicopters, and tilt-rotor aircraft. Therefore, test planners will need to thoroughly scrutinize the test requirements of ADS-33E-PRF to determine which requirements are applicable. The following flight test techniques and methods for rotary-wing stability and control testing are described in detail in the ADS-33E-PRF, ADS-33E-PRF Test Guide, or the ADS-33 Background Information and User's Guide.

a. Rotorcraft Limits (paragraph 3.1.15).

b. Pilot-Induced Oscillations (paragraph 3.1.16).

c. Residual Oscillations (paragraph 3.1.17).

d. Response Types (paragraph 3.2).

e. Hover and Low Speed Requirements (paragraph 3.3).

f. Forward Flight Requirements (paragraph 3.4).

g. Transition of a Variable Configuration Rotorcraft between Rotor-borne and Wing-borne Flight (paragraph 3.5).

h. Controller Characteristics (paragraph 3.6).

i. Specific Failures (paragraph 3.7).

j. Transfer between Response Types (paragraph 3.8).

k. Ground Handling and Ditching Requirements (paragraph 3.9).

l. Requirements for Externally Slung Loads (paragraph 3.10).

m. Mission Task Elements (paragraph 3.11).

4.4 Fixed-Wing Stability and Control.

The following flight test techniques and methods for fixed-wing stability and control testing are described in detail in USNTPS FTM-103[8].

a. Stalls. All airplanes are subjected to stall investigations for the following reasons:

(1) Safety and operational considerations.

(2) Actual flight tests are the only means of precisely determining stall characteristics.

(3) Expansion of the operational flight envelope.

(4) Determination of trim airspeeds for future tests.

b. Spins. Aircraft spin characteristics are evaluated to identify:

(1) Spin entry characteristics including post-stall gyrations.

(2) Aircraft behavior in a fully developed spin.

(3) Spin recovery techniques.

(4) Spin avoidance techniques.

c. Longitudinal Flying Qualities.

(1) Non-Maneuvering Tasks. The purpose of these tests is to evaluate the non-maneuvering longitudinal stability and control characteristics of the aircraft, including:

(a) Longitudinal control system mechanical characteristics.

(b) Longitudinal control force stability.

(c) Elevator position stability.

(d) Flight path stability.

(e) Longitudinal long term (phugoid) characteristics.

(f) Longitudinal trimmability.

(2) Maneuvering Tasks. The purpose of these tests is to evaluate the non-maneuvering longitudinal stability and control characteristics of the aircraft, including:

(a) Longitudinal short period characteristics.

(b) Pilot induced oscillations.

d. Lateral-Directional Flying Qualities. The purpose of these tests is to evaluate the lateral-directional stability and control characteristics of the aircraft, including:

(1) Lateral-directional control system mechanical characteristics.

(2) Lateral-directional trimmability.

(3) Aileron-only turn characteristics.

(4) Rudder-only turn characteristics.

(5) Static lateral-directional stability characteristics.

(6) Dynamic lateral-directional stability – spiral mode characteristics.

(7) Dynamic lateral-directional stability – Dutch roll mode characteristics.

e. Asymmetric Power Flying Qualities. The purpose of these tests is to evaluate the Asymmetric power stability and control characteristics of the aircraft, including:

(1) Minimum trim and minimum control airspeeds in equilibrium flight.

(2) Minimum control airspeeds with sudden engine failures.

(3) Minimum control ground speeds with sudden engine failures.

(4) Approach and landing characteristics with asymmetric power.

f. Transonic-Supersonic Flying Qualities.

4.5 Handling Qualities Assessments.

NASA Technical Note D-5153, *The Use of Pilot Rating in the Evaluation of Aircraft handling Qualities*[9], lays the foundation for the Cooper-Harper Handling Qualities Rating Scale as the standard for pilot-assigned handling qualities ratings. Assignment of handling qualities ratings (HQRs) is based on the principles of selecting mission representative tasks, performing the tasks in a simulated mission environment against clearly defined standards, observing the pilot workload required to accomplish the task, and determining if the attainable performance and workload required are acceptable for the mission. Tests designed with the intent to assign HQRs must adhere to these principles. For helicopter HQR assessments, ADS-33E-PRF provides a selection of mission task elements (MTEs) designed to assess many mission relatable flight sub-tasks. These MTEs include detailed objectives, maneuver descriptions, descriptions of test course (as required), and specific task performance standards. For tasks not included in ADS-33E-PRF, or for fixed-wing handling qualities assessments, the test plan must detail these items. When developing a task for which HQRs will be assigned, the maneuver description must be detailed enough to produce repeatable results for different test pilots. More specifically, the desired and adequate performance standards must be quantitative, measurable, and coherently determined to provide sensible HQR results. The individual aircraft Aircrew Training Manuals (ATMs) may be a source for maneuver descriptions and task performance standards; however, the test planning must ensure there is sufficient detail to conduct handling qualities assessments. For example, most helicopter ATMs have a running, sliding, or rolling landing task. The generic nature of the description of these tasks (required approach angle, airspeed/groundspeed, rate-of-descent, ground track alignment, etc.) may be insufficient without further definition. Furthermore, the task performance standards in the ATMs are insufficient to assign an HQR unless adequate and desired tolerances are defined. In some cases, the pilot performance standards identified in the ATM may be used for adequate performance and additional desired tolerances may be defined based on a fraction (or multiple) of the ATM performance standards.

