

NATIONAL TEST PILOT SCHOOL



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**Appendix D contains the list of NTPS Courses Coordinators.
Changes of the Appendix D will not require a revision of this Manual.**

List of Changes

Rev.	Date	Summary of Changes
4	2 June 2017	<ul style="list-style-type: none"> • Added Professional Course Module Descriptions for T&E 4003, Capstone Project • Updated Professional Course Module Descriptions for: <ul style="list-style-type: none"> • T&E 4008, Introduction to Systems Testing • T&E 4101 - Performance Flight Testing I • T&E 4102 Performance Flight Testing II • T&E 4103 Flying Qualities Flight Testing I • T&E 4104 Flying Qualities Flight Testing II • T&E 4107 Aircraft Icing Certification • T&E 4111 RW Performance Flight Testing I • T&E 4112 RW Performance Flight Testing II • T&E 4113 RW Flying Qualities Flight Testing I • T&E 4114 RW Flying Qualities Flight Testing II • T&E 4201 Avionics Systems Flight Testing • T&E 4202 Communications, Navigation and GNSS Flight Testing • T&E 4203 14 CFR Part 23/25/27/29 Avionics Certifications Flight Testing • T&E 4204 Flight Test of RADAR and Electronic Warfare Systems • T&E 4205 UAV Systems Test • T&E 4206 Air-to-Air and Air-to-Ground Weapons Integration • T&E 4207 Electro-Optics and Infrared Systems Flight Testing • Updated Academic Outcomes Cross Reference Tables in Appendix B • Edited to comply with BPPE Requirements. • List of Acronyms and Abbreviations added. • Formatted References to Modern Language Association (MLA) format.
5	1 November 2019	<ul style="list-style-type: none"> • Terminology changes to comply with WSCUC and BPPE nomenclature • Course Coordinator names moved to new Appendix D. • Course durations added. • Typical course schedules added. • Course prerequisites (if applicable) added. • Textbook references standardized to American Psychological Association (APA) citation format.
6	31 March 2021	<p>A broad update across the entire document to fix errors, update old information, and establish new practical credit hours. Some changes/updates made on almost every page of the document. Practical credit hours were increased by 1 credit hour for the following courses after a thorough review of the course content: T&E 4007, 4008, 4017, 4101, 4102, 4103, 4104, 4111, 4112, 4113, 4114, 4203, 4204, and 4207. As of this date, the content of this document has been pushed to Catalog and website updates.</p>
7	03 January 2022	<p>Pre-requisites introduced to join professional courses. Pre-requisites introduced for individual modules. Space Test & Evaluation Training Course added to the Curriculum. As of this date, the content of this document has been pushed to Catalog and website updates.</p>

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List of Acronyms and Abbreviations

ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-33	Aeronautical Design Standard-33
AFCS	Automatic flight control system
AGARD	Advisory Group for Aerospace Research and Development
AltMoC	Alternate Means of Compliance
CLHQ	Closed Loop Handling qualities
COI	Critical Operational Issues
COTS	Commercial Off The Shelf
CRM	Crew Resource Management
DGPS	Differential Global positioning System
DT&E	Developmental Test and Evaluation
EASA	European Aviation Safety Agency
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EO	Electro Optical
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCS	Flight Control System
FGS	Flight Guidance system
FMS	Flight Management System
FPS	Flight Path Stability
FQ	Flying Qualities
FTE	Flight Test Engineer
FTT	Flight Test Technique
FW	Fixed Wing
GC	Ground Course
GCS	Ground Control Station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	Human Factors
HMD	Helmed Mounted Display
ILS	Instrument Landing System
INS	Inertial Navigation System
IP	In Progress
Lat/Dir	Lateral-Directional
MATLAB	Matrix Laboratory
Mil-Hdbk	Military Handbook
MilSpec	Military Specification
MilStd	Military Standard
M _{MO}	Maximum Operating Mach Number
MOE	Measure of Effectiveness

MOS.....	Measure of Success
MOA.....	Measure of Acceptability
NATO.....	North Atlantic treaty Organization
NavAids.....	Navigational Aids
NTPS.....	National Test Pilot School
NVIS.....	Night Vision Imaging System
OT&E.....	Operational Test and Evaluation
P&FQ.....	Performance and Flying Qualities
PEC.....	Position Error Correction
PIO.....	Pilot Induced Oscillation
Qual Eval.....	Qualitative Evaluation
RML&A.....	Reliability, Maintainability, Logistics and Availability
RNP.....	Required Navigational Performance
RW.....	Rotary Wing
S&C.....	Stability and control
SimEx.....	Simulator Exercise
SRB.....	Safety Review Board
STI.....	Speech Transmission Index
TAA.....	Technologically Advance Aircraft
TAS.....	Traffic Avoidance System
TAWS.....	Terrain Awareness and Warning System
TCAS.....	Traffic Collision Avoidance System
TB.....	Trailing Bomb
TFB.....	Tower Flyby
TOEFL.....	Test of English as a Foreign Language
TPS.....	Test Pilot School
TRB.....	Technical Review board
TSPI.....	Time space Positioning Information
TTNT.....	Tactical Targeting Network
T&E.....	Test and Evaluation
UAV.....	Unmanned Aerial Vehicle
VC.....	Vertical Climb
V _{MCA}	Airborne Minimum Controllable Airspeed
V _{MCG}	Ground Minimum Controllable Airspeed
V _{MU}	Minimum Unstick Airspeed
VOR.....	Very High Frequency Omni Range
VSGS.....	Variable Stability Ground Simulator

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Master's Degree Curriculum

In order to graduate, student candidates for the Master's Degree must take a core curriculum and select one of two specialty tracks (Performance and Flying Qualities or Systems). Courses are offered in modules, nominally one week of theory and two weeks of practical exercises. Compulsory core modules include the Capstone Project (T&E 4003), Test Management and OT&E (T&E 4002) and depending upon their specialty, T&E 4101/4111, 4102/4112, 4103/4113, 4104/4114, Introduction to Fixed Wing/Rotary Wing Performance and Flying Qualities Flight Testing (T&E 4007/4017) and the Introduction to Systems Flight Testing (T&E 4008) if doing the P&FQ specialization or T&E 4201, 4202, 4203 and the Introduction to Fixed Wing/Rotary Wing Performance and Flying Qualities Flight Testing (T&E 4007/4017) if doing the Systems specialization. Students enrolled in the Professional course who complete the practical (flying) phase of the academic modules will be exempt from attending the introductory modules. Throughout the course of instruction, emphasis is given to flight test means of showing compliance with the Code of Federal Regulations title 14 (14 CFR), the European Aviation Safety Agency (EASA) Certification Specifications (CS) and military standards for piloted aircraft.

The culmination of the master's degree is a capstone project. This project serves as comprehensive project that utilizes much of the material taught during the entire course. All students in good standing must register for T&E 4003, Capstone Project, in the calendar year in which they anticipate submitting their report. Should they be unable to complete their report in that year, a grade of IP (In Progress) will be assigned but they will be required to re-enroll in T&E 4003 in any subsequent year in which they submit their report. Upon submission of a satisfactory report, a grade will be awarded in place of IP.

Students who are not registered for one of the NTPS professional courses have the option of arranging for use of NTPS assets or submitting a report based on a flight test related project with the approval of their academic advisor. In either case the project must represent original work. The student will design a plan of action, execute that plan, collect and analyze data, and produce final reports, both oral and written. Students who have registered for T&E 4003 but who do not submit a satisfactory report within five years after initial enrollment will be considered withdrawn and receive a grade of W (Withdrawal).

Completion of the master's degree program alone does not automatically qualify graduates as aircrew members (Test Pilot or Flight Test Engineer). To be qualified as an aircrew member, the relevant Professional Course or Category II course must be completed or significant flight test experience obtained.

Professional Courses

Test Pilot / Flight Test Engineer Professional Course

The Professional Course is the ultimate in flight test education. Graduates of this 50 week course are prepared to perform envelope expansion, civil certification, and military suitability flights meeting FAA/EASA certification or military specifications. This course is designed to turn experienced pilots and engineers into experimental test pilots and flight test engineers with the knowledge and practical experience to support development and certification of new or modified aircraft to stringent FAA/EASA/Military certification standards and/or to recommend the aircraft for specific military missions. This is not a basic flight training course. It is an intense academic curriculum designed to produce world class experimental test pilots and flight test engineers.

The course is structured in two phases: The Systems Phase begins in January and the Performance and Flying Qualities Phase begins in July. Students may join the course either in January ('A' Class) or June ('B' Class). All students should start with the T&E 4001 modules (if possible) and then join the applicable phase. Course subjects are taught in modular form, generally one week of theory followed by two weeks of practical laboratory exercises flight demonstrations, test planning, data collection and analysis, and reporting. Individual modules shown in the table below are defined in detail in Appendix A.

Required Modules

T&E 4001 Fundamentals of Flight Test	T&E 4201 Avionics Systems Flight Test
T&E 4002 Test Management and OT&E	T&E 4202 Navigation, Communications and GPS Testing
T&E 4003 Capstone Project	T&E 4203 14 CFR 23/25/27/29 Avionics Certification Testing
T&E 4101/4111 Performance Flight Testing I	T&E 4204 RADAR and EW Systems Testing
T&E 4102/4112 Performance Flight Testing II	T&E 4205 UAV Systems Test
T&E 4103/4113 Flying Qualities Flight Testing I	T&E 4206 Weapons Integration Testing
T&E 4104/4114 Flying Qualities Flight Testing II	T&E 4207 Electro-Optic and Infrared Systems Testing
T&E 4105 Modern Flight Control Systems	T&E 4208 HMD and NVG Testing
T&E 4106/4116 Loads, Flutter/Vibration	
T&E 4107 Civil Aircraft Icing Certification	

Master's Degree

Students who successfully complete the Test Pilot / Flight Test Engineer Professional Course will have completed all the required modules for the master's degree program and will graduate with one of the two master's degrees, depending on their undergraduate qualifications.

Pre-requisites

Pilot: A minimum of 750 hours of pilot-in-command time and a bachelor's degree in math, science or engineering (or equivalent military academy) plus medically qualified to perform flight duties.

Engineers: A bachelor's degree in math, science or engineering (or equivalent military academy) plus medically qualified to perform flight duties.

All Students: English language proficiency. Non-native English speakers must pass a Test of English as a Foreign Language (TOEFL) with a minimum score of 70 for pilots and 60 for FTEs. All students must study and understand the content of NTPS handbooks Volume I (Math and Physics

for Flight Testers) and Volume II (Aerodynamics for Flight Testers); both volumes are available for download at the NTPS website: <https://www.ntps.edu/information/tps-preparation.html>.

Performance and Flying Qualities Professional Course

One Performance and Flying Qualities Course is offered each year. The Performance and Flying Qualities Course is aligned with the Professional Course. Pilots and engineers attend the same theoretical classes and participate in many of the same practical exercises as the students in the applicable portion of the Professional Course. Emphasis is placed on mission suitability, civil certification and military standards for piloted aircraft. Safety in flight test is stressed in all aspects of the courses.

The Performance and Flying Qualities Course is 26 weeks long beginning in June. Students enrolled in the Master of Science degree program will receive credits towards their master's degree and can complete the remaining modules on a part-time basis.

Pre-requisites

Pilots: A minimum of 750 hours of pilot-in-command time and a bachelor's degree (or equivalent military academy) in math, science or engineering.

Engineers: A bachelor's degree (or equivalent military academy) in math, science or engineering, plus medically qualified to perform flight duties.

All Students: English language proficiency. Non-native English speakers must pass a Test of English as a Foreign Language (TOEFL) with a minimum score of 70 for pilots and 60 for FTEs. All students must study and understand the content of NTPS handbooks Volume I (Math and Physics for Flight Testers) and Volume II (Aerodynamics for Flight Testers); both volumes are available for download at the NTPS website: <https://www.ntps.edu/information/tps-preparation.html>.

Planned Modules

T&E 4001 Fundamentals of Flight Test	T&E 4104/4114 Flying Qualities Flight Testing II
T&E 4101/4111 Performance Flight Testing I	T&E 4105 Modern Flight Control Systems
T&E 4102/4112 Performance Flight Testing II	T&E 4106/4116 Structures, Loads, Flutter/Vibration
T&E 4103/4113 Flying Qualities Flight Testing I	T&E 4107 Civil Aircraft Icing Certification
	T&E 4003 Capstone Project

Systems Professional Course

One Systems Professional Course is offered each year. The Systems Course is aligned with the Professional Course. Pilots and engineers in this course attend the same theoretical classes and participate in many of the same practical exercises as the students in the applicable portion of the Professional Course. Emphasis is placed on mission suitability, civil certification and military standards for piloted aircraft. Safety in flight test is stressed in all aspects of the courses.

The Systems Flight Test Course is 24 weeks long. The course is held each year from January to June. Throughout the course there are multiple student-planned projects addressing all of the main systems taught.

There are nine modules in the course, which are the same for either fixed or rotary wing. Students enrolled in the Master of Science degree program will receive credits towards their master's degree and can complete the remaining modules on a part-time basis.

Pre-requisites

Pilots: A minimum of 750 hours of pilot-in-command time and a bachelor's degree in math, science or engineering (or equivalent military academy) plus medically qualified to perform flight duties.

Engineers: A bachelor's degree in math, science or engineering (or equivalent military academy) plus medically qualified to perform flight duties.

All Students: English language proficiency. Non-native English speakers must pass a Test of English as a Foreign Language (TOEFL) with a minimum score of 70 for pilots and 60 for FTEs.

Planned Modules

T&E 4001 Fundamentals of Flight Test	T&E 4205 UAV Systems Test
T&E 4201 Avionics Systems Flight Testing	T&E 4206 Weapons Integration Testing
T&E 4202 Communications, Navigation, and GPS Testing	T&E 4207 Electro-Optic and Infrared Systems Testing
T&E 4203 14 CFR 23/25/27/29 Avionics Certification Testing	T&E 4208 HMD and NVG Testing
T&E 4204 RADAR and Electronic Warfare Testing	

Category II Test Pilot / Flight Test Engineer Course

An eighteen-week course demonstrating techniques to evaluate fixed wing aircraft and helicopters for FAA/EASA certification. The course contains the EASA Category II training requirements. Training includes flight time in various aircraft. Systems, Performance, Flying Qualities and related FAA and EASA certification standards are emphasized.

