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1.1 WHY PERFORMANCE FLIGHT TESTING

Aircraft performance generally can be defined as the flight maneuvers an aircraft must execute for successful mission accomplishment. Expected performance parameters must be an integral part of the aircraft design process. Given the user’s performance expectations, the designer makes decisions regarding wing loading, power plant selection, airfoil selection, planform configuration, and other design considerations. All of these help tailor the design to give the aircraft the desired performance characteristics.

Actual aircraft performance characteristics are not always the same as the design or the predicted performance characteristics. Therefore, there is a need for performance flight testing to determine the actual performance. Performance flight testing is defined as the process of determining aircraft performance characteristics, or evaluating the energy gaining and losing capability of the aircraft. Determining aircraft performance depends upon fundamental knowledge in several disciplines including: atmospheric science; fluid dynamics; thermodynamics; subsonic aerodynamics; and supersonic aerodynamics. Performance measurement requires knowledge of the propulsion system characteristics of the aircraft. The flight test team must be familiar with the theory and operation of turbine engines, reciprocating engines, and propeller theory. They must understand the basic measurements, instrumentation techniques, and equipment to gather the data needed to determine the various elements of an aircraft's performance. The team uses these disciplines to form the basis for the flight test methods and techniques for performance flight testing.

Using appropriate test methods and techniques, the flight test team begins to answer questions about the aircraft's predicted or actual performance such as:

1. How fast will the aircraft fly?
2. How high will the aircraft fly?
3. How far and/or how long will the aircraft fly on a load of fuel?
4. How much payload can the aircraft carry?
5. How long a runway is required for takeoff and landing?

6. How fast will the aircraft climb?
7. How expensive is the aircraft to operate?
8. What is the aircraft's maximum sustained turn rate?

The results of performance flight testing are used for several purposes:

1. Determine mission suitability of the aircraft.
2. Determine if the aircraft meets specific contractual performance guarantees, or performance requirements as specified in the user generated requirements.
3. Provide data to construct aircraft flight manuals for use by operational aircrews.
4. Determine techniques and procedures for use by operational aircrews to attain optimum aircraft performance.
5. Determine an aircraft’s agility as measured by specific excess power and maneuverability.
6. Obtain research information to advance aeronautical science or to develop new flight test techniques.

1.2 FLIGHT TEST MANUAL OBJECTIVE

The objective of the Fixed Wing Performance Flight Test Manual (FTM) is to serve as a practical reference guide for planning, executing, and reporting fixed wing performance flight testing. The FTM is intended for use as a primary instructional tool at the U.S. Naval Test Pilot School (USNTPS) and as a reference document for those conducting fixed wing flight testing at the Naval Air Warfare Center Aircraft Division Center (NAVAIRWARCENACDIV) or similar organizations interested in fixed wing flight testing. It is not a substitute for fixed wing performance textbooks. Rather, the FTM summarizes applicable theory to facilitate an understanding of the concepts, techniques, and procedures involved in successful flight testing. The FTM is directed to test pilots and flight test engineers (FTE); it deals with the more practical and prominent aspects of performance issues, sometimes sacrificing exactness or completeness in the interest of clarity and brevity.

The FTM does not replace the Naval Air Test Center *Report Writing Handbook*. The FTM contains examples of performance parameters discussed in narrative and graphic format. It contains discussions of the effect various performance parameters have on mission performance and suitability, and a discussion of specification compliance where applicable. The examples in this manual show trends extracted from current aircraft and are in the format used at USNTPS.

Since this FTM is a text for USNTPS, it contains information relative to operations at USNTPS and NAVAIRWARCENACDIV; however, it does not contain information relative to the scope of a particular USNTPS syllabus exercise or to the reporting requirements for a particular exercise. Details of each flight exercise vary from time to time as resources and personnel change and are briefed separately to each class.

1.3 FLIGHT TEST MANUAL ORGANIZATION

1.3.1 MANUAL ORGANIZATION

The FTM is organized to simplify access to desired information. Although there is some cross referencing, in general, each chapter stands as a distinct unit. Discussions of flight test techniques are presented together with pertinent background analytic presentations. Most of the discussion applies to fixed wing aircraft in general; with specific examples given where appropriate. The contents are organized in a classical grouping and follow the chronology of the performance syllabus at USNTPS.