4.6 Wedge Envelope Investigation.

Although the term “wedge” is not a widespread-used term, this TOP defines it as a type of buildup, useful in many flight test applications. The concept of a wedge in this context implies that general handling qualities associated with basic flight conditions (e.g., sideslips, climbs, descents) will be incrementally assessed starting with the most benign airspeed (or other basic condition) and building up to largest target basic conditions. Within each basic condition, the perturbations from the initial state are built-up to their respective limits before proceeding to the next airspeed/condition. A wedge envelope investigation is used as an incremental approach to quickly and methodically investigate aircraft handling qualities characteristics for safety and general suitability. This test technique is often performed for the initial flights of a new configuration (external configuration, flight control system modifications, Automatic Flight

Control System (AFCS) control law changes, etc.). A wedge envelope investigation is a qualitative assessment of the aircraft's basic static and dynamic stability characteristics over a fairly small window of the expected flight envelope and is not intended to fully characterize any specific handling qualities. The wedge technique is not necessarily envelope expansion, as this will most often be conducted within an already defined operational flight envelope. However, the general wedge approach may be used when actual envelope expansion is required. During the wedge envelope investigation, the crew must be aware of any unusual or unexpected responses. Unusual/unexpected responses include, but are not limited to, sudden control reversals, unpredictable aircraft motions/control inputs in an unexpected direction or rate required to control the aircraft, divergent aircraft motions, significant vibration changes, pilot-induced oscillations (PIO), unexpected fluctuations of the power monitoring system indications, or uncommanded rotor speed fluctuations. Also, since the wedge technique uses generally benign buildup to steady-state flight conditions, generous control margins should always exist. During the wedge buildup, flight conditions that result in less than 20% control margin may be considered unusual. Twenty percent is not intended to be a limitation for this technique but rather a recommended planning consideration. Comparison to existing data for similar flight conditions (without the test modification) should provide insight to expected flight control positions. If any unusual/unexpected characteristic is encountered, the flight condition should be returned to the previously known acceptable flight condition and the flight will terminate, and subsequent discussions on how best to continue will be conducted by the test team. The wedge envelope investigation methodology may be used for both rotary wing and fixed wing aircraft. This technique may be applied to both hover/low airspeed flight and to forward flight. These methods are generic and may be tailored in the test planning to suit the test article as appropriate.

4.6.1 Hover and Low Airspeed Wedge Technique.

The hover wedge technique begins with the initial liftoff to hovering flight. During the application of power from flat pitch on the ground until the aircraft is stabilized at a hover, the crew must assess the aircraft center of gravity and correctness of the flight control responses. The liftoff should be aborted if minimum control margins are approached or any control response appears incorrect. The crew should be aware of the potential for dynamic rollover if the flight control systems are incorrect or the CG is unexpectedly out of limits. Once the aircraft is established at an in-ground effect (IGE) hover, the crew should verify aircraft systems displays are indicating appropriately, then conduct a normal landing from a hover, and then reestablish a stabilized IGE hover. Next, make very small inputs in each control axis (one at a time) to verify the proper aircraft response. An attempt should be made to make these inputs pure and singular axis to identify off-axis responses that may be attributable to the configuration change. Once the basic response of the aircraft to control inputs has been verified, slow directional flight (below effective translational lift (ETL)) should be verified. Starting with forward flight slowly accelerate to the target speed, stabilize momentarily, then decelerate back to a stabilized hover. Use the same technique to conduct lateral hover, both left and right, then rearward flight. Continue directional flight with incremental speed increases up to airspeeds 5 to 10 knots above ETL in each direction (or published aircraft limits for sideward/rearward flight). Next, conduct a series of maneuvers that might be described as aborted takeoffs. From a stabilized hover perform a normal takeoff to an airspeed 5 to 10 knots above ETL. As the target airspeed is approached, momentarily stabilize the airspeed and approximate altitude attained, then descend

and decelerate back to an IGE hover. Repeat this maneuver increasing the target airspeed in 10- to 20-knot increments until a normal climb airspeed (typically 60 to 80 knots) is achieved. Complete the hover and low airspeed wedge envelope investigation with a normal takeoff, traffic pattern at a slow cruise airspeed, and a normal approach to landing. Additional maneuvers that may be included in the hover wedge envelope investigation include: shallow forward flight turns as required to complete traffic pattern flight, vertical climbs/descents, hover out-of-ground-effect, slope landings, slide-on/roll-on landings, and hovering autorotations.