Planned Modules

T&E 4008 Introduction to Systems	T&E 4103 or 4113 Flying Qualities Flight Testing I
T&E 4001 Fundamentals of Flight Test	T&E 4104 or 4114 Flying Qualities Flight Testing II
T&E 4101 or 4111 Performance Flight Testing I	T&E 4105 Modern Flight Control Systems ** (Optional)
T&E 4102 or 4112 Performance Flight Testing II	T&E 4003 Capstone Project

This course includes seven mandatory modules. ** Modern Flight Control Systems is optional at additional cost. Students will participate in modules together with NTPS Professional Course students. Students enrolled in the Master of Science degree program will receive credits towards their master's degree and can complete the remaining modules on a part-time basis.

All Students: English language proficiency. Non-native English speakers must pass a Test of English as a Foreign Language (TOEFL) with a minimum score of 70 for pilots and 60 for FTEs. All students must study and understand the content of NTPS handbooks Volume I (Math and Physics for Flight Testers) and Volume II (Aerodynamics for Flight Testers); both volumes are available for download at the NTPS website: <https://www.ntps.edu/information/tps-preparation.html>.

Short Courses

Refer to Appendix B

On-Demand Courses

Refer to Appendix B

REFERENCES

- NTPS Policy Manual
- NTPS Organizational Management Manual
- NTPS Flight Test Manual Organizational Manual
- NTPS Safety Management Manual
- NTPS Training Manual

Appendix A

Professional Course Module Descriptions

In the following pages are detailed descriptions of the 22 modules that make up the Professional Course. The academic portions of the module descriptions make up the core of the Master's degree program. The academic modules can be taken on their own as short courses provided that prerequisite modules have been completed and entrance requirements have been met. In this case the students doing only the academics will normally attend with Professional Course students who are doing all elements of the module, both academic and practical.

Course and Lecture Outcome Definitions

The academic program at the National Test Pilot School makes a distinction between three levels of possible outcomes out of educational events. The possible outcome levels are presented hereinafter in an ascending order. Any higher hierarchy level includes, by definition, all lower hierarchy outcomes.

Be Familiar with - The student should have a general idea about the concept taught and the purpose of its use. Once presented with the subject in their professional career the student should have enough information to allow them to continue independent study on the subject.

Understand - The student should have a thorough grasp on the subject or concept including the process of its development from first principles. The student should apply his/her understanding of the subject in order to interrelate it with other concepts.

Know - The student should have the ability to apply his/her understanding of the subject or concept to solve practical engineering problems and being able to also assess the validity of his/her solution. The student should be comfortable enough to educate other persons on the subject.

T&E 4001 Fundamentals of Flight Test

Course Number and Name

T&E 4001 Fundamentals of Flight Test

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)

2. Pre-requisites

None

3. Text Books

4.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 1 Math and Physics for Flight Testers, Volume 1*, National Test Pilot School, Mojave, CA, Chapter 6.
 - NTPS Faculty, 2015, *National Test Pilot School Technical Reports Manual*, Rev M.

5. Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - Computer-based data analysis tools.
 - The techniques used to conduct a cockpit evaluation.
- b. Understand:
 - The purpose of flight test and evaluation and am familiar with the T&E process.
 - The roles and responsibilities of a test pilot and flight test engineer.
 - Human factors considerations applicable to conducting flight test.
 - Basic statistics concepts and how they apply to flight testing.
 - Areas to be considered in planning a mission and how to write test cards.
 - Risk management and safety considerations while planning and conducting a flight test program.
 - The format and content of technical reports, both written and oral.
 - The importance of crew resource management in test and evaluation.
- c. Know
 - None

Topics to be Covered

- 6.
- Overview. This is a foundational course for the Master's Degrees and the Test Pilot and Flight Test Engineer courses that covers the fundamental subjects of flight test. The role of the test pilot and flight test engineer is described along with an explanation of the different types of flight test including R&D, DT&E, and OT&E. Other key subjects covered include: Report Writing, Human Factors and Cockpit Evaluation, Test Planning, Risk Management, Safety in Flight Test, Data Analysis, Certification Standards, and Math/Physics Review.
 - Report Writing. The essential elements of good technical writing are emphasized as well as the basic requirements for test reports generally. Both written and oral reports are covered. Content is stressed over form.
 - Human Factors and Cockpit Evaluation. Human factors engineering and crew resources management principles are taught along with methodology for assessing a cockpit design. The student is assigned one of the school's aircraft for evaluation. The student will demonstrate Information Literacy by utilization of on-line databases in preparation for the ground cockpit evaluation. This exercise is to get the student thinking critically as well as provide experience in evaluating a cockpit. In addition, it provides the subject for their first report.
 - Test Planning and Data Card Preparation. General principles for test planning and the design of a flight test cards are covered.
 - Risk Management and Safety in Flight Test. Safety is emphasized throughout the course, however during the Introduction the tools and processes necessary to ensure safe testing are presented. The roles of test and safety review boards (TRB / SRB) and the development and use of test hazard analyses (THAs) are taught.
 - Data Analysis. Basic elements of statistical analysis of data are covered including probability distributions, confidence limits, and hypothesis testing. Tests for normality, sample size determination, and circular error probable are also taught using flight test examples. This topic has a graded exam.
 - Certification and Military Standards. An overview is given of all of the regulatory material that will be used during the course. These include Federal Aviation Regulations, Joint Airworthiness Regulations, MIL SPECS and MIL STDs.
 - Math and Physics. An exam is given during the first week to assess the student's preparedness in undergraduate math and physics. The grade on this exam is not part of the student's NTPS record. Rather, the exam is used to determine which students may need extra tutorial assistance during the early part of the course.

Specific Course Information

- a. This three-week course is typically offered twice a year and consists of academic lecture, laboratory exercises, and airborne flight instruction offered daily on a Monday through Friday schedule.
- 7. b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Introduction/Tour	3
Test Pilot Job Description	1
Flight Test Engineer Job Description	1
Human Factors	2
Crew Station Evaluation and Assignment	2
Oral and Written Reports and Test Plans	3
Flight Test and Evaluation Principles (DT/OT&E)	2
FTE Fundamentals of Flight	3
Spreadsheets in Flight Test	3
Introduction to modeling software (n/a Masters Focused)	3
Control Room Familiarization	1.5
Test Conductor Training	1.5
Risk Management and Flight Test Safety	2
Mission Planning and Test Cards	2
Statistics and Data Analysis	7
Crew Resource Management	2
History of Civil Certification	1
Civil vs. Military Certification	1
Instrumentation Systems	3

Total: 44

c. Laboratory Hours

Laboratories	Hrs
Crew Station Eval Exercise	5
Test Conductor Exercises - Simulator and TM Room	2
CRM Exercises Simulator and TM Room	4

Total: 11

d. Reports and Exams

Reports and Exams	#
Daily Flight Reports (n/a Master Focused)	1
Cockpit Eval Oral Report	1
Cockpit Eval Written Report (substantial report)	1
Math and Physics Exam	1
Statistics and Data Analysis Exam	1

Total: 6

e. Flying Hours (n/a Masters Focused)

Flights	Hrs
Local Area Orientation	1.3
Test Conductor Demo	1.0

Total: 2.3

f. Fixed-wing Familiarization Flying Hours (n/a Masters Focused)

Familiarization Flights	Hrs
Single engine propeller	2.0
Single engine complex	2.0
Multi-engine propeller	2.0
Multi-engine turboprop	1.0
Tailwheel	1.0
Sabreliner	1.0
Impala	1.0
L-39	1.0
T-38	1.0

Total: 12.0

g. Rotary-wing Familiarization Flying Hours (n/a Masters Focused)

Familiarization Flights	Hrs
OH-58	2.0
BO-105	2.0
UH-1N	2.0
A-109	2.0
Single engine propeller	2.0
Single engine complex	1.0
Multi-engine propeller	1.0

Total: 12.0

8. Note: some, but not all familiarization flights will occur during the Fundamentals module. Some flights will be delayed until later modules when the specific aircraft will be used.

Process of Evaluation

Written Examination on Statistics and Data Analysis.

Written reports:

Daily flight report

One substantial written on Crew Station Evaluation.

Oral report on Crew Station Evaluation.

T&E 4002 Test Management and Operational Test and Evaluation

Course Number and Name

T&E 4002 Test Management and Operational Test and Evaluation

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)

2. **Pre-requisites**

T&E 4001

3. **Text Books**

4.
 - Giadrosich, Donald L., 1995, *Operations Research Analysis in Test and Evaluation*, Reston VA: American Institute of Aeronautics and Astronautics, Inc., Chapters 8, 11, and 13.
 - NTPS Faculty, 2014, *National Test Pilot School Professional Course Textbook Series, Volume 6 Operational Test and Evaluation and Test Management*, National Test Pilot School, Mojave, CA.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - budget tracking and the Earned Value Management concept
- b. Understand:
 - the requirements process and how user requirements drive the scope of test programs
 - the similarities and differences between OT&E and DT&E
 - the resource factors which must be considered during T&E planning
 - the elements of RML&A tests including their purpose and challenges
 - the basic management concepts needed to manage a test program
 - risk management and safety considerations while planning and conducting a flight test program
6. c. Know:
 - how to develop COI/MOE/MOS/MOAs from user requirements/capabilities documents

Topics to be Covered

- Acquisition Process
- T&E

- OT&E
- Requirements Process and Test Criteria
- COI/MOE/MOS/MOA Exercises
- COI/MOE/MOS/MOA oral reports
- RML&A
- Sim Ex test concept preparation time
- Sim Ex Test Concept Presentation to TRB/SRB
- Flight Test Scheduling and Budgeting
- Risk Management and Safety in Flight Test
- Leadership Principles
- Simulation Exercise Evaluation
- Flight Test Organizational Structure
- Test Resource Planning
- Earned Value Management for T&E
- How Business Does Business
- Sim Ex oral report preparation time
- Test Item Configuration Control
- Commercial Off The Shelf Test Challenges
- Best T&E Practices and Lessons Learned
- Sim Ex oral report
- Feedback

7. **Specific Course Information**

This one-week course is typically offered twice a year and consists of academic lecture and laboratory exercises. It is offered daily on a Monday through Friday schedule.

Test and Evaluation is an integral part of the acquisition process. As such, flight testers need to understand the programmatic aspects of their business. This course prepares students to manage flight test programs/projects by providing an understanding of the role of T&E within the acquisition process, and the role of T&E within a typical program office. It examines the requirements process and introduces typical test management issues such as budget management, contractor business environment, schedule management, resources planning, and test item configuration control. In order to broaden the tester's horizon, the module also introduces Operational Test and Evaluation (OT&E) principles, as well as Reliability, Maintainability, Logistics and Availability (RML&A) concepts. Finally, the module introduces the students to the challenges of testing commercial off the shelf (COTS) systems.

- a. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Introduction	0.5
Acquisition Process Overview	1
T&E Process	1
Operational Test & Evaluation	1.5
Requirements Process and Test Criteria	1
SimEx COI/MOE/MOA Exercise Brief & Test Card Review	2.5
RML&A Academics, Briefs, & Data Card Review	3
How Business Does Business	1
Flight Test Scheduling and Resourcing	1
Flight Test Organization and Roles	1
Test Management	2
Test Budget Monitoring	1
Test Item Configuration Control	1
Commercial Off the Shelf Challenges	1
Leadership in T&E	1
White Board Exercise Brief	0.5
Best T&E Practices and Lesson Learned	1
Flight Test Risk Management and Flight Test Safety	1.5

Total: 22

- b. Laboratory Hours

Laboratories	Hrs
White Board Exercise 2 Hours	
SimEx COI/MOE/MOA Exercise	10
RML&A Exercise	7

Total: 19

- c. Reports and Exams

Reports and Exams	#
SimEx Oral Report	1
RML&A Oral Report	1

Total: 1

8. d. Flying Hours
This module does not include flying.

Process of Evaluation

Oral Report: Sim Ex Test Report

T&E 4003 Capstone Project

Course Number and Name

T&E 4003 Capstone Project

Credits and Contact Hours

3 credits (minimum 90 student work hours)

1.

Pre-requisites

2.

All compulsory core courses for Master’s Focused students

3.

Specific Course Information

4.

For Professional Course students, the capstone project is a comprehensive ground and flight exercise offered once annually at the completion of the Performance and Flying Qualities phase for TP/FTE Course students. The capstone project is intended to encapsulate the entire process of a flight test program. This is primarily an independent study course with in-flight exercises included. Under the supervision of a staff instructor, the students conduct and develop mission analysis, test planning, test plan reviews for safety and technical completeness, flight test execution, data analysis and reporting, both oral and written. To the extent possible, the scope of the project should include elements of performance, flying qualities and systems, as they apply to the assigned mission and purpose of the project. To demonstrate Information Literacy, the student will utilize on-line flight test databases in preparation of the test plan for the project. The project is normally accomplished in small teams on an aircraft or system not previously used during the course of instruction, but complete unfamiliarity is not a requirement. Even though teamwork is emphasized on test preparation, execution and analysis, every student should individually prepare a formal written report.

For the Master’s Focused students, the Capstone Project is an extensive flight test engineering related project conducted under the supervision of a faculty advisor (or a designated representative) and includes a significant written and oral report. The Capstone Project may be a traditional professional course style final project as indicated above or it may be a different style flight test related test project, research study, independent study, or practical exercise that encompasses at least 90 hours of flight test engineering related student work. A Capstone Project proposal must be submitted to and approved by the CAO prior to the project start.

a. Reports and Exams

Reports and Exams	#
Test Plan	1
Oral Report	1
Written Report (substantial report)	1

Total: 3

b. Flying Hours

Flights	Hrs
Data Flights – up to four flights (if a flying Capstone)	6.0

Total: 6.0

Process of Evaluation

Graded team test plan, team oral report and individual formal written report.