Chapter 1, Introduction, is an overview of the FTM including the objectives of performance testing, flight test conditions and pilot technique, and use of confidence levels.

Chapter 2, Pitot Static System Performance, deals with determining true airspeed (V_T), calibrated pressure altitude (H_{P_c}), airspeed position error (ΔV_{pos}), altimeter position error (ΔH_{pos}), Mach number (M), and probe temperature recovery factor (K_T). Tower fly-by, paced, measured course, space positioning, smoke trail, trailing source, and radar altimeter test methods are discussed.

Chapter 3, Stall Speed Determination, deals with determining stall speed in the takeoff and landing configurations. The variation in indicated stall speed as a function of gross weight is discussed. Determining calibrated stall speed is discussed.

Chapter 4, Level Flight Performance, examines the concepts of thrust and fuel flow required for jet aircraft, and power required for propeller driven aircraft. Range and endurance are determined. The constant weight to pressure ratio method (W/δ) is emphasized.

Chapter 5, Excess Power Characteristics, deals with determining the specific excess power (P_S) characteristics of an aircraft. The level acceleration method is emphasized.

Chapter 6, Turn Performance and Agility, is concerned with sustained and instantaneous turning performance as measures of maneuverability. Sustained turning performance load factors, turn rates, and turn radii are discussed as well as instantaneous turning performance at onset, tracking, and limit buffet levels. Steady turns, windup turns, and loaded level acceleration methods are discussed.

Chapter 7, Climb Performance, examines verification of climb schedules and combat ceiling requirements. Determining climb schedules from acceleration data and the sawtooth climb method are discussed.

Chapter 8, Descent Performance, discusses verification of descent performance in relation to airspeed, angle of attack, time and fuel used for minimum rate of descent from altitude. The sawtooth descent method is emphasized.

Chapter 9, Takeoff And Landing Performance, is concerned with takeoff performance, landing performance, and short takeoff and landing (STOL) performance. Corrections to standard conditions for wind, runway slope, thrust, weight, and density are considered, as well as pilot technique.

Chapter 10, Standard Mission Profiles, presents aircraft standard mission profiles for use in evaluating performance characteristics in a simulated mission environment.

1.3.2 CHAPTER ORGANIZATION

Each chapter has the same internal organization where possible. Following the chapter introduction, the second section gives the purpose of the test. The third section is a review of the applicable theory. The fourth discusses the test methods and techniques, data requirements, and safety precautions applicable to those methods. The fifth section discusses data reduction and the sixth pertains to data analysis. The seventh section covers relevant mission suitability aspects of the performance parameters. The eighth section discusses specification compliance. The ninth is a glossary of terms used in the chapter. Finally, the tenth section lists applicable references.

1.4 EFFECTIVE TEST PLANNING

To plan a test program effectively, sound understanding of the theoretical background for the tests being performed is necessary. This knowledge helps the test team establish the optimum scope of tests, choose appropriate test techniques and data reduction methods, and present the test results effectively. Because time and money are scarce resources, test data should be obtained with a minimum expenditure of both. Proper application of theory ensures the tests are performed at the proper conditions, with appropriate techniques, and using efficient data reduction methods.

1.5 RESPONSIBILITIES OF TEST PILOT AND FLIGHT TEST ENGINEER

Almost every flight test team is composed of one or more test pilots and one or more project engineers. Team members bring together the necessary expertise in qualitative testing and quantitative evaluation. To perform the necessary tests and evaluations, the test pilot must know the applicable theory, test methods, data requirements, data analysis, instrumentation, and specifications. The flight test engineer must possess a thorough knowledge of the pilot tasks required for mission performance in order to participate fully in the planning and execution of the test program.

1.5.1 THE TEST PILOT

The test pilot is proficient in the required flight skills to obtain accurate data. The pilot has well developed observation and perception powers to recognize problems and adverse characteristics. The pilot has the ability to analyze test results, understand them, and explain the significance of the findings. To fulfill these expectations, the pilot must possess a sound knowledge of:

1. The test aircraft and fixed wing aircraft in general.
2. The total mission of the aircraft and the individual tasks required to accomplish the mission.
3. Theory and associated test techniques required for qualitative and quantitative testing.
4. Specifications relevant to the test program.
5. Technical report writing.