4.6.2 Forward Flight Wedge Technique.

This method typically uses three to five airspeed increments from at or just below the minimum power required airspeed up to V_H. The wedge envelope investigation is conducted by first establishing a level flight profile at the minimum target airspeed. Once it is determined that there is no flight safety risk at that stabilized flight condition, a sideslip condition is introduced using the smallest target increment. Both left and right sideslip are assessed at that increment before proceeding to the next larger sideslip increment. The incremental process is continued until reaching maximum planned out of trim condition. Upon completion of the sideslip assessment, a stabilized level flight condition is reestablished. From the level flight condition perform a buildup in bank angle for coordinated turning flight, both left and right. Coordinated turns should be built-up to the desired maximum target angle of bank. During this buildup, sustained stabilized airspeed and altitude are not specifically required and large power changes to attempt to maintain airspeed/altitude should be avoided. The turning flight investigation is intended to verify the absence of any unexpected characteristics for normal enroute maneuvering. Upon completion of the turning assessment, a stabilized level flight condition is reestablished. From a stabilized level flight condition, two to three power increments above and below the power required for level flight are determined (up to maximum continuous power and down to minimum collective pitch/zero percent torque). Power is applied to begin a climb at the first torque increment while maintaining the initial level flight airspeed. Upon evaluating for adverse handling qualities, power is increased to the next power increment. Once maximum continuous power (MCP) is reached, the aircraft is reestablished at level flight at the initial airspeed, then decreased power increments are conducted down to minimum collective pitch or zero percent torque. Upon completing the sideslips, turns, climbs, and descents at the first target airspeed, the process is repeated the next airspeed increment.

4.7 Flight Guidance Systems.

Automatic Flight Control Systems and Coupled Flight. Recent advances in technology have provided modern aircraft with a number of different Flight Guidance Systems (FGS), which serve as aids to pilots and help to reduce overall cockpit workload. These systems vary in complexity and levels of maturity across platforms but are typically composed of sensors, onboard computers, and aircrew displays. More advanced FGS are often integrated with aircraft AFCS, or similar functioning trim systems, and auto-thrust or auto-throttle mechanisms. This integration is typically referred to as coupled flight. The different techniques used to assess FGS and Coupled Flight are abundant and each individual system deserves careful analysis before test design. A thorough assessment of the AFCS (or similar system) in accordance with Appendix VIII, USNTPS FTM-107 will usually serve as the foundation for advanced testing. Beyond that,

pilot interaction with the FGS, aircrew alerts, mode annunciation and transitioning, coupled flight performance, and workload analysis should all be considered. Where relevant, FAA Advisory Circular (AC) 25.1329-1B, *Approval of Flight Guidance Systems*,[10] should also be consulted. Instrumentation techniques are as varied as the test methodologies but may include aircraft data bus monitoring, cockpit video, appropriate workload assessment techniques, and potentially a secondary time, space, and position data source.

4.8 Weapons Testing.

In general, the scope and test procedures required for weapons testing is dictated by the system characteristics, system integration to the aircraft platform, and the extent that the new system is modified from the previous system (if that is the case). These factors can vary dramatically. For example, minimal testing may be required for a redesigned pintle mount for non-integrated door gun on a utility aircraft; whereas a significant test scope might be necessary for a highly integrated new multi-mode missile or rocket systems on attack aircraft. The following are some of the major sub-categories of weapons testing that may be applicable to any weapons test.

a. Crew Interface and Integration. This testing involves verification of the controls and displays associated with the tested weapon system functionality. This should be a thorough assessment of all functions (firing rates, firing modes, zones, trajectories, projectile types, fusing selections, cueing selections, etc.) that are exposed for crew manipulation. Initially, this testing should be conducted with the aircraft static and with non-firing weapons (training missile, inert rounds, simulation devices, etc.). For integrated weapons systems, this will often be done with data bus monitoring instrumentation to verify proper bus level communications. Also, instrumentation may be designed to capture the analog or digital signals to the various weapons firing interface (e.g., rocket fusing signals, firing impulses, etc.).

b. Live-Fire System Functionality. This testing is an extension of the crew interface and integration testing that focuses on the system operation in actual live fire. This should consist of functional verification of proper system response to all firing rates and modes. For example, for gun testing, each firing rate or burst setting should be verified; for rocket tests, each firing mode (singles/pairs/ripple etc.) should be verified.