5.

T&E 4007 Introduction to FW P&FQ Flight Testing

Course Number and Name

T&E 4007 Introduction to Fixed Wing Performance and Flying Qualities Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

3.
 - None, but familiarity with the NTPS handbooks Volume I (Math and Physics for Flight Testers) and Volume II (Aerodynamics for Flight Testers) is highly recommended and encouraged in preparation for the course; both volumes are available for download at the NTPS website: <https://www.ntps.edu/information/tps-preparation.html>

Text Book

4.
 - NTPS Faculty, 1995, *Introduction to Performance and Flying Qualities Flight Testing*, National Test Pilot School, Mojave, CA.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - Aircraft Control Systems.
 - Jet Cruise.
 - Mach Effects on Stability and Control
 - Dimensional Analysis
 - Drag Polar
 - Takeoff and Landing
 - Energy Management
 - Subsonic Aerodynamics
 - Closed Loop Handling Qualities
 - Aero-elasticity
 - Standard Atmosphere
 - Longitudinal Non-Linearities
 - Light Aircraft Engine-Out
 - Transonic Aerodynamics
- b. Understand:
 - Pitot-Statics
 - Propeller Cruise
 - Climb Performance

- Longitudinal Static Stability
- Longitudinal Maneuvering Stability
- Lateral-Directional Static Stability
- Stalls
- Equations of Motion and Dynamics

c. Know

- None

Topics to be Covered

- Introduction
- Dimensional Analysis
- Subsonic Aerodynamics
- Standard Atmosphere
- Pitot-Statics
- Drag Polar
- Propeller Cruise
- Jet Cruise
- Climb Performance
- Aircraft Control Systems
- Longitudinal Static Stability
- Longitudinal Maneuvering Stability
- Lateral-Directional Static Stability
- Longitudinal Non-Linearities
- Transonic Aerodynamics
- Mach Effects on Stability and Control
- Equations of Motion and Dynamics
- Closed Loop Handling Qualities
- Energy Management
- Stalls
- Light Aircraft Engine-Out
- Aeroelasticity
- Takeoff and Landing

Specific Course Information

Course Content

This two-week course is offered twice a year. The course consists of academic lectures and in-flight instruction presented daily on a Monday through Friday schedule. It is designed to satisfy the demand for engineers, pilots and flight test support personnel who require some practical experience in aircraft performance, stability and control, handling qualities, flight test instrumentation data handling, as well as a working knowledge of civil and military requirements pertaining to piloted aircraft. The objective is to provide the student with

practical in-flight data gathering experience and an overview to flight test engineering. Classroom sessions are tailored to prepare the students for practical in-flight tests. Flights are performed in an aircraft instrumented to serve as an in-flight laboratory. On each of the sorties the students participate as flight test engineers, gathering data for post-flight analysis. An additional sortie is flown in a light aircraft to allow the students to get practical hands-on experience in performing the various flight test techniques. At the conclusion of the course, students present their findings and recommendations on both mission suitability and regulatory compliance in an oral report to the staff.

Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Introduction	1
Dimensional Analysis	1
Subsonic Aerodynamics	2
Standard Atmosphere and Pitot-Statics	2
Drag Polars	1
Propeller Cruise Performance	2
Flight Controls	2
Climb Performance	1.5
Longitudinal Static Stability and Nonlinearities	2.5
Maneuvering Stability	1.5
Transonic Aerodynamics	1
Lateral-Directional Static Stability and Nonlinearities	2
Stall Theory	1
Equations of Motion and Dynamic Stability	2
Mach Effects on Flying Qualities	1
Jet Cruise Performance	2
Takeoff and Landing Performance	1.5
Closed Loop Handling Qualities	2
Engine Out Asymmetrics	1.5
Aeroelasticity	1.5
Energy Management	1

Total: 33

Reports and Exams

Reports and Exams	#
Oral Report on P&FQ	1

Total: 1

Flying Hours

Flights	Hrs
PEC Data Flight	0.7
Cruise Data Flight	0.7
Climb Data Flight	0.7
Long Stat Data Flight	0.7
Man Stab Data Flight	0.7
Lat-Dir Static Data Flight	0.7
Stalls and Dynamics Data Flight	0.7
FTT Demo	1.5

Total: 6.4

Process of Evaluation

8. Oral report on Pitot-Static, Cruise Performance, Climb Performance, Longitudinal Static Stability, Maneuvering Stability, Lateral Directional Static Stability, Stalls, and Dynamic Stability.

T&E 4008 Introduction to Systems Testing

Course Number and Name

T&E 4008 Introduction to Systems Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

None

3. **Text Book**

4. McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, Raleigh, NC: SciTech Publishing, Chapters 1, 2, 3, 4, 5, 7 and 8.

Course Learning Outcomes

5. Anticipated Course Learning Outcomes
 - a. Be familiar with:
 - Avionics flight test process, specifications and regulations.
 - Areas to be considered in planning a mission and how to write test cards.
 - The format and content of technical reports, both written and oral.
 - Risk management and safety considerations while planning and conducting a flight test program.
 - Human factors and workload evaluation.
 - Communications and navigation systems testing.
 - Data bus structure and TSPI.
 - Airborne radar testing.
 - Passive Electro-optical (ultraviolet, visible and infrared) systems testing.
 - Software development testing.
 - Electromagnetic compatibility and interference
 - b. Understand:
 - The approach to safely and effectively execute ground and flight test of avionic systems.
 - The techniques used to conduct a cockpit evaluation.
 - The techniques for evaluating GNSS.
 - The techniques for evaluating systems for Required Navigation Performance (RNP) operations.
 - The techniques for evaluating workload.
 - The techniques for evaluating ground based NavAids.
 - c. Know

- None

Topics to be Covered

- Introduction
- Avionics Flight Test Process
- Technical and Safety Review Boards
- 6. • Sortie Planning and Data Cards
- Human Factors
- Basic Navigation
- Radio Navigation Aids
- GNSS
- TSPI
- ADS-B
- Workload
- Crew Station Evaluation
- Navigation Data Reduction
- Report Writing
- EMI/EMC
- Communications Testing
- Databusses
- Software Development
- Electro Optics
- RADAR Testing

7.

Specific Course Information

a. Course Content

This two-week course is offered twice a year and consists of academic lecture, laboratory exercises and in-flight instruction daily on a Monday through Friday schedule. It is designed to provide an overview of Systems testing and is ideally suited to newcomers entering the field, experienced personnel who are returning to the field or need refresher training, and flight test managers or support personnel newly assigned to a systems flight test program. In addition to systems theory and operating practice, the principles and techniques of avionics flight testing are emphasized to provide students with a firm understanding and background necessary to participate immediately in any flight test program upon return to their respective organizations. Practical flight exercises are structured to build on material covered in the classroom lectures and to reinforce the students' knowledge through practical application of theory. Students will conduct a final project and present their findings and recommendations on mission suitability and specification compliance in an oral briefing.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Introduction	1.0
Avionics Flight Test Process	1.0
Technical and Safety Review Boards	2.0
Sortie Planning and Data Cards	1.0
Human Factors	2.0
Basic Navigation	1.0
Radio Navigation Aids	1.0
GNSS	2.0
TSPI	1.0
ADS-B	1.0
Workload	2.0
Crew Station Evaluation	2.0
Navigation Data Reduction	1.5
Report Writing	1.0
EMI/EMC	1.0
Communications Testing	1.0
Databusses	2.0
Software Development	1.0
Electro Optics	2.0
RADAR Testing	2.0
FW Vol X Workload FTT Briefing	1.0
FW Vol X NavAid/GNSS FTT Briefing	1.0

Total: 30.5

- c. Instructional Laboratory Hours

Laboratories	#
Crew Station Evaluation	1.0
Camber Simulator	1.0
Spatial Frequency	1.0
Garmin G1000 Tutorial	2.0

Total: 5.0

- d. Reports and Exams

Reports and Exams	#
Oral Report	1

Total: 1

e. Flying Hours

Flights	Hrs
Workload Demo	1.0
NavAid/GNSS Demo	1.5
Project Data Flight	1.5
Total:	4.0

Process of Evaluation

Written report:

Initial flight report on Project Data Flight

Oral report:

- 8. Project Data Flight

T&E 4017 Introduction to RW P&FQ Flight Testing

Course Number and Name

T&E 4017 Introduction to Rotary Wing Performance and Flying Qualities Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

None

3. **Text Book**

4.
 - Prouty, Raymond R., 2006, *Helicopter Performance, Stability, and Control*, Malabar, FL: Kregier Publishing Company, Chapters 1, 3 and 9.
 - Leishman, J.G., 2000, *Principles of Helicopter Aerodynamics*, Cambridge, UK: Cambridge University Press, Chapters 2, 3, 4, and 5.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcome

- a. Be familiar with:
 - The Standard Atmosphere
 - Various Types of Rotor Systems
 - Closed Loop Handling Qualities
 - Low Airspeed Characteristics
 - Mechanical Characteristics of Flight Controls
 - Height-Velocity Testing
 - Engine Characteristics
 - Takeoff and Landing Performance
 - Aircraft control Systems
- b. Understand:
 - Pitot-Static Systems Theory and Flight Testing
 - Turbine Engine Flight Testing
 - Hover Performance Flight Testing
 - Level Flight Performance Flight Testing
 - Forward Flight Climb and Descent Flight Testing
 - Longitudinal Static and Dynamic Stability
 - Lateral-Directional Static and Dynamic Stability
- c. Know

- None

Topics to be Covered

- Introduction
- Standard Atmosphere
- Pitot-Static Systems
- 6. • Turbine Engines Performance and Assessment
- Rotor Systems
- Standard Atmosphere
- Pitot-Static Systems Theory and Testing
- Turbine Engine Assessment and Performance
- Rotor Systems
- Hover Performance
- Level Flight Performance
- Forward Flight Climb and Descent Performance
- Low Airspeed Characteristics
- Mechanical Characteristics of Flight Controls
- Height-Velocity Flight Testing
- Takeoff and Landing Performance
- Longitudinal Static and Dynamic Stability
- Lateral-Directional Static and Dynamic Stability

7. Specific Course Information

a. Course Content

This two-week course is offered on-campus once a year. The course includes academic lectures, laboratory exercises, in-flight instruction and flight-test data analysis daily on a Monday through Friday schedule. The aim of the course is to introduce pilots, engineers, flight test support and management personnel to helicopter flight test theory and procedures. This course can also serve as a refresher course for experienced flight test personnel. The scope of the course includes the evaluation of helicopter performance, handling qualities, data acquisition and analysis, as well as an overview of applicable civilian regulations (US CFR title 14 and EASA) and military specifications pertaining to piloted helicopters. The academic classes prepare the students to effectively plan and conduct helicopter flight tests. Students participate as flight test engineers on several flights in an instrumented helicopter, gathering data for post-flight analysis. The students present their findings and recommendations on mission suitability and regulatory compliance in a group oral briefing to the staff.

Academic lecture hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Introduction	1
Standard Atmosphere	1
Pitot-Static Systems and Testing	2
Engine Assessment and Performance	2
Rotor Systems	2
Hover Performance	2
Level Flight Performance	2
Climb and Descent Performance	2
Low Airspeed	2
Flight Control Mechanical Characteristics	2
Longitudinal Static Stability	2
Lateral-Directional Static Stability	2
Longitudinal Dynamic Stability	2
Lateral-Directional Dynamic Stability	2
Height Velocity Envelope	2
Closed Loop Handling Qualities	2
Takeoff and Landing Performance	2
Automatic Flight Control Systems	2

Total: 34

Laboratories

Laboratories	Hrs
FTT Demonstrations in 'FlyIt' Simulator	5

Total: 5

Reports and Exams

Reports and Exams	#
Oral Report on Performance and Flying Qualities	1

Total: 1

Flying Hours

Flights	Hrs
PEC and Hover Performance	1.0
Level Flight and Engine Performance	1.0
Engine Assessment and Climb and Descent Performance	1.0
Static Stability and Low Airspeed	1.0
Dynamic Stability	1.0

Total: 5.0

Process of Evaluation

Oral group report on test results from a flight where the student acted as the test conductor.

8.

T&E 4101 FW Performance Flight Testing I

Course Number and Name

T&E 4101 FW Performance Flight Testing I

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
2. 3 credits practical (minimum 30 hours)

Pre-requisites

3. T&E 4001

Text Book

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 2 Aerodynamics for Flight Testers*, National Test Pilot School, Mojave, CA, Chapters 1, 2, 3, 4 and 7.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 3 Fixed-Wing Performance Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 1, 2, 3, 4, 5, 11 and 12.
5.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 1 thru 6.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with
 - The fundamentals of dimensional analysis.
 - Subsonic aerodynamics principles.
- b. Understand
 - Standard atmosphere and the associated tables.
 - Pitot static principles and PEC requirements
 - Reciprocating engines and propeller theory and applicable certification requirements.
 - Takeoff and landing theory and requirements
- c. Know
 - How drag polars are determined and how they are used for modeling
 - How to measure and evaluate pitot static position errors.

- How to test and evaluate takeoff and landing performance.
- How to test and evaluate the cruise performance of propeller-driven aircraft.
- How to measure the weight and center of gravity of an aircraft.

Topics to be Covered

6.
 - Subsonic, incompressible aerodynamics. After explaining dimensional analysis tools, the steady state flow of an incompressible fluid is described. Development of lift and drag is explained along with the multiple components of drag. The course completes with analysis of drag polars, which leads directly into cruise theory.
 - Pitot-statics. Once the standard atmosphere, its origins and its derivation are developed, typical sources of sensing errors in both speed and altitude are identified along with flight test methods for determining the errors. Both CFR/EASA CS and military requirements are explained.
 - Propeller cruise theory. The theory, flight test data collection methods, and data analysis techniques for the stabilized method are taught for propeller-driven aircraft.
 - Takeoff and landing performance theory. The theory pertaining to determining and standardizing both takeoff and landing performance is developed. Flight test methods are taught along with restrictions imposed by civil certification rules.
 - Takeoff speed development. How to develop a takeoff speed schedule for transport category aircraft is explained. This includes the myriad of relevant restrictions on the speed schedule such as abused rotations, minimum control speed on ground and in air, both static and dynamic, speed required after takeoff following a critical engine failure, etc.