The test pilot understands the test aircraft in detail. The pilot considers the effects of external configuration on aircraft performance. The test pilot should have flight experience in many different types of aircraft. By observing diverse characteristics exhibited by a variety of aircraft, the test pilot can make accurate and precise assessments of design concepts. Further, by flying many different types, the pilot develops adaptability. When flight test time is limited by monetary and time considerations, the ability to adapt is invaluable.

The test pilot clearly understands the aircraft mission. The test pilot knows the specific operational requirements the design was based on, the detail specification, and other planning documents. Knowledge of the individual pilot tasks required for total mission accomplishment is derived from recent operational experience. Additionally, the pilot can gain knowledge of the individual pilot tasks from talking with other pilots, studying operational and tactical manuals, and visiting replacement pilot training squadrons.

An engineering test pilot executes a flight test task and evaluates the validity of the results to determine whether the test needs to be repeated. Often the test pilot is the best judge of an invalid test point and can save the test team wasted effort. The test pilot's knowledge of theory, test techniques, relevant specifications, and technical report writing may be gained through formal education or practical experience. An effective and efficient method is through formal study with practical application at an established test pilot school. This education provides a common ground for the test pilot and FTE to converse in technical terms concerning aircraft performance and its impact on mission suitability.

1.5.2 THE FLIGHT TEST ENGINEER

The FTE has general knowledge of the same items for which the test pilot is mainly responsible. Additionally, the FTE possesses sound knowledge of:

1. Instrumentation requirements.
2. Planning and coordination aspects of the flight test program.
3. Data acquisition, reduction, and presentation.
4. Technical report writing.

These skills are necessary for the FTE to form an efficient team with the test pilot for the planning, executing, analyzing, and reporting process.

Normally, the FTE is responsible for determining the test instrumentation. This involves determining the ranges, sensitivities, frequency response required, and developing an instrumentation specification or planning document. The FTE coordinates the instrumentation requirements with the instrumentation engineers who are responsible for the design, fabrication, installation, calibration, and maintenance of the flight test instrumentation.

The FTE is in the best position to coordinate all aspects of the program because he or she does not fly in the test aircraft often and is available in the project office. The coordination involves aiding in the preparation and revision of the test plan and coordinating the order of the flights. Normally, the FTE prepares all test flight cards and participates in all flight briefings and debriefings.

A great deal of the engineer's time is spent working with flight and ground test data. The FTE reviews preliminary data from wind tunnel studies and existing flight tests. From this data, critical areas may be determined prior to military flight testing. During the flight tests, the engineer monitors and aids in the acquisition of data through telemetry facilities and radio, or by flying in the test aircraft. Following completion of flight tests, the engineer coordinates data reduction, data analysis, and data presentation.

The FTE uses knowledge of technical report writing to participate in the preparation of the report. Usually, the FTE and the test pilot proofread the entire manuscript.

1.6 PERFORMANCE SYLLABUS

1.6.1 OVERVIEW

The performance syllabus at USNTPS consists of academic instruction, flight briefings, demonstration flights, practice flights, exercise flights, flight reports, and evaluation flights. The performance phase of instruction concludes with an individual evaluation flight and a group Navy Technical Evaluation (NTE) formal oral presentation. The final exercise at USNTPS is a simulated Navy Developmental Test IIA (DT IIA). This exercise incorporates all the performance, stability, control, flying qualities, and airborne systems instruction into the total evaluation of an airborne weapon system.

The performance syllabus includes exercises in performance demonstration; performance practice; pitot static system performance; range and endurance performance; specific excess energy; climb, descent, takeoff, and landing performance; and turn performance. The syllabus is presented in a step-by-step, building block approach allowing concentration on specific objectives and fundamentals. This approach focuses on individual flight characteristics at the expense of evaluating the total weapon system. Progress through the syllabus is toward the end objective, the evaluation of the aircraft as a weapon system in the mission environment. The details of the current syllabus are contained in *U.S. Naval Test Pilot School Notice 1542*.