c. Safe Separation. Safe Separation testing involves determining if the fired projectiles (and expended shells, casings, links, launch motors, etc.) will safely clear all parts of the aircraft in all potential firing conditions and firing modes. This is often done by analysis during the system design phase but may require verification by test. Safe separation testing may be conducted by various methods. In some cases, it may be possible to instrument the aircraft to verify that firing signals are inhibited in cases where the system is designed to preclude certain undesirable weapons firing situations, for example masking angles for flex-mounted off-axis guns or high/low g software inhibits. In other cases it may be necessary to conduct actual live fire, in a buildup manner, to achieve engagements at the edges of the allowable firing envelope. The allowable firing envelope should consider airspeed (including sideward and rearward), sideslip for forward flight, normal acceleration, pitch and roll attitudes and rates, and yaw rates for hover, as appropriate. Additionally, all aircraft configurations should be considered in determining potential worst cases. For example, aircraft gross weight and CG may affect

projectile trajectories, aircraft external configuration may interfere with the expendables (aircraft doors open/closed, doors installed/removed, landing gear up/down, high skid gear configuration, deployability landing gear configuration, retractable components-antennas, lights, etc.). Safe separation live-fire testing is typically documented with high speed video recordings.

d. Handling Qualities. If the external configuration has changed with the installation of the test system, it may be necessary to determine any handling qualities impacts due to the aerodynamic effects of the external configuration. This may be a simple wedge envelope investigation flight verification or it may be a range of specific classic static and dynamic handling qualities test for direct comparison to the baseline configuration. Additionally, the handling qualities transients that result from the recoil, back blast effects, and the rapid weight changes associated with ammunition expenditure should be assessed.

e. Weapons Accuracy. Weapons accuracy testing is generally only necessary to meet a system specification requirement. If there is a system specification requirement, this testing, data collection methodology, and scoring system must be designed to facilitate the metrics defined in the specification requirement. For the area fire weapons there have been several methods employed. The Aerial Weapon Scoring System (AWSS) is the Army standard for objective scoring of cannon, machine-gun, and rocket firing during aviation gunnery. Also, Yuma Test Center has developed a method for video recording weapons impacts from a hovering helicopter high overhead of a gridded impact area.

f. Noise Characteristics. Weapons firing noise characteristics may need to be documented for new weapons or ammunition where previous assessments are no longer valid. These noise data should be collected at high sample rates to capture the peak impulse values. The noise/pressure sensors are typically positioned in the close proximity to where the flight crew head positions will be. The impulse data collected are usually provided to the US Army Center for Health Promotion and Preventive Medicine (CHPPM) who provides the procuring agency with a Health Hazard Assessment report.

g. Loads and Vibration. Loads testing may be necessary to collect data for structural engineers to do structural substantiation of the weapons attachments to the aircraft, pylons/mounts, or fuselage in the area of the attachment. This usually entails strain gauges that measure the deformation of the material in locations such that the engineers can assess life cycle fatigue of the components. Similarly, vibration testing may include these same components to quantify the oscillatory motions for the purpose of understanding the structural loads as well as potential effects on projectile dispersion. Additionally, tests associated with measuring vibrations resulting from weapons firing may extend to other components of the airframe, drive system, rotors, electrical equipment, mission equipment, etc., if the firing characteristics of the test system are considerably different than what has been previously tested.

h. Blast Pressure Effects. The effects of weapons firing blast pressure have caused physical damage to aircraft including shattering Plexiglas windows/chin bubbles, damaging sheet metal panels, and engine surges due to projectile exhaust gas ingestion in the engine inlet. Blast pressure effects testing can be required to document these potential adverse effects on the airframe and/or engine(s). This testing may entail instrumenting a critical location to identify

peak pressures or instrumenting the fuselage skin with an array of pressure transducers to determine the blast pressure pattern. Additionally, an engine inlet rake may be required to investigate projectile exhaust gas ingestion, which has proven to be problematic during Hydra 70 2.75 inch rocket firing.

4.9 Mission Maneuvers Testing.

Mission maneuver testing is typically conducted to subject the test aircraft to mission representative tasks for the purpose of assessing the system at an operational level. There may be many varying reasons for this type of assessment, but if conclusions may be drawn from this type of testing, the test planners must consider if there is a need to make the test results repeatable. Using Aircrew Training Manual (ATM) tasks is an acceptable method for planning these test events, but these ATM tasks often do not provide the rigor to make the test results repeatable. The importance of repeatability is often not evident until follow-on testing is conducted, and the follow-on test is seeking increased performance for a previously identified shortcoming/deficiency. The test planners must determine if there needs to be additional controls, descriptions, or standards to make the results of the tests repeatable.