7. **Specific Course Information**

- a. Course Content

This one/three-week course is offered once per year on-campus and once per year distance learning, and consists of academic lecture, laboratory exercises and in-flight instruction offered daily on a Monday through Friday schedule. An intensive overview of the methods used to make performance evaluations of propeller driven aircraft. Emphasis is placed on subsonic aerodynamics, pitot-statics and reciprocating engine theory. Cruise performance testing methods for propeller aircraft is stressed. Takeoff and landing theory and flight test methods for all types of aircraft is also covered.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Performance I Overview	0.5
Dimensional Analysis	1.5
Standard Atmosphere	1.0
Subsonic Aerodynamics and Tutorial	4.0
Drag Polars	1.0
Drag Polars Tutorial	1.0
Pitot-Static Theory	2.0
Pitot-Static Requirements	1.0
PEC FTTs	1.0
PEC Tutorial	1.0
Reciprocating Engines and Tutorial	3.0
Propeller Theory and Tutorial	3.0
Propeller Aircraft Cruise and Tutorial	4.0
Weight and Balance Theory	1.0
Takeoff and Landing	2.0
Takeoff Speed Development	1.5
Instrumentation	1.0
Glider Operations	2.0
Demo Flight Briefings	2.0
Total:	33.5

- c. Laboratory Hours

Laboratories	Hrs
Tower Fly By Tower Control and Data Monitor	2.0
FTT Practice and Control Room Familiarization	3.0
Total:	5.0

- d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	9
Written Exam	1
Individual/Group Oral Exam/Review	1
Formal Oral Report	1
Written Report (substantial)	1
Total:	13

e. Flying Hours

Flights	Hrs
GC/TFB/GPS FTT and Cruise FTT Demo	1.3
Glider Fam and Drag Polar	1.0
Trailing Cone/GPS Data	1.0
TFB Data	1.0
Prop Cruise $P_{iw}V_{iw}$ Data	1.3
Eng Out Drag Polar Demo/Data	1.0
T/O and Ldg Data with DGPS	1.0
Pace/Chase Demo	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Pilots Only)	1.0
Total:	9.6

f. Additional simulator time

Simulator	Hrs
Performance I FTT Practice	2.0
Total:	2.0

8. **Process of Evaluation**

Written Examination:

One exam encompassing all academic topics.

Individual/Group Oral examination/Review:

One exam encompassing all academic topics and practical applications.

Written reports:

Daily flight reports

One substantial written on one of the following: Pitot-Statics, Drag Polars, Propeller Cruise Performance, Takeoff and Landing.

Oral reports:

One oral report on one of the following: Pitot-Statics, Drag Polars, Propeller Cruise Performance, Takeoff and Landing.

Graded Data Flights:

Pitot-Statics

Drag Polars

Propeller Cruise Performance

Takeoff and Landing

T&E 4102 FW Performance Flight Testing II

Course Number and Name

T&E 4102 FW Performance Flight Testing II

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001 & 4101

3. **Text Book**

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 2 Aerodynamics for Flight Testers*, National Test Pilot School, Mojave, CA, Chapters 5 and 6.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 3 Fixed-Wing Performance Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 6, 7, 8, 9, 10, 11 and 13.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 7-11.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with
 - Supersonic Aerodynamics Principles
 - Transonic Aerodynamics Principles
- b. Understand
 - Turbine engine theory and test procedures.
 - Optimization and Prediction of Cruise Performance
 - Aircraft energy management concepts.
 - Advanced Performance – Gathering Techniques
- c. Know
 - Climb performance theory and test methods.
 - Turn performance theory and test methods.
 - Stall theory and test methods.
 - How to test and evaluate cruise performance of a jet aircraft.

Topics to be Covered

6.
 - Propulsion theory. Methods of aircraft propulsion from reciprocating piston engines to hypersonic scramjets are covered. The course focus is on turboprop and turbojet engines, including both high and low bypass turbofan engines.
 - Jet cruise performance testing. This course extends the propeller aircraft theory previously developed into analyzing jet-powered cruise performance with particular emphasis to the W/δ method.
 - Transonic and supersonic aerodynamics. Compressible fluid dynamics is covered. The transonic regime is treated qualitatively with specific examples and problems. Supersonic flight problems are analyzed quantitatively with reliance on shock tables for both oblique and normal shock problems. Engine inlet efficiency is analyzed.
 - Excess energy theory. Climb performance theory is explained along with traditional flight test methods such as sawtooth climbs and level accelerations. Data reduction and correction to standard conditions is detailed. Turn performance and energy management are also covered.
 - Advanced performance methods. Dynamic, non-steady state methods of gathering required performance data are analytically developed. Flight test techniques, instrumentation required and data reduction methods are all explained.
 - Stall theory and flight test. Boundary layer and flow separation theory is also discussed. Civil and military aircraft stall definitions are explained along with their diverse requirements on speed, warning and characteristics of aircraft stalls.

7. **Specific Course Information**

- a. Course Content

This one/three-week course is conducted once per year on-campus and once per year distance learning, and consists of academic lecture, laboratory exercises and in-flight instruction. It is a continuation of the theory and flight test techniques employed during the performance evaluations of propeller-driven aircraft, and provides an intensive overview of the methods used to make cruise performance evaluations of turbine and jet powered aircraft. Emphasis is placed on stalls and turbine/jet engine theory. Climb and turn performance testing for all types of aircraft is also taught. Energy management and transonic/supersonic aerodynamics are also covered.

Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Performance II Overview	1.0
Transonic Aerodynamics	1.0
Climb Performance and Tutorial	3.0
Turbine Engines and Tutorial	4.0
Turn Performance and Tutorial	3.0
Energy Management and Tutorial	2.5
Stall Performance and Tutorial	3.0
Jet Aircraft Cruise and Tutorial	4.5
Supersonic Aerodynamics	3.0
Advanced Performance Test Methods	2.0
Supersonics Aerodynamics Tutorials	2.0
Demo Flight Briefings	2.0

Total: 31.0

Laboratory Hours

Laboratories	Hrs
FTT Practice and Control Room Familiarization	3.0

Total: 3.0

Reports and Exams

Reports and Exams	#
Daily Flight Reports	9
Formal Oral Report	1
Written Report (substantial)	1
Written Exam	1
Individual/Group Oral Examination/Review	1

Total: 13

Flying Hours

Flights	Hrs
Climb/Accel Demo	1.0
Jet Cruise (W/ δ) Demo	1.0
Stall Speed Demo	1.0
Jet Cruise Data	1.5
Turn Demo	1.0
Climb/Accel/Turn Data	1.0
Stall Speed Data	1.0
Advanced Performance Methods Demo (Pilots Only)	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Pilots Only)	1.0
Total: 9.5	

Additional simulator time

Simulator	Hrs
Performance II FTT Practice	2.0
Total: 2.0	

8. **Process of Evaluation**

Written Examination:

One exam encompassing all academic topics.

Individual/Group Oral Examination/Review:

One exam encompassing all academic topics and practical applications.

Written reports:

Daily flight reports

One substantial written on one of the following: Climb Performance, Jet Aircraft Cruise, Stall Performance.

Oral reports:

One oral report on one of the following: Climb Performance, Jet Aircraft Cruise, Stall Performance.

Graded Data Flights

Climb Performance

Jet Aircraft Cruise

Stall Performance.

T&E 4103 FW Flying Qualities Flight Testing I

Course Number and Name

T&E 4103 FW Flying Qualities Flight Testing I

1.

Credits and Contact Hours

3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2.

Pre-requisites

3.

T&E 4001, 4101 & 4102

Text Book

4.

- NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 4 Fixed-Wing Flying Qualities Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 1 thru 8.
- NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 12 thru 16.

5.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with
 - Aircraft trim systems.
 - Mach effects on stability and control.
- b. Understand
 - Mechanical flight control systems.
 - Regulatory requirements of each type of stability.
 - The big picture of flying qualities evaluation.
 - How to determine the engine-out capability of an aircraft.
- c. Know
 - How to determine the longitudinal static stability of an aircraft.
 - How to determine the maneuvering stability of an aircraft.
 - How to determine the lateral-directional static stability of an aircraft.

- How to determine the flight path stability of an aircraft.

Topics to be Covered

- Mechanical flight control systems. Reversible flight controls are emphasized in this portion of the course, described along with methods and techniques for tailoring the flying qualities of the aircraft by the use of tabs, springs, bobweights, and similar devices.
- 6. • Static stability. Theory, flight test techniques and regulatory requirements for static stability in all axes. Included are longitudinal static stability, both controls fixed and free, maneuvering stability, and lateral-directional static stability.
- Lateral Control. Theory, flight test techniques and regulatory requirements for roll performance.
- Asymmetrics. Engine out flight test methods for determining the minimum control speed in the air, both static and dynamic, and also on the ground during takeoff roll following an engine failure.
- Flight path stability. The effect of performance parameters on the flying qualities during approach to landing are explained along with both the flight test methodology and the military requirements.
- Trim systems. Both civil and military regulations and flight test procedures are taught. Steady state trim and dynamic configuration change requirements are covered.

7. Specific Course Information

a. Course Content

This one/three-week course is offered once per year on-campus and once per year distance learning, and consists of academic lectures, laboratory exercises and in-flight instruction presented daily on a Monday through Friday schedule. It is an intensive overview of the methods used to make static stability determinations of aircraft. Subjects include the theory, regulatory requirements and flight test techniques involved in determining the longitudinal, lateral-directional, maneuvering, and flight path stability of single and multi-engine aircraft. Engine out testing of multi-engine aircraft is included along with a brief explanation of mechanical flight control systems and Mach effects on stability and control.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.\

Academic Subjects	Hrs
Flying Qualities I Overview	1.0
Mechanical Flight Controls/Hangar Tour	3.0
Longitudinal Static Stability	3.5
Longitudinal Static Stability Tutorial	2.0
Stability Augmentation	1.0
Trim Theory and Tutorial	1.5
Lat/Dir Static Stability	3.5
Lat/Dir Static Stability Tutorial	1.5
Lateral Control	1.0
Maneuvering Stability and Tutorial	3.0
Engine Out Theory and Tutorial	3.5
Mach Effects on S&C	1.0
Flight Path Stability	1.0
Demo Flight Briefings	2.0

Total: 28.5

Laboratory Hours

Laboratories	Hrs
Long Stat/Man Stab Variable Stability Sim	3.0
Lat/Dir Static Stab and Engine Out Sim	3.0
T-38 Ground Calibration FCS Data	2.0

Total: 8.0

Reports and Exams

Reports and Exams	#
Daily Flight Reports	10
Formal Oral Report	1
Written Report (substantial)	1
Written Exam	1
Individual/Group Oral Examination/Review	1

Total: 14

Flying Hours

Flights	Hrs
Long Stat, Man Stab Demo	1.2
Lat/Dir Demo	1.0
Roll and Trim Demo	1.0
Engine Out V_{mca} Demo	1.0
LS/MS Data	1.2
Lar/Dir Data	1.0
Engine Out V_{mca} Data	1.0
Transonic/FPS Demo/Data	1.0
Conventional Landing Gear Aircraft Fam (Pilots Only)	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Pilots Only)	1.0

Total: 10.4

Additional simulator time

Simulator	Hrs
FQ I FTT Practice	2.0

Total: 2.0

Process of Evaluation

Written Examination:

One exam encompassing all academic topics.

8. Individual/Group Oral Examination/Review:

One exam encompassing all academic topics and practical applications.

Written reports:

Daily flight reports

One substantial written on one of the following: Longitudinal Static Stability and Maneuvering Stability, Lateral-Directional Static Stability, Engine Out.

Oral reports:

One oral report on one of the following: Longitudinal Static Stability and Maneuvering Stability, Lateral-Directional Static Stability, Engine Out.

Graded Data Flights

Longitudinal Static Stability and Maneuvering Stability

Lateral-Directional Static Stability

Engine Out

T&E 4104 FW Flying Qualities Flight Testing II

Course Number and Name

T&E 4104 FW Flying Qualities Flight Testing II

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001, 4101, 4102 & 4103

3. **Text Book**

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 4 Fixed-Wing Flying Qualities Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 9 thru 15.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 17 thru 25.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be Familiar with
 - The fundamentals of aircraft motion analysis and the equations of motion.
 - Aircraft coupling dynamics
- b. Understand
 - Aircraft dynamics theory
 - Regulatory requirements pertaining to aircraft dynamics
 - Regulatory requirements pertaining to aircraft departure susceptibility, and spin recovery devices.
- c. Know
 - Flight test techniques used to quantitatively and qualitatively determine aircraft dynamics
 - Spin theory and flight test techniques
 - Closed-loop handling qualities testing and techniques.
 - How to determine the stall characteristics of an aircraft.

Topics to be Covered

- Equations of motion. Detailed equations of motion are taught along with the transformation between the principle reference systems - body, wind and stability axes.
- Motion analysis. Basic tools for studying the response of a linear system are provided; Fourier and Laplace transforms, frequency spectra, Bode plots, transfer functions are all discussed. Dynamic responses of elementary first order and second order systems are described along with practical methods for experimentally measuring motion characteristics and model parameters.
- Dynamic stability. The theory of aircraft open-loop dynamic motions is taught. Flight test methods along with civil and military requirements are explained for all of the dynamic modes: short period, phugoid, Dutch roll, roll mode and the spiral.
- High angle of attack and spin theory. The basic theory of spins and deep stalls is covered followed by flight test methods and finally both civil and military requirements. Alternate recovery methods are covered along with important test planning considerations for all out of control flight tests.
- Closed-loop handling qualities. The importance of stressing the aircraft flight control system during developmental testing is emphasized. The importance of manned, subjective evaluation of aircraft handling qualities is discussed. The fundamental role of CLHQ evaluation in the aircraft DT&E and OT&E process is highlighted. Use of the Cooper-Harper pilot rating system is taught along with various ways of assessing the sensitivity to pilot-induced oscillations. The design and execution of operationally germane CLHQ tests is highlighted.
- Performance modeling and parameter identification project. The student will apply the knowledge obtained from 4101, 4102, 4103 and 4104. Working as a team the student will validate performance models and estimate select stability and control parameters using flight test methods.