1.6.2 USNTPS APPROACH TO PERFORMANCE TESTING

The USNTPS provides an in-service aircraft for performance testing; and although the aircraft is not a new one, the USNTPS assumes it has not been evaluated by the Navy. The syllabus assumes a DT IIA was not conducted and USNTPS is designated to conduct a Navy Technical Evaluation for aircraft performance. The aircraft is assumed designated for present day use. Stability and control, weapons delivery, and other testing is assumed to be assigned to other directorates of NAVAIRWARCENACDIV. The student is charged with the responsibility of testing and reporting on the engine and airframe performance characteristics of the syllabus aircraft.

Mission suitability is an important phrase at NAVAIRWARCENACDIV, and its importance is reflected in the theme of flight testing at USNTPS. The fact an aircraft meets the requirements of pertinent Military Specifications is of secondary importance if any performance characteristic degrades the airplane's operational capability. The mission of each aircraft is discussed and students conclude whether or not the performance characteristics they evaluate are suitable for the intended mission. This conclusion is supported by a logical discussion and analysis of qualitative and quantitative observations, drawing on recent fleet experience.

The evaluation of aircraft performance for comparison to specification requirements, contract guarantees, or other airplanes require accurate quantitative data. At USNTPS, every effort is made to test under ideal weather conditions with all sensitive instrumentation operational; however, problems may arise occasionally which cause errors in the data. If bad weather, instrumentation failure, or other factors result in large errors or excessive data scatter, the student critiques the data; and if warranted, the flight is reflown. Precisely accurate data are not required before the data are presented in a student report. However, it is important to know if errors in the data exist and their effect on the results. The primary purpose of the performance syllabus at USNTPS is learning proper flight test techniques and the basic supporting theory.

1.6.3 FLIGHT BRIEFINGS

Printed and oral flight briefings are presented by the principal instructor for each exercise. The flight briefing gives specific details of the exercise and covers the objective, purpose, references, scope of test, method of test, test planning, and report requirements. The briefing also covers the applicable safety requirements for the exercise as well as administrative and support requirements.

1.6.4 DEMONSTRATION FLIGHTS

Demonstration flights are preceded by thorough briefings including: theory, test techniques, analysis of test results in terms of mission accomplishment and specification requirements, and data presentation methods. In flight, the instructor demonstrates test techniques, use of special instrumentation, and data recording procedures. After observing each technique, the student has the opportunity to practice until attaining reasonable proficiency. Throughout the demonstration flight, the instructor discusses the significance of each test, implications of results, and variations in the test techniques appropriate for other type aircraft. Students are encouraged to ask questions during the flight as many points are explained or demonstrated easier in flight than on the ground. A thorough post flight discussion between instructor and students completes the demonstration flight. During the debrief, the data obtained in flight are plotted and analyzed.

1.6.5 PRACTICE FLIGHTS

Each student is afforded the opportunity to practice the test methods and techniques in flight after the demonstration flight and prior to the exercise or data flight. The purpose of the practice flight is to gain proficiency in the test techniques, data acquisition, and crew coordination necessary for safe and efficient flight testing.

1.6.6 EXERCISE FLIGHTS

Each student usually flies one flight as part of each exercise. The student plans the flight, has the plan approved, and flies the flight in accordance with the plan. The purpose of the flight is to gather qualitative and quantitative data as part of an overall performance evaluation. The primary in flight objective is safe and efficient flight testing. Under no circumstances is flight safety compromised.

1.6.7 REPORTS

A fundamental purpose of USNTPS is to assist the test pilot/FTE team to develop their ability to report test results in clear, concise, unambiguous technical terms. After completing the exercise flight, the student reduces the data, and analyzes the data for mission suitability and specification compliance. The data are presented in the proper format and a report is prepared. The report process combines factual data gathered from ground and flight tests and analysis of its effect on mission suitability. The report conclusions answers the questions implicit in the purpose of the test.

1.6.8 PROGRESS EVALUATION FLIGHT

The progress evaluation flight is an evaluation exercise and an instructional flight. It is a graded check flight on the phase of study just completed. The flight crew consists of one student and one instructor. The student develops a flight plan considering a real or simulated aircraft mission and appropriate specification requirements. The student conducts the flight briefing, including the mission, discussion of test techniques, and specification requirements.