4.10 Aircraft Flight Simulator Evaluations.

In general, many of the same test techniques are used to evaluate fixed-base or full-motion flight simulators as for the actual aircraft. Especially in regard to mechanical characteristics and flying qualities, simulator evaluations are frequently efforts to better replicate the actual aircraft. The test team and customer must agree to a definition of satisfactory simulator performance before test initiation. The "instrumentation" used to collect the data are network and bus data recorders that monitor inputs to and outputs from the flight model. However, these signals do not represent the end state felt by the pilot. For example, pilot-induced oscillations in a simulator can be the cumulative result of the flight model, transport delay in the processing of the simulator video graphics seen by the pilot, and transport delay in the generation of mechanical movement of the simulator, which result in the proprioceptive cues sensed by the pilot. Test methods applicable to evaluation of aircraft simulators can be found in TOP 7-3-061 Simulator Test and Evaluation[11]. Additional reference material may be found in FAA AC 120-63, *Helicopter Simulator Qualification*[12].

5. DATA REQUIRED.

The required data for each test covered in this TOP are detailed in the references noted in each section or for the specific tests in the appendices.

6. PRESENTATION OF DATA.

The data presentation for each test covered in this TOP is detailed in the references noted in each section or for the specific tests in the appendices.

APPENDIX A. DRIVETRAIN TORSIONAL STABILITY

A.1 THEORY.

A.1.1 Drivetrain torsional stability is a characteristic of the drivetrain operating as a system; engine(s), driveshafts, gearboxes/transmissions, and mast(s). The characteristic of interest is the dynamic response to a transient condition. The transient could be a result of a gust, a power change by the main or tail rotor, or a change in engine power applied to the system. Engine response to a change in power demanded at the rotor is the primary forcing function to drivetrain torsional stability. Torsional stiffness of the drive system also contributes to the dynamic torsional response. Torsional stiffness can be represented by spring constant, and the drivetrain components will oscillate (torsionally) when excited at the natural frequency. During normal flight, it is possible to make disturbance inputs to the system that correspond to the natural frequency of the torsional stiffness of the drivetrain system. Additionally, the engine governing system may possess mechanical or electronic control characteristics that can excite the torsional natural frequency or may incorporate logic or filters intended to avoid known drivetrain natural frequencies.

A.1.2 Drivetrain torsional response may depend on initial conditions. Specifically, the dynamic torsional response to power applications depends on the flight mode in which they are applied. For example, in low power descents there may be an easily excitable response especially at the engine/rotor coupling/decoupling rotational speeds. For this reason torsional stability testing should be done from several different initial conditions.

A.1.3 Torsional stability testing is typically conducted as part of initial aircraft qualification but may be conducted following any modifications to an aircraft's drivetrain or fuel control governing system. For the aircraft to be deemed suitable, objectionable torsional oscillations should not be easily excited with normal control inputs. Further, inputs made at the drivetrain's natural frequency should not result in a divergent or persistent oscillatory response.

A.2 TEST METHODS AND TECHNIQUES.

Testing the torsional stability of the drivetrain system is conducted by making oscillatory or pulse control inputs to excite the drivetrain torsional natural frequency, and then recording the engine and rotor response. Typically, this is done by a collective controller frequency sweep through the drivetrain natural frequency, although lateral (in forward flight due to the transient torque response) or directional controller inputs may also be used to excite drivetrain responses. Also, on some systems, it may be necessary to devise alternate test methodologies to accomplish the objective of the test. If the collective cycling and pulse methods do not yield the intended torsional excitation (due to collective stick travel limitations, for example), methods using pedal inputs or fuel flow interruption may be necessary. Knowledge of the drivetrain system is helpful in determining the input frequency. If the natural frequency of the drivetrain system is known, it may be possible to directly target this response. If the natural frequency is not known, a frequency sweep in accordance with ADS-33E-PRF could be used to determine the drivetrain torsional response. In any case, the same precautions used for frequency sweep testing should be

applied to torsional stability testing. Initial torsional stability tests may be conducted with the aircraft restrained to the ground. Hover, level forward flight, and minimum power descents should also be evaluated. Additional test considerations and requirements are discussed in Section 3 – Engine Airframe Compatibility of ADS-1B-PRF[13].

A.3 DATA REQUIRED.

Drivetrain transient responses are typically coherent across the components of the drivetrain system, possibly with some phase-lagged engine response. Time history data are required for engine/transmission torque, engine gas producer speed (N_G), engine power turbine speed (N_P), engine turbine gas temperature, fuel Flow, main rotor speed (N_R), control positions, throttle position, and drivetrain loads (if required). The torsional stability of the drivetrain system can typically be determined by recording engine/mast torque(s), fuel flow, and engine/rotor speeds. If drivetrain integrity is in question, additional structural instrumentation on the drivetrain components will be necessary.