7.

Course Content

- a. This one/three-week course is offered once per year on-campus and once per year distance Learning, and consists of academic lecture, laboratory exercises and in-flight instruction. It is an intensive overview of the methods used to make dynamic stability determinations and handling qualities evaluation of aircraft.

Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
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Flying Qualities II Overview	1.0
Linear Systems Analysis and Tutorial	4.0
Axis Transformation	1.0
Motion Analysis	3.0
Motion Analysis Tutorial	1.0
Equations of Motion	2.0
Dynamic Stability	5.0
Dynamic Stability Tutorial	1.0
Stall Characteristics	1.0
High Angle of Attack and Spins	4.0
High Angle of Attack and Spins Tutorial	2.0
Closed Loop Handling Qualities and Tutorial	3.0
Roll Coupling	1.0
Demo Flight Briefings	2.0
Total:	31.0

Laboratory Hours

Laboratories	Hrs
Dynamic Stability Simulator, Control Room and Data Analysis	3.0
CLHQ FTT Simulator Practice	3.0
Total:	6.0

Reports and Exams

Reports and Exams	#
Daily Flight Reports	12
Formal Oral	1
Written Report (substantial)	1
Written Exam	1
Individual/Group Oral Examination/Review	1
Total:	16

Flying Hours

Flights	Hrs
Prop Spin/Chase Demo (Pilots Only)	1.0
Dynamics Demo	1.2
CLHQ Demo	1.2
Stall Characteristics Demo	1.0
CLHQ Data	1.1
Dynamics Data	1.0
Spin Data	1.0
Spin Chase Data (Pilots Only)	1.0
Stall Characteristics Data	1.0
Level D sim for V_{μ} , V_{mcg} , V_{mca} and dynamics $> M_{mo}$	4.0
Qual Eval Demo	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Pilots Only)	1.0
Total:	15.6

Additional simulator time

Simulator	Hrs
FQ II FTT Practice	2.0

Total: 2.0

Process of Evaluation

Written Examination:

One exam encompassing all academic topics.

8. Individual/Group Oral Examination/Review:

One exam encompassing all academic topics and practical applications.

Written reports:

Daily flight reports

One substantial written on one of the following: Dynamic Stability, Spins, Handling Qualities, Roll Performance.

Oral reports:

One oral report on one of the following: Dynamic Stability, Spins, Handling Qualities, Roll Performance.

Graded Data Flights

Dynamic Stability

Spins

Handling Qualities

Roll Performance

T&E 4105 Modern Flight Control Systems

Course Number and Name

T&E 4105 Modern Flight Control Systems

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
2 credits practical (minimum 20 hours)

2. **Pre-requisites**

T&E 4001, 4101 (or 4111), 4102 (or 4112), 4103 (or 4113) & 4104 (or 4114)

3. **Text Book**

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 4 Fixed-Wing Flying Qualities Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 9, 12 and 15.
 - NTPS Faculty, 2017, *National Test Pilot School Professional Course Volume 8 Rotary Wing Flying Qualities Testing*, National Test Pilot School, Mojave, CA, Chapters 11 thru 14.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 17 thru 25.
 - Distefano III, Joseph, Stubberud and Allen R., Williams, Ivan J., 2014, *Feedback and Control Systems*, Second Edition, McGraw-Hill, New York, NY, Chapters 2, 9, 10, 13, 15 and 16.
 - Cook, Michael V., 2013, *Flight Dynamics Principles, A Linear Approach to Aircraft Stability and Control*, Elsevier, Waltham, MA, Chapters 4, 5, 6 and 11.
- 5.

Course Learning Outcomes

Anticipated Course Learning Outcomes

1. Be familiar with
 - Block diagram representation of a system and block diagram Algebra.
 - Generic structure of flight control systems.
 - The Poles and zeros formalism of a system
 - Application of Pre-filters in modern flight controls systems.
 - Response feedback technique used by modern flight control systems in order to augment stability of an aircraft.
 - Effects of common parameters feedback on aircraft stability.

- Basic concepts of systems command and dynamic inversion.
 - General design criteria used for modern flight controls.
2. Understand
- The relationship between poles location on the S-Plane and dynamic modes of the system.
 - The relationship between transfer functions and frequency response of a system
 - The meaning of Gain and Phase margins and how to extract those from the Bode plots.
 - The basic approach in flight testing of a highly augmented aircraft.
3. Know
- How to apply the Laplace transformation in solving equations of motion.
 - How to construct Bode plots and how to interpret the frequency response information they retain.
 - How to implement the Root Locus analysis in order to assess the closed loop stability of a system.
 - How to use software to solve for basic stability augmentation problems.

Topics to be Covered

- 6.
- Dynamics Review
 - S-Plane and Bode Plots
 - Block Diagrams
 - FCS Overview
 - FCS Strategies and Design Criteria
 - Pre-Filters
 - Response Feedback
 - Command Systems and Dynamic Inversion
 - Root Locus Analysis
 - Augmentation Effect of Various Feedback Parameters
 - Fixed Wing Example
 - Bode Plots Stability Analysis
- 7.
- FCS Issues and Testing
 - Rotary Wing Example

Specific Course Information

a. Course Content

This one week/three week course is offered once per year on-campus and consists of a 1-week academic module followed by a 2-week period of In-Flight Variable Stability flying. The course is designed to provide a “top-level” introduction to Modern Flight Control Systems (FCS’s). Basic elements of modern FCS’s are reviewed along with typical basic structures and system elements for modern fly-by-wire FCS’s. Classic linear control tools (Root Locus, Bode Plots, Block Diagram Algebra) and their practical application are discussed. Modern software analysis tools are introduced and demonstrated using the

associated Control System Toolbox during the course. Handling qualities criteria and special issues related to modern complex FCS's such as Pilot Induced Oscillations (PIO's) are reviewed. The need for systematic closed-loop handling qualities evaluations is emphasized. Different control strategies are presented (pre-filters, response feedback, g-command and q-command systems, dynamic inversion, model following). The effects of common control system feedback implementations are presented using software and the NTPS Variable Stability Ground Simulator (VSGS). Command path shaping and the effects of time delay and rate limiting are also discussed. Course learning objectives are reinforced when students go through a hands-on guided demonstration on the VSGS. The objective of the course is to provide a high level of understanding of the Principles, Issues, and Test Methods related to modern FCSs to enable the student to conduct a professional engineering evaluation. Daily review, tutorials and a final written exam are part of the course.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
MF Controls and Sim Overview	1
Revision of Dynamics and Math Tools	3
S-plane and Bode Plots	2.5
Flight Controls System Overview	1.5
Block Diagrams	1.5
Response Feedback	2
Prefilters	1.5
Root Locus Analysis	2
Effect of Common Feedback	2
Command Systems and dynamic Inversion	2
Bode Plot Stability Analysis	2
Strategies and Design Criteria	4
Flight Controls Systems Issues and Testing	2
FW Augmentation Example	2
RW Augmentation Example	2
Tutorials	9

Total: 40

- c. Laboratory Hours

Laboratories	Hrs
Variable Stability Ground Simulator	3

Total: 3

d. Reports and Exams

Reports and Exams	#
Written Exam	1
Analysis Software Based Exam	1
Variable Stability Flight Daily Reports	3
Qual Eval Daily Reports	4

Total: 9

e. FW Flying Hours

FW Flights	Hrs
Inflight Variable Stability Longitudinal Flight	1.7
Inflight Variable Stability Lateral/Directional Flight	1.7
Inflight Variable Stability Evaluation Flight	1.7
Qual Evals	4.0

Total: 9.1

f. RW Flying Hours

RW Flights	Hrs
Inflight Variable Stability ADS-33, Time Delays, Sensitivity	1.5
Inflight Variable Stability Augmentation Strategies	1.5
Inflight Variable Stability Evaluation Flight	1.0
Qual Evals	5.0

Total: 9.0

g. Additional simulator time

Simulator	Hrs
Variable Stability Simulator	1.0

Total: 1.0

8.

Process of Evaluation

Examinations:

One written exam encompassing S-plane, Bode plots, Block diagrams, Prefilters, Response Feedback, Root-Locus analysis and Bode plots based stability analysis.

One computer software-based exam to design control laws for either a FW or a RW aircraft to increase its dynamic stability to meet a pre-defined criteria.

T&E 4106 FW Loads, Flutter and Stores Testing

Course Number and Name

T&E4106 Loads, Flutter and Stores Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credit practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001, 4101, 4102, 4103 & 4104

3. **Text Books**

4.
 - Norton, William J., et al, 2016, *National Test Pilot School Professional Course Volume 15 Loads, Flutter and Vibrations Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 1 thru 8, 10 and 11.
 - Lomax, Ted L., 1996, *Structural Loads Analysis for Commercial Transport Aircraft*, The American Institute of Aeronautics and Astronautics, Reston, VA, Inc., 1996.
 - Wright, Jan R. and Cooper, Jonathan E., *Introduction to Aircraft Aeroelasticity and Loads*, Second Edition, Hoboken, NJ: John Wiley and Sons, Ltd., 2014.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with
 - The aero-elastic effects of an aircraft.
- b. Understand
 - The properties of different materials used in aircraft.
 - Performing basic loads testing of aircraft.
 - Loads and ground vibration test methods.
- c. Know
 - The flight test techniques employed to determine aircraft in flight loads.
 - The flight test techniques employed to demonstrate an aircraft is free from adverse aero-elastic.
 - The theory and test methods to clear stores for carriage.
 - The theory and test methods to clear stores for separation.

Topics to be Covered

- Basic Stress/Strain Analysis
- Material Science
- Basic Load Analysis
- 6. • Aero-elastic Effects
- Flutter
- GVT and Ground Loads Testing
- Captive Carriage
- Instrumentation and Data Reduction Techniques
- Control Room Procedures

Specific Course Information

- 7. a. Course Content

This one/two week course is offered once per year on-campus and consists of academic lecture, laboratory exercises and in-flight instruction presented daily on a Monday through Friday schedule. The course is designed to provide an extensive review of vehicle structures, loads and flutter testing and takes the student from basic properties of materials, through advanced instrumentation methods for determining flutter regions and divergence. Industry standards for determining loads limits and freedom from flutter are addressed as well as possible ways for obtaining required data in a limited amount of flight time. A study of the instrumentation installation on an aircraft enhances the students’ knowledge of the correct test methods for in-flight loads and flutter determination. Unique stores load and flutter/vibrations issues are examined as well as theory and methods for clearing stores for external carriage and separation/launch.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Loads and Flutter Overview/Introduction	1
Structures, Dynamics and Materials	5
Instrumentation and Control Room Procedures	2
Loads Theory	4
Aero-elasticity Theory	4
Stores Certification	8
Loads FTT Vol 10 Briefing	1
Loads Data Assignment	1
Loads and Flutter Tutorial	2

Total: 28

c. Laboratory Hours

Laboratories	Hrs
TM Room Orientation/Use	3
Loads Calibration Exercise	3
GVT Exercise	3

Total: 9

d. Reports and Exams

Reports and Exams	#
Loads and Flutter Oral Report	1
Written Exam on Loads, Flutter and Stores	1
Daily Flight Reports for all Data Flights	4

Total: 6

e. Flying Hours

Flights	Hrs
Loads Demo	1.0
Captive Carry Demo with Stores	1.0
Loads TM Data	1.0
Asymmetric Stores Demo	1.0

Total: 4.0

8.

Process of Evaluation

Written Examination:

Comprehensive examination covering all academic lectures.

Written reports:

Daily flight reports

Oral reports:

One oral report on Impala loads data flight.

Graded Data Flight

Loads data flight

T&E 4107 Civil Aircraft Icing Certification

Course Number and Name

T&E 4107 Civil Aircraft Icing Certification

Credits and Contact Hours

1. 1 credit theory (minimum 10 hours)

Pre-requisites

T&E 4001

3. **Text Book**

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapter 29.

Course Learning Outcomes

- 5.

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - Icing regulations and FAA / EASA guidance materials.
 - Icing Certification procedures and processes.
 - 14 CFR Part 25 and 29 / CS 25 and 29 Icing Envelopes and the need and methods for converting them to other exposure distances.
- b. Understand:
 - The unique problems associated with airframe icing.
 - Icing cloud formation.
 - Data collection, reading, and data analysis procedures.
 - Icing test principles and the reasons for dry air, simulated ice accretions and natural icing tests.
 - The requirement for measuring icing cloud parameters.
- c. Know
 - None

Topics to be Covered

- Overview
- The Physical Environment
- Earth and It’s Atmosphere
- 6. • The Regulatory Environment
- FAA Icing Envelopes
- FAA Certification Requirements
- Ground and Flight Testing
- Tanker Testing
- Performance and Flying Qualities Testing with Ice Shapes
- Testing in Natural Icing Conditions
- Finding Icing Clouds
- Data Collection, Analysis and Presentation

Specific Course Information

- 7. a. Course Content

This one-week course is offered up to two times per year on-campus and once per year distance learning, and consists of academic lecture and in-flight instruction. Content includes an in-depth discussion of icing cloud microphysics and atmospheric thermodynamics, FAA icing certification requirements, and ground and flight test procedures necessary to validate aircraft and ice protection systems to show compliance with the Federal Aviation Regulations.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject (Icing)	Hrs
Icing - Cloud Physics	1
Airframe ice accretion	1
Ice protection systems	1
Ice contaminated tailplane stall	1
Freezing rain, drizzle, supercooled large droplets	1
14 CFR 25/29, Appendix C and O	2
Icing Certification Process, AC-20-73	1.5
AC-25-25A	0.75
Tunnels, rigs and tanker tests	0.75

Total: 10

f. Reports and Exams

Reports and Exams	#
Written Exam	1
Daily flight report	1

Total: 2

g. Flying Hours

Flights	Hrs
Icing Demo	1.2

Total: 1.2

Process of Evaluation

- 8. Graded written exam
- Graded flight

T&E 4111 RW Performance Flight Testing I

Course Number and Name

T&E 4111 RW Performance Flight Testing I

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001

3. **Texts and Reference Materials**

4.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 2 Aerodynamics for Flight Testers*, National Test Pilot School, Mojave, CA, Chapters 1, 2 and 3.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 7 Rotary Wing Performance Flight Testing*, National Test Pilot School, Mojave, CA, Chapters 1 thru 9.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 101 thru 104.
 - Prouty, Raymond R., 2006, *Helicopter Performance, Stability, and Control*, Malabar, FL: Kregier Publishing Company, Chapters 1, 2, 4 and 10.
 - Leishman, J.G., 2000, *Principles of Helicopter Aerodynamics*, Cambridge, UK: Cambridge University Press, Chapters 2, and 5.