As the student demonstrates knowledge of test techniques in flight, the student is expected to comment on the impact of the results on the real or simulated mission. The instructor may comment on validity of the results obtained, errors or omissions in test procedures, and demonstrate variations in test techniques not introduced previously.

During the debrief the student presents, analyzes, and discusses the test results. The discussion includes the influence of the results on aircraft mission suitability.

1.7 PERFORMANCE FLIGHT TEST CONDITIONS AND PILOT TECHNIQUES

1.7.1 ATTITUDE FLYING

In flight test, attitude flying is absolutely essential. Under a given set of conditions (altitude, power setting, center of gravity), the aircraft airspeed is entirely dependent upon its attitude. The pilot’s ability to fly the aircraft accurately depends upon the ability to see and interpret small attitude changes. This is best done by reference to the outside horizon. Any change in aircraft attitude is noticed by reference to the visual horizon long before the aircraft instruments show a change. Thus, it is often possible to change the attitude of the aircraft from a disturbed position back to the required position before the airspeed has changed. The outside horizon is useful as a rate instrument. For example if a stabilized point is required, the pilot holds zero pitch rate by holding aircraft attitude fixed in relation to an outside reference. If, as in acceleration run, the airspeed is continuously increasing or decreasing, the pilot makes a steady, smooth, and slow change in aircraft attitude.

The method of lining up a particular spot on the aircraft with an outside reference can be useful, but may waste time. Often, a general impression is all that is necessary. The pilot can see the pitch rate is zero by using peripheral vision while also glancing at the airspeed indicator or other cockpit instruments. As soon a pitch rate is noted, the pilot can make proper control movements to correct the aircraft attitude. The pilot must maintain situational awareness at all times during the flight.

If necessary to stabilize on an airspeed several knots from the existing airspeed, time can be saved by overshooting the required pitch attitude and using the rate of airspeed change as an indication of when to raise or lower the nose to the required position. A little practice allows the pilot to stabilize at a new airspeed with a minimum amount of airspeed overshoot in the least time.

1.7.2 TRIM SHOTS

Hands off, zero control force, steady trim conditions are required for stable test points. The point where all forces and moments are stabilized with a zero control force is a trim shot or trim point.

Normal attitude flying techniques are used for coarse adjustments to stabilize and trim at a particular speed or Mach number at a constant altitude. Stable equilibrium or unstable equilibrium techniques are then employed to establish precisely the desired airspeed and altitude. Once the proper attitude and power setting are established, the force is trimmed to zero while holding the required control position. The control is released to check for a change in pitch attitude. If the attitude changes, the pilot puts the attitude back at the trim position and retrims. Lateral and directional controls are used to hold the wings level and maintain constant heading and coordinated flight. The control forces are held in order to accomplish this, then the forces are relieved by proper trim actuation. The method of moving the trim device and allowing the aircraft to seek a new attitude hands off is very time consuming and inaccurate. The pilot should hold the aircraft attitude fixed and then relieve the existing control forces by trimming.

1.7.3 TEST CONDITIONS

There are three basic test conditions at which a pilot operates an aircraft while conducting performance testing. Each test condition requires specific flight techniques and uses different primary flight instruments for pilot reference. These conditions are stable equilibrium, unstable equilibrium, and nonequilibrium. Equilibrium test conditions are present when the aircraft is stabilized at a constant attitude, airspeed and altitude. A stable equilibrium condition is a condition in which the aircraft, if disturbed, returns to its initial condition. An unstable equilibrium test point is a point from which the aircraft, if disturbed, continues to diverge. A nonequilibrium condition is a condition during which there is a change in airspeed and/or altitude.