A.4 TEST CRITERIA.

Balanced, wings level, unaccelerated flight (or restrained to the ground).

A.5 DATA REQUIREMENTS.

Record the time history response until any oscillations are damped.

A.6 SAFETY CONSIDERATIONS.

Divergent drivetrain torsional oscillation responses can rapidly grow to catastrophic levels. Frequency sweep testing precautions prescribed in ADS-33E-PRF must be observed. Further, recovery techniques should be identified and practiced before conducting this testing. Typically, a smooth, fairly large collective reduction may be the best recovery technique for a divergent oscillatory torsional response. For minimum power descent torsional stability testing, a smooth collective increase to a mid-power setting should eliminate unexpected dynamic response. The potential for drivetrain failure must be considered, and suitable forced (autorotative) landing areas must be readily available. For restrained operations, the aircraft response to other than drivetrain oscillations should be previously known. If the restraint system induces lightly damped aircraft responses that are otherwise not present, restrained torsional stability testing may not be advisable.

A.7 DATA REDUCTION.

Fast Fourier Transform of the response data may be conducted to determine the dominant frequency(ies) of the drivetrain response.

APPENDIX B. RUNNING LINES ENGINE PERFORMANCE

B.1 INTRODUCTION.

During the lifecycle of a helicopter, changes sometimes have to be made to adapt to current threats that may affect the installed engine power available. One example of this is the incorporation of inlet filters or exhaust suppressors, which change the mass flow properties of the engine. Running Lines testing is used to characterize the effects of such modifications. Such a test requires back-to-back testing of the modified and unmodified configurations to compare power available curves.

B.2 PURPOSE OF TEST.

The objective of the Running Lines test method is to determine installed engine power available. To determine aircraft performance, power available must be measured and combined with airframe power required to obtain aircraft performance parameters. Power available is normally documented early in a program and is collected concurrently with other testing. The procedures presented in USNTPS FTM-106 require an inlet instrumentation rake as well as flying to the extremes of the flight envelope to gather sufficient inlet and engine performance data to build confidence in the power available curve. The Running Lines test technique provides another way of gathering the data and potentially gathering it more efficiently.

B.3 THEORY.

Because the Running Lines test method requires split power-lever adjustments, the procedure can only be used on multi-engine aircraft. The theory and concepts used in standard engine performance from USNTPS FTM-106 can be applied to Running Lines. The following equations are referenced in the FTM.

The corrected engine performance parameters are:

$$ESHP_{corr} = \frac{ESHP}{\delta_{T2}\sqrt{(\theta_{T2})}}$$

$$W_{fcorr} = \frac{W_f}{\delta_{T2}\sqrt{(\theta_{T2})}}$$

$$T_{5corr} = \frac{T_5}{\theta_{T2}}$$

$$N_{1corr} = \frac{N_1}{\sqrt{(\theta_{T2})}}$$

Where:
ESHP - Engine shaft horsepower
$ESHP_{corr}$ - Corrected engine shaft horsepower

W_f - Fuel flow
W_{fcorr} - Corrected fuel flow
T_5 - Power turbine inlet temperature
T_{5corr} - Corrected power turbine inlet temperature
N_1 - Engine gas generator speed
N_{1corr} - Corrected engine gas generator speed
δ_{T2} - Inlet pressure ratio
θ_{T2} - Inlet temperature ratio

B.4 TEST TECHNIQUE.

Running Line engine performance data are recorded during steady, unaccelerated flight conditions while maintaining a constant inlet mach number. However, unlike the techniques in the FTM, Running Lines testing is a dedicated engine performance test.

> Note: There still is a need to have the inlet performance data, so if changes have been made around the inlet area, an inlet instrumentation rake may still be required to capture inlet performance data. If inlet changes/affects can be ruled out, then inlet data must be obtained from previous testing.

Data points are flown while maintaining a constant pressure altitude and true airspeed to achieve the constant inlet Mach number. At least two mission-representative airspeeds should be flown. One of these should be the maximum endurance airspeed should be flown to allow for the largest possible engine torque split.

B.5 DATA REQUIRED.

Q, N_1, T_5, W_f, N_R, V_{true}.

B.6 TEST PROCEDURE.

B.6.1 Establish trimmed, ball-centered level flight at the target airspeed with all power levers in the FLY position. Adjust one power lever back until achieving a 5% to 10% torque split between the engine being reduced and the other engine(s). After recording stable data for 60 seconds, adjust the reduced engine power lever again until an additional 5% to 10% torque split is accomplished. Repeat this process until an engine limit is reached or rotor speed begins to droop. The splitting of power levers continues until low engine torque reaches 20% torque or the high engine reaches a single-engine limit or the average dual-engine torque reaches the allowable maximum. Once a limit is reached, return the retarded engine power lever to the FLY position, and repeat the process for the other engine(s).