- 5.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with
 - Standard atmosphere and the associated tables.
 - The non-uniform induced velocity theory through the hovering disk
 - Basic definitions of disk loading, power loading, solidity ratio and figure of merit
- b. Understand
 - The fundamentals of dimensional analysis
 - Subsonic aerodynamics principles
 - Pitot static principles and PEC requirements
 - Momentum theory and blade element theory
 - Determination of turbine engine characteristics

- The effect of atmospheric properties and rotor parameters on the hover and vertical climb performance of a helicopter.
- c. Know
- How Coefficient of Power and Coefficient of Thrust are used for determining hover ceiling
 - How to measure and evaluate pitot static position errors
 - How to test and evaluate hover performance of rotary wing aircraft
 - How to assess engine performance
 - How to measure the weight and center of gravity of an aircraft.

Topics to be Covered

6.
 - Rotor Theory. The basics of rotor systems are covered, followed by detailed discussion of momentum and blade element theory pertinent to hover performance.
 - The procedure of weighing a helicopter and determining its center of gravity location.
 - Subsonic, incompressible aerodynamics. The steady state flow of an incompressible fluid is described. Development of lift and drag is explained along with the multiple components of drag.
 - Pitot-statics. Once the standard atmosphere, its origins and its derivation are developed, typical sources of sensing errors in both speed and altitude are identified along with flight test methods for determining the errors. Civil CFR/CS and military requirements are explained, as well as low airspeed reference systems.
 - Hover and Vertical Climb Performance. The theory behind hover performance is developed. Flight test methods are taught, along with civil certification and military requirements.
 - Turbine engine performance and assessment. The methodology of measuring the available power of a turbine engine is explained in detail accompanied with through discussion about dimensional analysis.
- 7.

Course Description

a. Course Content

This one/three week course is offered once per year on-campus and includes classroom lecture, laboratory exercises and in-flight instruction. The course is designed to provide an intensive overview of the methods used to measure and predict performance of turbine engine helicopters. Emphasis is placed on subsonic aerodynamics, dimensional analysis, International Standard Atmosphere, pitot-static and turbine engine theory. Hover and vertical climb performance theory and flight testing methods are stressed.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
RW Performance I Overview	1
Dimensional Analysis	1.5
Standard Atmosphere	1.5
Subsonic Aerodynamics	3
Pitot-Static Theory and Requirements	3
Classic PEC and GPS for PEC	2
PEC Tutorial	2
Momentum Theory, Hover Performance and Tutorial	4
RW Engine Assessment	2
Weight and Balance Determination	2
RW Turbine Engine Performance and Tutorial	3
RW Vertical Climb Performance and Tutorial	3
Flight Test Instrumentation	1
RW Vol 10 FTT Briefing	2
Data Assignments	1

Total: 32

- c. Laboratories

Laboratories	Hrs
Weight and Balance Lab	2

Total: 2

- d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	10
Formal Oral Report	1
Written Report (substantial)	1
RW Performance I Exam	1
Individual/Group Oral Exam/Review	1

Total: 14

e. Flying Hours

Flights	Hrs
GC/GPS Demo	1.0
PEC GC/GPS Data	1.0
PEC TB Demo/Data	1.0
PEC TB Pace Chase	1.0
Engine Assessment Demo/Data	1.5
Free Flight Hover Demo	1.2
Free Flight Hover Data	1.2
Tethered Hover Demo/Data	0.8
Vertical Climb Demo/Data	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA only)	1.0

Total: 10.7

f. Additional simulator time

Simulator	Hrs
Performance FTT's FlyIt sim	2.0

Total: 2.0

8. **Process of Evaluation**

Written Examination:

One exam encompassing Subsonic Aerodynamics, Pitot-Statics, Engine Assessment and Performance, Hover Performance and Vertical Climb Performance

Individual/Group Oral Examination/Review:

One exam encompassing Subsonic Aerodynamics, Pitot-Statics, Engine Assessment and Performance, Hover Performance and Vertical Climb Performance

Written reports:

Daily flight reports

One substantial written on one of the following: Pitot-Statics, Hover Performance, or Engine Performance

Oral reports:

One oral report on one of the following: Pitot-Statics, Hover Performance, or Engine Performance

Graded Data Flights

PEC GC/GPS

PEC Trailing Device/Pace Chase

Tethered Hover

Free Flight Hover

Engine Assessment and Performance

Vertical Climb

Graded AltMoC Sortie (EASA Only)

T&E 4112 RW Performance Flight Testing II

Course Number and Name

T&E 4112 RW Performance Flight Testing II

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001 & 4111

3. **Text Book**

4.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 7 Rotary Wing Performance Flight Testing*, , National Test Pilot School, Mojave, CA, Chapters 10 thru 16.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 105 thru 108.
 - Prouty, Raymond R., 2006, *Helicopter Performance, Stability, and Control*, Malabar, FL: Kregier Publishing Company, Chapters 3, 4 and 5.
 - Leishman, J.G., 2000, *Principles of Helicopter Aerodynamics*, Cambridge, UK: Cambridge University Press, Chapters 2, and 5.
- 5.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with
 - FADEC testing.
- b. Understand
 - Transonic aerodynamics principles.
 - Autorotational descent performance.
- c. Know
 - Climb and descent performance theory and test methods.
 - Take-off/landing performance theory and test methods.
 - Height-velocity theory and test methods.
 - Level flight performance theory and test methods.
 - How to predict significant airspeeds from performance data.
 - The effects of engine failure

Topics to be Covered

- Forward Flight Performance. Level flight range and endurance theory is covered, as well as forward flight climb and descent. Flight test methods and civil certification and military requirements are taught.
- 6. • Engine failure effects are taught. Within this subject a thorough investigation into the main rotor speed decay is given, including the mathematical model behind it..
- Takeoff and Engine Failure. Takeoff distance development for rotary wing aircraft is explained, as well as engine failure testing for single and multi - engine helicopters. This includes abused rotations, hover reference height, Height Velocity Curve Development, Category A and B testing, etc.
- The methodology behind the development of the H-V diagram is taught and demonstrated in flight.
- Basic concept of Full Authority Digital Engine Control (FADEC) and the methodology for flight testing FADEC helicopters (public domain information).

Specific Course Information

7. a. Course Content

This one/three-week course is offered once per year on a daily basis Monday through Friday. It consists of classroom lecture, laboratory exercises and in-flight instruction. Without CAO approval, *T&E 4111 RW Performance Flight Testing I* is a prerequisite. The course is a continuation of the theory and flight test techniques employed during T&E 4111 (RW). An intensive overview of the methods used to measure and predict forward flight performance of turbine helicopters. . Climb and descent performance testing is also taught, as is engine failure testing for single and multi-engine helicopters. The course also includes a through look into the takeoff and landing performance of a helicopter including the civilian regulation requirements.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
RW Performance II Overview	1
Transonic Aerodynamics	1
RW Level Flight Perf/Tutorial	5
RW FWD Flight Climb Perf/Tutorial	5
Rotor Speed Decay/Tutorial	3
RW Auto Descent Perf/Tutorial	3
Height Velocity Diagram	2
RW Takeoff and Landing Performance	3
DGPS Fam	1
RW Engine Failure Perf	2
FADEC Testing	2
Data Assignments	1
RW FTT Vol 10 Briefings	2

Total: 31

c. Reports and Exams

Reports and Exams	#
Daily Flight Reports	9
Formal Oral	1
Written Report (substantial)	1
RW Perf II Exam	1
Individual/Group Oral Exam/Review	1

Total: 13

d. Flying Hours

Flights	Hrs
Level Flt Perf Demo	1.0
Level Flight Perf Data	1.0
Climb and Descent Demo	1.0
Climb and Descent Data	1.0
Auto H-V Flare Effectiveness Demo	1.0
Auto H-V Curve Determination Demo	1.5
T/O and Landing Demo	1.5
T/O and Landing Data	1.5
FTT Review/Evaluation/AltMoC Sortie (EASA only)	1.0

Total: 10.5

e. Additional simulator time

Simulator	Hrs
Performance FTT's FlyIt sim	2.0

Total: 2.0

8.

Process of Evaluation

Written Examination:

One exam encompassing Level Flight, Climbs and Descents, H-V diagram, Take-off and Landing, and Rotor Speed Decay

Individual/Group Oral Examination/Review:

One exam encompassing Level Flight, Climbs and Descents, H-V diagram, Take-off and Landing performance, and Rotor Speed Decay

Written reports:

Daily flight reports

One substantial written on one of the following: Level Flight, Climbs and Descents, Take-off and Landing

Oral reports:

One oral report on one of the following: Level Flight, Climbs and Descents, Take-off and Landing

Graded Data Flights

Level Flight

Climb and Descent

Auto H-V

T/O and Landing

Graded AltMoC Sortie (EASA Only)

T&E 4113 RW Flying Qualities Flight Testing I

Course Number and Name

T&E 4113 RW Flying Qualities Flight Testing I

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001, 4111 & 4112

3. **Text Book:**

4.
 - Prouty, Raymond R., 2006, *Helicopter Performance, Stability, and Control*, Malabar, FL: Kregier Publishing Company, Chapters 7, 8 and 9.
 - Leishman, J.G., 2000, *Principles of Helicopter Aerodynamics*, Cambridge, UK: Cambridge University Press, Chapters 4, 6 and 7.
 - Padfield, Gareth D., 2007, *Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modelling*, Hoboken, NJ: Blackwell Publishing, Chapters 2, 4, 5 and 6.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 8 Rotary Wing Flying Qualities Testing*, National Test Pilot School, Mojave, CA, Chapters 1 thru 6.
5.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 109 thru 112.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with
 - None
- b. Understand
 - Flight controls mechanical characteristics.
 - Fundamentals of helicopter equations of motion.
 - Helicopter trim systems.
 - Closed-loop handling qualities.
 - The applicable Mil and CFR/CS regulatory requirements.
 - Rotor system characteristics.

c. Know

- How to determine the critical azimuth in the low airspeed envelope.
- How to determine the longitudinal static stability of a helicopter using the appropriate flight test techniques.
- How to determine the maneuvering stability of a helicopter using the appropriate flight test techniques.
- How to determine the lateral-directional static stability of a helicopter using the appropriate flight test techniques

Topics to be Covered

- 6.
- Flight Control Mechanical Characteristics. Irreversible flight controls are emphasized in this portion of the course, described along with methods for measuring and assessing their characteristics. Trim systems and regulatory requirements are covered. This topic is enforced with a laboratory exercise where the students practice the method of evaluating mechanical characteristics of helicopter flight controls.
 - Stability and Control Derivatives. The various helicopter stability and control derivatives are introduced. The physical contributions of different components to the various derivatives are shown.
 - Rotor Systems. The aerodynamic contributions of the main and tail rotor to stability and control of conventional helicopters is taught. Alternative configurations such as tandem, coaxial, NOTAR are introduced.
 - Equations of Motion. Students are taught the derivation of the equations of motion for a helicopter, common assumptions and simplifications. For supporting the derivation of the EOM the students are introduced with the mathematical concept of axis transformation and Euler angles.
 - Static stability. The theory, flight test techniques and regulatory requirements for helicopter static stability is taught. Included are longitudinal static stability, maneuvering stability, and lateral-directional static stability.
 - Low Airspeed. Students are taught the theory, flight test techniques and regulatory requirements for helicopters in the low airspeed regime. Aerodynamic interaction between main/tail rotors and the ground is taught. Students will learn how to determine the critical azimuth and how to measure control margins.
 - .
- 7.
- Closed Loop Handling Qualities. Students are taught how to develop mission relevant closed loop handling qualities tasks, CLHQ test methodology and the use of appropriate rating scales (e.g. Cooper Harper Rating scale). Simulation is used to develop qualitative evaluation skills.

Specific Course Information

a. Course Content

This one/three-week course is offered once per year on-campus. It consists of classroom lectures, laboratory exercises and in-flight instruction. The course is designed to provide an intensive overview of the methods used to determine static stability of helicopters. Subjects

include the theory, regulatory requirements and flight test techniques involved in determining the longitudinal, maneuvering and lateral-directional, stability of helicopters. Mechanical flight control systems, low airspeed stability and control and closed loop handling qualities are also taught.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
RW Flying Qualities I Intro	1
Flight Controls Mechanical Characteristics/FTT's	3
Rotor Systems	2
Axis Transformation and Euler angles	2
RW Equations of Motion Derivation	4
RW S&C Partial Derivatives	2
RW Longitudinal Static Stability Theory and FTT's	3
RW Lateral-Directional Static Stability Theory and FTT's	3
RW Closed Loop Handling Qualities	2
RW Low Airspeed Theory and FTT's	2
Example Questions Tutorial	4
Data Assignments	1
RW FTT's Vol 10 Briefings	2

Total: 31

- c. Laboratories

Laboratories	Hrs
RW FCMC Demo/Data Lab	2
RW Low Airspeed Lab	2

Total: 4

- d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	8
Formal Oral	1
Written Report (substantial)	1
RW FQ I Exam	1
Individual/Group Oral Exam/Review	1

Total: 12

e. Flying Hours

Flights	Hrs
RW Longitudinal Static Stability Demo	1.0
RW Lateral-directional Static Stability Demo	1.0
CLHQ and FCMC Demo	1.0
CLHQ and FCMC Data	1.0
RW Static Stability Data	1.5
Low Airspeed Demo	1.2
Low Airspeed Data	1.2
FTT Review/Evaluation/AltMoC Sortie (EASA Only)	1.0

Total: 8.9

f. Additional simulator time

Simulator	Hrs
FQ FTT's FlyIt sim	2.0

Total: 2.0

Process of Evaluation

8.