1.7.4 STABLE EQUILIBRIUM CONDITIONS

Stable equilibrium data points are obtained in both level and turning flight when operating at airspeeds greater than the airspeed for minimum drag (stable portion of the thrust or power required curve). The test technique for obtaining stable equilibrium data is to adjust altitude first, power second, and then wait until the aircraft stabilizes at the equilibrium flight airspeed. Altitude must be maintained precisely and thrust/power must not be changed once set. If this technique is followed, a time history of airspeed is used to determine when the equilibrium data point is obtained. For most tests, when the airspeed has changed less than 2 kn in the preceding 1 minute period, an equilibrium data point is achieved. Stable equilibrium test conditions are obtained best by approaching them with excess airspeed. This approach ensures convergence, whereas an accelerating approach may converge only after fuel exhaustion. The flight test technique used in obtaining stable equilibrium conditions is called the constant altitude or front side method.

The primary parameters for pilot reference when obtaining data points under stable equilibrium conditions are altitude, vertical speed, heading for straight flight, and bank angle for turning flight. There is no substitute for a good visual horizon. In airplanes equipped with automatic flight control systems (AFCS) which incorporate attitude, altitude, and heading hold modes, stable equilibrium data points can be obtained by using these modes provided the AFCS sensitivity is adequate for the test. In straight flight, stable equilibrium conditions can be achieved by using altitude and heading hold modes. In turning flight, stable equilibrium conditions can be achieved by using altitude and attitude hold modes.

1.7.5 UNSTABLE EQUILIBRIUM CONDITIONS

Unstable equilibrium data points are more difficult to obtain and require proper technique. For the unstable equilibrium data points, indicated airspeed is held constant. Altitude, engine speed, or bank angle is adjusted as required by the test being conducted. Unstable equilibrium data points are associated with the unstable portion of the thrust or power required curve. To obtain data points under these conditions, the desired test airspeed is established first, then the throttle is adjusted to climb or descend to the desired test altitude. The vertical speed indicator is an important instrument in achieving equilibrium conditions. With throttle set, the vertical speed is stabilized while maintaining the desired test airspeed. A throttle correction is made and the new stabilized vertical speed is observed. The approximate engine speed required for level flight can be determined by correlating the values. For example, while attempting to obtain a level flight data point at 135 KIAS, the pilot determined 88% produced an 800 ft/min climb in the vicinity of the desired test altitude and 80% produced a 200 ft/min descent. The test pilot determined a 1% change represented a 125 ft/min change in vertical speed. By adjusting throttle to 81.6%, equilibrium level flight conditions are achieved. Normal pilot technique usually enables the engine to be set to within 1% or 2% of the proper engine speed, then the averaging technique is useful. A variation of this technique must be used in turning flight when the throttle is set at MIL and cannot be used as the adjustable variable. In this case, bank angle (or load factor) is related to vertical speed in the same manner engine speed was related to vertical speed in the straight flight conditions. The flight test technique used in obtaining unstable equilibrium conditions is called the constant airspeed or back side method.

The primary parameters for pilot reference when obtaining data points under unstable equilibrium conditions are airspeed, vertical speed, heading for straight flight, and bank angle for turning flight. For tests in which rate of climb can be corrected to thrust or power required, achieving equilibrium at zero vertical speed is not necessary. A small altitude change over a short time period can be used to correct the test results to level conditions. In other tests, achieving zero vertical speed is necessary. Sufficient practice usually results in a satisfactory ability to obtain zero vertical speed at the desired test altitude in less time than it takes to determine an average rate of climb correction. The constant airspeed technique can be used to obtain test data under stable equilibrium conditions as well. Normally, automatic flight control systems offer little advantage over manual control in obtaining unstable equilibrium data points.

1.7.6 NONEQUILIBRIUM TEST POINTS

Nonequilibrium test points are usually the most difficult to obtain. They preclude stable conditions or the ability to trim to maintain constant conditions. The pilot does, however, have some schedule to follow in achieving a satisfactory flight path or flight test condition. Some nonequilibrium tests such as acceleration runs are performed at a constant altitude. Others, such as climbs and descents, are performed according to an airspeed schedule. Nonequilibrium test points require smoothly capturing, transitioning between data points, and maintaining a schedule.

The primary reference parameters for nonequilibrium tests is dictated by the specific test being performed. An AFCS can be an aid in obtaining nonequilibrium data. The degree it can be employed depends upon the specific test and the capability of the modes. Good heading hold and altitude hold modes can be valuable in obtaining level acceleration test data. Climb and descent tests can be performed using Mach or indicated airspeed hold modes if they have sufficiently high gain to maintain the desired schedule accuracy.