B.6.2 The use of lockout (or other manual governing mode) is recommended for the initial small torque splits to better attain torque stability and bypass the torque sharing characteristic of dual engine aircraft.

B.6.3 Bleed air systems should be off.

> Note: For this test the single engine temperature limits should be established and briefed before flight.

B.7 DATA REQUIREMENTS.

1. Stabilize 60 s minimum prior to recording data
2. Record stabilized data 60 s
3. $N_R \pm 0.2\%$
4. $N_1 \pm 0.1\%$
5. $T_5 \pm 5$ °C
6. $V_{true} \pm 1$ kt

B.8 SAFETY CONSIDERATIONS.

Know and adhere to normal operating procedures and all limitations. Exercise care while manipulating the power levers. Consider having the non-flying pilot manipulate the engine power controls during the test. This enables the flying pilot to maintain the aircraft on speed/altitude and to control the collective in the event of an emergency.

B.9 DATA REDUCTION.
The following equations are used in engine performance data reduction:

$$ESHP = (K_Q)(Q)(N_R)$$

Where:
K_Q - Engine torque constant, with applicable units
for the specific helicopter to convert measured Q and NR to ESHP - hp
Q - Engine torque
NR - Main rotor speed.

$$ESHP_{corr} = \frac{ESHP}{\delta_{T2}\sqrt{(\theta_{T2})}}$$

$$W_{fcorr} = \frac{W_f}{\delta_{T2}\sqrt{(\theta_{T2})}}$$

$$T_{5corr} = \frac{T_5}{\theta_{T2}}$$

$$N_{1corr} = \frac{N_1}{\sqrt{(\theta_{T2})}}$$

Plot $ESHP_{corr}$ as a function of N_{1corr}.

Plot T_{5corr} as a function of N_{1corr}.

Plot W_{fcorr} as a function of N_{1corr}.

APPENDIX C. FIXED-WING ZERO-THRUST SINK (GLIDE)

C.1. THEORY.

C.1.1 The purpose of the zero-thrust sink test technique is to determine the zero-thrust performance characteristics of the aircraft. In a stabilized, zero-thrust descent the forces acting on the aircraft can be reduced to lift, weight, and drag as depicted in figure C-1.

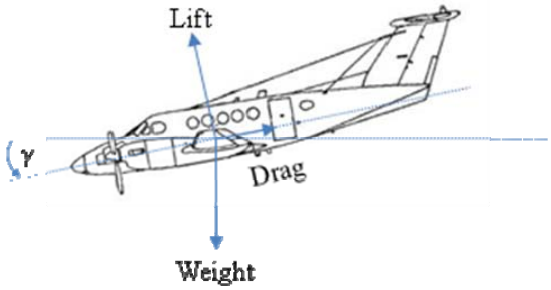


Figure C-1. Forces in a Stabilized, Zero-Thrust Descent

C.1.2 The angle formed between the horizontal plane and the flight path of the aircraft is referred to as the flight path angle (γ) and is a function of the aircraft descent rate (dh/dt) and true airspeed (V_T). During a stable, constant true airspeed descent ($dV_T/dt = 0$), the forces acting on the aircraft can be resolved using the following equations:

$$L = W \times \cos(\gamma) \qquad \text{(Eq 1.1)}$$

$$D = W \times \sin(\gamma) \qquad \text{(Eq 1.2)}$$

$$\gamma = \sin^{-1}\left(\frac{dh/dt}{V_T}\right) \qquad \text{(Eq 1.3)}$$

Assuming a parabolic drag polar (C_{Di} is proportional to C_L^2), and ignoring Mach effects, the drag and lift coefficients can be determined by substituting into Eq 4.10 and Eq 4.15 below.

$$C_D = \frac{D}{qS} \qquad \text{(Eq 4.10, (ref 5))}$$

$$C_L = \frac{L}{qS} \qquad \text{(Eq 4.15, (ref 5))}$$

Where: q = Dynamic pressure (psf)

S = Wing area (ft^2)

A drag polar (ΔC_D) can be determined by plotting C_D versus C_L^2 and fitting a first-order equation to the test points, which results in the following equation:

$$C_D = C_{D_0} + \frac{\Delta C_D}{\Delta C_L^{\,2}} C_L^{\,2} \qquad \text{(Eq 1.4)}$$

Where: C_D = coefficient of drag

C_{Do} = coefficient of drag for zero lift (intercept of C_D axis)

$\frac{\Delta C_D}{\Delta C_L^{\,2}}$ = slope of drag polar

C.1.3 When completing a configuration "A" to configuration "B" comparison, this test technique allows changes in aircraft performance caused by aircraft modifications, to be quantified.

C.2. TEST METHOD.