Written Examination:

Rotary Wing Static Stability, Equations of motion, Closed Loop Handling Qualities, Low Airspeed Flying Qualities and Flight Control Mechanical Characteristics

Individual/Group Oral Examination/Review:

Rotary Wing Static Stability, Equations of motion, Closed Loop Handling Qualities, Low Airspeed Flying Qualities and Flight Control Mechanical Characteristics

Written report: Rotary Wing Flying Qualities

Oral report: Rotary Wing Flying Qualities

Graded Data Flights

RW Static Stability

CLHQ and FCMC

Low Airspeed

Graded AltMoC Sortie (EASA Only)

T&E 4114 RW Flying Qualities Flight Testing II7

Course Number and Name

T&E 4114 RW Flying Qualities Flight Testing II

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001, 4111, 4112 & 4113

3. **Text Books**

4.
 - Prouty, Raymond R., 2006, *Helicopter Performance, Stability, and Control*, Malabar, FL: Kregier Publishing Company, Chapters 7, 8 and 9.
 - Leishman, J.G., 2000, *Principles of Helicopter Aerodynamics*, Cambridge, UK: Cambridge University Press, Chapters 4, 6 and 7.
 - Padfield, Gareth D., 2007, *Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modelling*, Hoboken, NJ: Blackwell Publishing, Chapter 6, 7 and 8.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 8 Rotary Wing Flying Qualities Testing*, National Test Pilot School, Mojave, CA, Chapters 6 thru 12.
5.
 - NTPS Faculty, 2021, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 113 thru 115.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - AFCS flight testing.
 - Data analysis software applications.
- b. Understand:
 - Fundamentals of aircraft motion analysis.
 - The regulatory requirements pertaining to helicopter dynamics.
 - Helicopter coupling dynamics.
 - ADS-33 closed loop handling qualities testing and techniques.
 - Rotary wing control and gust response.

c. Know:

- The flight test techniques used to quantitatively and qualitatively determine helicopter dynamics.

Topics to be Covered

6.
 - Motion Analysis. First and second order systems, analysis of time histories, introduction to frequency domain analysis using root locus diagrams and bode plots, characteristic equations, Laplace transforms, transfer functions and state-space representation of equations of motion.
 - Introduction to Analysis Software. Introduction to the use of analysis software for analyzing aircraft dynamic modes of motion.
 - Dynamic stability. The theory of helicopter open-loop dynamic motions is taught for the longitudinal and lateral-directional axes. Flight test methods along with civil and military requirements are explained for all of the classical dynamic modes of a helicopter.
 - Automatic Flight Control Systems. The generic design and operation of a helicopter AFCS is taught. Flight test techniques along with civil regulations are explained.
 - Qualitative Evaluations. The method and flight test techniques use to conduct a limited scope qualitative evaluation are explained.
 - ADS-33. The background and theory of response types, handling qualities levels, useable cue environment, augmentation requirements, and mission task elements are taught.

7. **Specific Course Information**

a. Course Content

This one/three-week course is offered once per year on-campus daily on a Monday through Friday basis. It includes classroom lectures, laboratory exercises and in-flight instruction. Unless approved by the Faculty Council, *T&E 4113 RW Flying Qualities Flight Testing I* is a prerequisite. The course is an intensive overview of the methods used to make dynamic stability determinations of helicopters. Subjects include rotary wing equations of motion, dynamics requirements and flight test techniques. Included is a brief review of mathematical concepts used for analysis in the frequency domain such as the Laplace transform.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
RW Flying Qualities II Overview	1
Introduction to System Analysis	3
Motion Analysis – 1 st Order Systems	2
Motion Analysis – 2 nd Order Systems	2
RW Longitudinal Dynamic Stability Theory & FTT's	3
RW Lateral Directional Dynamic Stability Theory & FTT's	3
RW Automatic Flight Controls Systems	3
RW ADS 33	4
RW Motion Analysis Tutorials	6
Software Applications	2
Data Assignments	1
RW Dynamics FTT's Vol. 10 Briefings	2

Total: 32

- c. Laboratory Hours

Laboratories	Hrs
RW APC and Lab	1.5

Total: 1.5

- d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	8
Formal Oral Report	1
Written Report (substantial)	1
Test Plan	1
RW FQ II Written Exam	1
Individual/Group Oral Exam/Review	1

Total: 13

e. Flying Hours

Flights	Hrs
RW Dynamics Demo	1.2
RW Dynamics Data	1.2
Qualitative Evaluation Demo	1.0
AFCS Evaluation Demo	1.5
AFCS Evaluation Data	1.5
ADS-33 Demo	1.5
ADS-33 Data	1.5
Performance FTT Review (as required)	1.0
Flying Qualities FTT Review (as required)	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Only)	1.0

Total: 12.4

f. Additional simulator time

Simulator	Hrs
FQ FTT's FlyIt sim	2.0

Total: 2.0

Process of Evaluation

8.

Written Examination:

Rotary Wing Dynamic Stability, ADS-33 Testing, AFCS Testing.

Individual/Group Oral Examination/Review:

Rotary Wing Dynamic Stability, ADS-33 Testing, AFCS Testing.

Test Plan:

ADS-33

Written report:

Rotary Wing Flying Qualities.

Oral report:

Rotary Wing Flying Qualities

Graded Data Flights.

Dynamics Data

ADS-33 Data

AFCS Data

Graded AltMoC Sortie (EASA Only)

T&E 4116 RW Loads and Vibrations Testing

Course Number and Name

T&E4116 Loads and Vibrations Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credit practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001, 4111, 4112, 4113 & 4114

3. **Text Books and References**

4.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 15 Loads, Flutter and Vibrations Flight Testing*, , National Test Pilot School, Mojave, CA, Chapters 1 thru 7 and 9.
 - Bielawa, R.L., 2006, *Rotary Wing Structural Dynamics and Aeroelasticity*, Reston VA: American Institute of Aeronautics and Astronautics, Inc. Chapters 6,7.
 - Byars EF, Snyder RD, *Engineering Mechanics of Deformable Bodies*, Second edition. Chapters 1 thru 6, 10 and 16.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with
 - The properties of materials used in RW aircraft structures.
 - Flight Test Instrumentations (FTI) used for RW aircraft loads and vibration testing.
 - The basic concepts and methods to alleviate inherent vibrations in RW aircraft.
 - The regulatory requirements pertaining to RW aircraft vibration levels.
- b. Understand
 - The principal of operation of a stain-gauge.
 - The method of transforming in-plane stresses and strains.
 - The mechanism which governs the manifestation of main and tail rotor alternating loads as discrete fuselage vibrations.
- c. Know
 - The flight test technique (FTT) used to conduct a RW aircraft vibration survey.
 - The practicality of decomposing a time-based measured signal into its frequency content using a FFT algorithm in Analysis Software.

Topics to be Covered

- Basic Stress/Strain Analysis
- Material Science
- Basic Load Analysis
- 6. • Vibrations Theory
- Vibration Analysis (FFT)
- Instrumentation and Data Reduction Techniques
- RW Aircraft Vibration Survey Flight Test Technique

Specific Course Information

- a. Course Content
7. This one-week course is offered once per year on-campus, daily on a Monday through Friday basis. It includes classroom lecture and in-flight instruction. The course is designed to provide an extensive review of vehicle structures and then loads and vibration testing takes the student from basic properties of materials through advanced instrumentation methods for determining vibration frequencies. Industry standards for determining loads limits and vibration analysis are addressed as well as possible ways for obtaining required data in a limited amount of flight time. A study of the instrumentation installation on an aircraft enhances the students' knowledge of the correct test methods for in-flight loads and vibration determination.
- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subjects	Hrs
Loads and Vibration Overview/Introduction	1
Structures, Dynamics and Materials	5
Instrumentation and Control Room Procedures	2
Strain Gauges- Concepts and Applications	2
In-plane Stress and Strain Transformation	3
Beam Deflection Theory	2
Helicopter Vibration Theory	4
ADS-27A Standard Practice	2
Fast Fourier Transform- Theory & Practicality	4
Loads & Vibrations FTT Vol 10 Briefing	2
Loads & Vibrations Data Assignment	1
Loads and Vibrations Tutorials	6

Total: 34

c. Reports and Exams

Reports and Exams	#
Loads and Vibrations Oral Report (Substantial)	1
Helicopter Vibrations Survey Written Report (Substantial)	1
Written Exam on Loads & Vibrations	1
Daily Flight Reports for all Flights	2

Total: 5

d. Flying Hours

Flights	Hrs
Loads & Vibrations Demo	1.0
Loads & Vibrations Data Flight	1.0
FTT Review/Evaluation/AltMoC Sortie (EASA Only)	1.0

Total: 3.0

Process of Evaluation

8.

Written Examination:

Comprehensive examination covering all academic lectures.

Written reports:

Daily flight reports

Vibrations survey written report (group effort)

Oral reports:

Oral report on vibrations survey.

Graded Data Flight

Loads and vibration data flight

T&E 4201 Avionics Systems Flight Testing

Course Number and Name

T&E 4201 Avionics Systems Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credit practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001

3. **Text Book and References**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapters 1, 2 and 3.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapter 51.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - Avionic systems databus specifications and regulations
 - Electrical, electromagnetics and logic circuits as they relate to Avionics flight testing
 - Cyber security impacts on avionics system flight testing
- b. Understand:
 - Other types of Data Busses
 - The unique problems associated with Avionics Systems Flight Testing
 - Software test and configuration management principles
6. c. Know:
 - Workload evaluation test techniques for Avionic systems.
 - Workload data collection and data analysis procedures
 - MIL-STD-1553B data bus architectures

Topics to be Covered

- Introduction to Avionics Systems Test
- Test and Evaluation of Integrated Systems
- Software Development and Test

- Cyber security in Flight Testing
- Avionics Systems Development and Certification
- Time, Space, Position, Information (TSPI)
- Practical Electronics for Flight Tester
-
- Data Acquisition , Reduction, and Analysis
- MIL-STD-1553B data bus architecture
- Other types of data busses (ARINC,CAN,TCP/IP,AFDX)
- Workload evaluation

Specific Course Information

a. Course Content

7. This one/three-week course is offered once per year on-campus and once per year distance learning. The program includes classroom lecture, laboratory exercises and in-flight instruction. This course is designed to provide the fundamental groundwork for all subsequent systems modules. An overview of testing integrated avionics systems is discussed. Software and avionics systems development and testing is explained. Types of Time, Space, Position Information (TSPI) and their relationship to flight test requirements are discussed. The basics of electrical circuits, electromagnetism and logic circuits are discussed. Data bus architecture and protocols shall be explained with an emphasis on MIL-STD-1553/SAE AS 15531. Data acquisition, correlation, merging and analysis with an inclination towards true versus predicted performance shall be explained.

b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction - Systems Overview	1.0
Avionics Systems Flight Test and Tutorial	4.0
Test and Evaluation of Integrated Systems	2.0
Cyber Security in Flight Testing	1.0
Software Development and Testing	2.0
Avionics Systems Development and Certification	2.0
Time Space Position Information (TSPI) and Tutorial	3.0
Practical electronics for Flight Testers	2.0
Data Acquisition, Reduction and Analysis	1.5
MIL-STD-1553B Data Bus architecture and tutorial	3.0
Other types of Data Busses (ARINC,CAN,TCP/IP,AFDX)	2.0
Workload Evaluation and Tutorial	6.0
Workload Vol 10 FTT Brief	1.0
Data Assignments	1.0

Total: 31.5

c. Instructional Laboratory Hours

Aircraft Laboratories	Hrs
Basic Aircraft Navigation Tutorial	2.0
Garmin G1000 Tutorial	2.0
Garmin 96C Tutorial	1.0
GPS Navigation G1000 Cockpit Trainer Tutorial	2.0
FMS/FGS G1000 Cockpit Trainer Tutorial	2.0

Total: 9.0

d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	4
Formal Oral Report	1
Written Exam	1
Individual/Group Oral Exam/Review	1

Total: 7

e. Flying Hours

Flights	Hrs
GPS Navigation TAA	1.5
FMS/FGS TAA	1.5
Workload FTT Demo	1.0
Workload Data	1.5

Total: 5.5

8.

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

Individual/Group Oral Examination/Review:

One exam/review encompassing all academic lectures

Written reports:

Daily flight reports (2 TAA, 1 Demo and 1 Data)

Oral report:

One oral report on Workload assessment

Graded Data Flights:

Workload

T&E 4202 Communications, Navigation and GNSS Flight Testing

Course Number and Name

T&E 4202 Communications, Navigation and GNSS Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credit practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book and References**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapters 4 and 5.
 - Biezd, Daniel J., 1999, *Integrated Navigation and Guidance Systems*, Reston VA: American Institute of Aeronautics and Astronautics, Inc.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, , National Test Pilot School, Mojave, CA, Chapters 52 thru 54.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with the fundamentals of:
 - Antennas
 - EMI/EMC
 - Inertial Navigation Systems
 - Integrated Navigation Systems
 - Data Link Communications and Tactical Datalinks
 - Transponders and ADS-B
- b. Understand the:
 - Fundamental concepts behind GNSS and GNSS augmentation systems.