1.7.7 ENERGY MANAGEMENT

Proper energy management is critical to effective use of scarce flight test resources. Energy conservation when progressing from one test point or condition to another allows acquisition of a greater quantity of data.

The test pilot is mentally ahead of the aircraft and flight profile. The pilot is aware of the next test point and effects a smooth energy conserving transition from point to point. A smooth transition between points might include trading airspeed for an airspeed/ altitude entry condition for a succeeding test point.

The test should be planned to make maximum use of the entire flight profile. Takeoff, climb, descent, and landing tests can be combined with tests conducted at altitude.

1.8 CONFIDENCE LEVELS

The quality of a data point, whether it meets test requirements and test conditions, is determined by the test pilot/test team at the time the data are gathered. Confidence levels (CL) are a quantitative data rating scheme used to relate information about the quality of the data. The assignment of a CL to a data point is important to provide the test team and other future users of the data assistance in:

1. Determining how strong a conclusion can be based upon the data point.
2. Weighing of data when curve fitting.
3. Prioritizing further tests.

Low CLs can result from several causes. The following are some of the primary factors affecting CLs:

1. Atmospheric conditions (turbulence, wind shear).
2. Aircraft condition (marginal or degraded engine performance).
3. Pilot technique.

The following quantitative scale is used to quantify confidence levels.

Table 1.1
CONFIDENCE LEVELS

LEVEL	DESCRIPTOR	DESCRIPTION
1	Poor	Use only for order of magnitude assessment.
2	Marginal	Pilot technique/environmental conditions slightly outside of desired tolerances; accuracy sufficient to give good idea of the actual value, but not to support conclusion regarding specification compliance.
3	Acceptable	Tolerances just within the limits of acceptability as defined in the method of test. Useable for specification compliance.
4	Good	Tolerance well within the defined limits for the test.
5	Excellent	Tolerance limited only by the accuracy of the instrumentation used.

Levels 2, 3 and 4 have specific definitions in terms of established test standards. Most of the student test data falls into one of these categories. The meaning of the confidence level assignment should be unambiguous once the test standards are defined.

Some examples of using CLs are presented below.

1. A level acceleration is flown with +300 ft altitude deviation and +0.l g n_z excursion. The confidence level is 3.

2. A climb schedule is flown in smooth air with +2 KIAS airspeed deviation without noticeable n_z excursion. The confidence level is 4.

3. A sawtooth climb is flown smoothly with an airspeed deviation of ±5 kn. Confidence level is 2.

The use of confidence levels is encouraged throughout the performance syllabus. With experience, confidence levels are of significant value when used during the flying qualities syllabus.

1.9 FLIGHT SAFETY

1.9.1 INCREMENTAL BUILD-UP

The concept of incremental build-up is one of the most important aspects of flight testing. Build-up is the process of proceeding from the known to the unknown in an incremental, methodical pattern. Flight tests are structured in this manner. Testing begins with the best documented, least hazardous data points and proceeds toward the desired end points always conscious of the aircraft, pilot, and evaluation limits. There should be no surprises in flight test. In the event a data point yields an unexpected result or a series of data points creates an unexpected trend, evaluation stops until the results are analyzed and explained.

1.10 GLOSSARY

1.10.1 NOTATIONS

AFCS	Automatic flight control system	
CL	Confidence level	
ΔH_{pos}	Altimeter position error	ft
DT IIA	Developmental Test IIA	
ΔV_{pos}	Airspeed position error	kn
FTE	Flight test engineer	
FTM	Flight Test Manual	
g	Gravitational acceleration	ft/s^2
H_{P_c}	Calibrated pressure altitude	ft
K_T	Temperature recovery factor	
M	Mach number	
MIL	Military power	

NAVAIRWARCENACDIV	Naval Air Warfare Center Aircraft Division	
NTE	Navy Technical Evaluation	
n_z	Normal acceleration	g
P_s	Specific excess power	ft/s
STOL	Short takeoff and landing	
USNTPS	U.S. Naval Test Pilot School	
V_T	True airspeed	
W/δ	Weight to pressure ratio	

1.11 REFERENCES

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