C.2.1. The maneuver is flown by making a series of constant-airspeed, zero-thrust descents through a target altitude band at airspeeds covering the desired test range. The altitude band for each descent is usually ±500 ft from the target altitude (example: if the target altitude was 10,000 ft, the altitude band would begin at 10,500 ft and end at 9,500 ft). Each descent is accomplished at the same starting altitude and is over the same altitude band. Observed airspeed is held constant throughout the descent and should remain within ±1 kt of the target airspeed. If the airspeed is not stabilized at the target airspeed by the start of the altitude band, the off-target airspeed (±1 kt) is maintained throughout the altitude band instead of attempting to correct to the target airspeed. Before beginning the descents, the wind direction and magnitude are determined at the target altitude. To minimize the effects of the wind, descents are flown with the winds at a 90-deg or 270-deg azimuth to the aircraft. To further reduce the effects of wind, descents for each airspeed are immediately repeated at the reciprocal heading.

C.2.2. To begin the maneuver, the aircraft is stabilized in the appropriate test configuration at 2,000 ft above the altitude band (this altitude can be adjusted based on the pilot's ability to stabilize the aircraft prior to the start of the test altitude band). The crew executes a dual-engine shut down, and the propellers are feathered in accordance with the operator's manual. The pilot initiates a descent and trims the aircraft to maintain a stabilized descent at the target airspeed and heading. Once the engines have been shut down, the fuel weight is recorded. Upon reaching the top of the altitude band, a stopwatch is started to measure elapsed time through the band, and V_o, H_{po}, OAT, and rate of descent are recorded. At each 100-ft increment throughout the descent, the elapsed time is recorded. Upon reaching the bottom of the altitude band, the exact time is recorded along with the total elapsed time, V_o, H_{po}, OAT, and descent rate. Once the engines have been restarted, the pilot initiates a climb and stabilizes at an altitude above the test band to repeat the maneuver on a reciprocal heading at the same airspeed. The maneuver is repeated in both directions for each airspeed.

C.3. DATA REQUIREMENTS.

The following data are recorded for each descent:

a. t – Time. At the top and bottom of the altitude band.

b. Δt – Elapsed time (sec). The length of time to descend from the top of the altitude band to the bottom of the altitude band.

c. V_o – Observed airspeed (KOAS). The stabilized airspeed at which the descent was flown.

d. H_{po} – Observed pressure altitude (ft). The observed pressure altitude should be recorded at the top and bottom of the altitude band.

e. OAT – Outside air temperature (°C). The outside air temperature should be recorded at the top and bottom of the altitude band.

f. Fuel Weight (lb) – Recorded once the engines have been shut down at the start of each descent.

g. Descent Rate (fpm) – Recorded to check against the processed data.

h. Aircraft Configuration – The aircraft configuration to include the position of flaps, landing gear, propellers, and external equipment (as required).

C.4. SAFETY CONSIDERATIONS/RISK MANAGEMENT.

C.4.1. The propellers-feathered glide test requires simultaneous in-flight shutdown of both engines, and the potential exists for failure of one or both engines to restart. As a result of making a forced landing, possible loss of the test aircraft and/or injuries to the crew may be sustained. The most credible severity of this hazard is CATASTROPHIC and the probability is SELDOM, resulting in a HIGH (I-D) risk level.

C.4.2. To reduce risk, the test will be conducted at an altitude sufficient to perform a power-off glide to a forced landing at an established airfield. The crew will thoroughly review and be familiar with emergency engine air-start procedures. A chase aircraft will be used for air traffic avoidance and communication. The crew will practice flight profile using zero-thrust technique before shutting down engines.

APPENDIX D. GLOSSARY

Term	Definition
AC	Advisory Circular
AFCS	Automatic Flight Control System
ATM	Aircrew Training Manual
AWSS	aerial weapons scoring system
CHPPM	US Army Center for Health Promotion and Preventive Medicine
ETL	effective translational lift
FTM	Flight Test Manual
HQ	handling qualities
IGE	in-ground effect
MCP	maximum continuous power
OGE	out-of-ground effect
PIO	pilot-induced oscillations
SAS	stability augmentation system
SCAS	stability and control augmentation system
TOP	Test Operations Procedure
Vcruise	recommended cruise airspeed
Vh	maximum level flight airspeed
Vmax glide	airspeed for maximum glide distance performance
Vmax R/C	airspeed for maximum rate of climb
Vmax range	airspeed for maximum range performance
Vmin R/D	airspeed for minimum rate of descent performance in autorotation
USNTPS	U.S. Naval Test Pilot School

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Flight Test Directorate (TEDT-AC-FT), US Army Aviation Technical Test Center, Cairns Army Airfield, Fort Rucker, AL 36362-5276. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.