- c. Know the technique for:
 - Evaluating radio communication intelligibility
 - Evaluating GNSS as installed on aircraft
 - Evaluating systems for Required Navigation Performance (RNP) operations
 - Evaluating ground based NavAids

Topics to be Covered

- Antennas
- EMI/EMC
- 6. • Radio Aids to Navigation
- Communication Flight Testing
- Data Link Communications
- Tactical Data Links
- Transponders
- ADS Systems
- Introduction to GNSS
- GNSS Augmentation Systems
- GNSS Flight Testing
- Inertial Navigation Systems
- Integrated Navigation Systems
- Navigation Flight Testing

7. Specific Course Information

- a. Course content

This one/two-week course is offered once per year on-campus and once per year distance learning. It consists of academic lectures, laboratory exercises and in-flight instruction. The course is an extensive examination of Avionic communications and navigation systems, their modes of operation, and procedures for evaluating and testing the equipment are formulated. Electromagnetic interference and compatibility testing is discussed. Voice and datalink communication testing is discussed. Ground based radio navigation aids and GNSS flight testing are discussed. Inertial navigation systems and the testing of integrated navigation systems are explained. Two practical exercises are performed: communications testing, and NavAid/GNSS testing.

- b. Academic Lectures Hours are shown in the following table, in sequence typically scheduled. Course coordinator have latitude to vary the sequence if required.

Academic Subject	Hrs
Communication, Navigation and GNSS Overview	0.5
EMI/EMC	2.0
Radio Aids to Navigation	2.0
Antennas	1.0
Communication Flight Testing	1.0
Vol 10 Communication FTT Briefing	1.0
Communications Demo/Data Tutorial	1.5
Datalink Communications	2.0
Tactical Datalinks	2.0
Transponders and ADS-B	3.0
Introduction to GNSS	2.0
GNSS Augmentation Systems	1.5
GNSS Flight Testing and Tutorial	3.0
Inertial Navigation Systems	2.0
Integrated Navigation Systems	1.5
Communication and Navigation Flight Testing Tutorial	2.0
Vol 10 NavAid/GNSS FTT Briefing	1.0
Data Assignment	1.0

Total: 30

c. Instructional Laboratory Hours

Laboratories	Hrs
Communications Demo/Data Flight - TM Room Evaluation	1.5

Total: 1.5

d. Reports and Exams

Reports and Exams	#
Daily Reports	3
Formal Oral Report	1
Written Exam	1
Individual/Group Oral Exam/Review	1

Total: 6

e. Flying Hours

Flights	Hrs
Communications Demo/Data	1.0
NavAid/GNSS Demo	1.5
NavAid/GNSS Data	1.5
FTT Review/Evaluation/AltMoC Sortie (EASA only)	1.0

Total: 5.0

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

Individual/Group Oral Examination/Review:

One exam/review encompassing all academic lectures

8.

Written reports:

Daily flight reports

Oral report:

One oral report on NavAid/GNSS assessment

Graded Data Flights

NavAid/GNSS data flight

T&E 4203 14 CFR Part 23/25/27/29 Avionics Certification Flight Testing

Course Number and Name

T&E 4203 14 CFR Part 23/25/27/29 Avionics Certifications Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapter 6.
 - Code of Federal Regulations, Title 14 – Aeronautics and Space
 - Regulations (EU) 2018/1139 of the European Parliament and of the Council

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - The history and overview of Civil certification requirements
 - Civil certification requirements for software
 - Civil certification requirements for Avionic systems
 - b. Understand:
 - Civil certification requirements for crew station controls and displays
 - Human Factor effects on Civil certification requirements for Avionic systems
 - Civil certification requirements for Flight Management Systems and Flight Guidance Systems
 - Civil certification requirements for landing systems
 - c. Know:
 - The Civil certification process for issuing design, production and airworthiness approvals
 - The test and evaluation process of avionic systems to show compliance with Civil regulations
6.
 - The Civil certification process for issuing design, production and airworthiness approvals
 - The test and evaluation process of avionic systems to show compliance with Civil regulations

Topics to be Covered

- History and Overview of Civil Certification

- Design, Production and Airworthiness Approval Process
- Avionics Software Certification Requirements
- Crew station controls and displays Certification Requirements
- Human Factors Principles and Certification
- Weather RADAR
- Flight Management Systems
- Automatic Landing Systems
- Flight Guidance Systems (Autopilots and Flight Directors)
- Airworthiness Approval of Positioning and Navigation Systems
- Reduced Vertical Separation Minima
- TCAS-II, TAS, ADS-B
- Ground Proximity Warning Systems
- Enhanced Vision Systems, Enhanced Flight Vision Systems, Synthetic Vision Systems and Combined Vision Systems

Specific Course Information

7.

a. Course Content

This one/three-week course is offered once per year on-campus and once per year distance learning. It consists of academic lectures, laboratory exercises and in-flight/simulator instruction. The primary emphasis in this academic module will be on the evaluation of civil avionics systems and the means of showing compliance with the applicable Civil Regulations i.e., Code of Federal Regulations Title 14 and Regulations (EU) 2018/1139 of the European Parliament and of the Council. Since many of the civilian requirements are now applicable in military aircraft, this module is especially important for those individuals involved with showing military compliance with these civil requirements. The importance of Flight Management System evaluation in today's automated cockpits will be emphasized. The student will be instructed in the evaluation and test of proximity warning systems such as Traffic Alert and Collision Avoidance (TCAS) and Terrain Awareness and Warning Systems (TAWS). Flight Guidance Systems, Automated Landing Systems, Weather RADAR, Reduced Vertical Separation Minima and civil certification of positioning and navigation systems will be examined. A history of the Civil certification regulations and other documentation, as well as the Human Factors impact to certifications, will be addressed. Controls and Displays implementation, and Software considerations in the certification process, as well as considerations for complex systems are also identified.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction	0.5
FAA History and Overview of FAR's in the CFR	1.5
FAA Certification Process	2.0
Software Considerations in the TSO Program	1.0
EASA History and Certification Process	1.0
FAA/EASA Certification Tutorial	1.0
Certification Consideration for Complex Systems	2.0
Controls and Displays: Human Factors Principles and Certifications	2.0
Weather Radar	1.0
Flight Management Systems (FMS)	1.0
FMS Tutorial (Honeywell and/or Universal)	2.0
Automatic Landing systems	2.0
Flight Guidance Systems	2.0
Airworthiness Approval of Positioning and Navigation Systems (AC 20-138D)	3.0
RVSM	1.0
Proximity Warning Systems (TCAS-II, TAS, ADS-B)	3.0
Ground Proximity Warning Systems (TAWS/HTAWS)	2.0
Enhanced Vision Systems (EVS, EFVS, SVS and CVS)	1.0
Data Assignment	1.0

Total: 30.0

- c. Instructional Laboratory Hours

Laboratories	Hrs
Flight Management System Demo	2.0

Total: 2.0

- d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	3
Written Examination	1
Written Test Plan (substantial)	1
Formal Oral Report	1
Written Test Report (substantial)	1
Individual/Group Oral Exam/Review	1

Total: 8

e. Flying Hours

Flights	Hrs
Civil Certification Evaluation (FW course only)	12
Civil Certification Evaluation (if RW Option used)	4.5

FW Total: 12.0

RW Total: 4.5

Process of Evaluation

Written Examination:

- 8. One exam encompassing all academic lectures

Individual/Group Oral Examination/Review:

- One exam/reveiw encompassing all academic lectures

Written reports:

- Daily flight reports

- Test Plan

- Test Report

Oral report:

- One oral report on Civil Certification

Graded Data Flights:

- Civil Certification

T&E 4204 Flight Test of RADAR and Electronic Warfare Systems

Course Number and Name

T&E 4204 Flight Test of RADAR and Electronic Warfare Systems

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapters 8 and 9.
 - Stimson, George W., 2014, *Introduction to Airborne Radar*, 3rd Edition, London, UK: SciTech Publishing.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapter 58.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - EW Introduction and Integrated Air Defense systems (IADS)
 - Electronic Attack
 - Electronic Protection
 - Electronic Support
- b. Understand:
 - Basic RADAR fundamentals
 - RADAR modes of operation
 - Pulsed, Doppler and Pulse Doppler RADAR
 - Test and Evaluation of EW Systems
- c. Know:
 - Test and Evaluation of Air-to-Air RADAR
 - Test and Evaluation Air-to-Ground RADAR

Topics to be Covered

- Introduction to RADAR
- RADAR Range Equation
- Pulsed Radar Operations and test methods
- 6. • Doppler Radar Operations
- Pulse Doppler Modes of Operation and test methods
- Miscellaneous RADAR Tests
- RADAR Detection Calculations
- Special Cases: Detection of Targets at Sea
- EW Introduction and Integrated Air Defense systems (IADS)
- Electronic Attack, Protection and Support
- EW Systems Test and Evaluation

Specific Course Information

7. a. Course Content

This one/three-week course is offered once per year on-campus, daily on a Monday through Friday basis. It consists of academic lecture, laboratory exercises and in-flight instruction. The course is designed to assist the student in the development and test of airborne RADAR systems. Highlights of this course include hands-on operation of the NTPS RADAR Toolkit. This simulation is a complex, real-world, energy level model of the emitted radio transmissions and simulated environment. Students will see firsthand what the effect of changing RADAR parameters has on RADAR performance. Lectures cover the many types and functions of today's multi-mode RADARs and evaluating performance through flight test.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Radar and Electronic Warfare Overview	0.5
Applications and Employment of Radar	1.0
Decibels	1.0
Electromagnetic Waves	1.0
Radar Range Equation Lecture and Tutorial	2.5
Radar Detection Lecture and Tutorial	2.5
Pulse Radar	3.0
Pulsed Radar Test Methods	3.0
Pulsed Radar Tutorial	2.0
Doppler Radar	3.0
Doppler Radar Test Methods	2.0
Doppler Radar Tutorial	2.0
Air-to-Ground Radar Testing (includes maritime)	2.0
FM Ranging	1.0
Weather Radar	1.0
Low Observables	1.0
Weather Radar Ground Mapping Vol 10 FTT Brief	1.0
Radar and EW Flight Testing (Tutorial)	2.0
Air-to-Ground Falcon sim. Brief	1.0
EW Introduction and IADS	1.0
EW Electronic Attack	1.0
EW Electronic Protection	1.0
EW Electronic Support	1.0
EW Systems Test and Evaluation	2.0
Data Assignment	1.0

Total: 39.5

c. Instructional Laboratory Hours

Laboratories	Hrs
Radar Simulator Tutorial	2.0
A/A Radar Tutorial	2.0
A/A Radar Demo	2.0

Total: 6.0

d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	2
Written Report (Substantial)	1
Written Examination	1
Formal Oral Report	1
Individual/Group Oral Exam/Review	1

Total: 6

e. Flying Hours

Flights	Hrs
Weather Radar Ground Mapping Demo	1.7
FTT Review/Evaluation/AltMoC Sortie (EASA only)	1.0

Total: 2.7

f. Additional simulator time

Simulator	Hrs
Radar Evaluation	6.5

Total: 6.5

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

Individual/Group Oral Examination/Review:

8. One exam/review encompassing all academic lectures

Written reports:

Daily flight report

Oral report:

One Air-to-Air Radar oral report

Graded Data Flights: Air-to-Air Radar

T&E 4205 UAV Systems Test

Course Number and Name

T&E 4205 UAV Systems Test

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credits practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapter 12.
 - NTPS Faculty, 2019, National Test Pilot School Professional Course Volume 10 Flight Test Techniques, National Test Pilot School, Mojave, CA, Chapters 59 thru 61.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

Be familiar with:

- The techniques for UAV guidance, control, and limit protection flight test
- The techniques for UAV command and control link and sensor link ground/flight test
- Airworthiness Requirements (Civil and Military) for UAVs
- The requirements for assessing human factors of UAV Ground Control Stations (GCSs)

Understand:

- The fundamental differences in ground/flight testing of a UAV system versus a manned aircraft
- The primary modes for controlling a UAV, to include Remotely Piloted Vehicle (RPV) and Command Directed Vehicle (autonomous) operations
- The fundamentals behind UAV data link communications
- The concept of sense and avoid systems and their importance to UAV operations
- The techniques and data analysis for Unmanned Air Vehicle (UAV) systems ground/flight test

Know:

- The techniques for assessing human factors of UAV Ground Control Stations (GCS)

- The development of a structured test plan/cards for UAV systems ground/flight test
- The fundamentals of safety planning and risk mitigation for UAV systems ground/flight test
- The approach to safely and effectively executing a UAV systems flight test sortie

Topics to be Covered

- Welcome Overview of UAV Systems Integration
- Human Factors
- 6. • Controls and Displays
- Control Room Operations Human Factors and CRM
- Ground Testing (including build-up techniques to flight)
- Remotely Piloted and Command Directed Vehicle (autonomous) modes
- Command and Control Links
- Latency
- Sensor Links
- Telemetry
- Frequencies
- Data Link Range and Reliability
- Failure Modes/Contingency Management
- Guidance and Control Systems
- Navigation
- Positional and Vertical Accuracy
- Guidance Modes
- Mission Planning
- 7. • Loss of Command and Control Communications

Specific Course Information

a. Course Content

This one/two-week course is offered twice a year, daily on a Monday through Friday basis. It consists of academic lecture and laboratory exercises. The course is designed to address the unique testing requirements when evaluating a UAV system. It is assumed that the participants are generally knowledgeable in manned aircraft flight testing as this course builds on that knowledge. The students will be involved with UAV missions. Course lectures will introduce the students to UAV-specific testing when compared to manned Fixed and Rotary Wing testing. Issues such as data latency, human factors, data link coverage, failure modes, contingency management, telemetry issues, guidance, navigation and control, mission planning, and sensor cueing/integration will be addressed. Flight Test

Techniques for testing both Remotely Piloted and Command Directed (autonomous) Vehicle modes will also be covered.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction	0.5
UAV Overview and Flight Test Factors	2.0
UAV Guidance, Navigation, and Control	3.0
UAV Lessons Learned	1.5
GCS Functional Description	2.0
SCS Functional Description	1.0
UAV Walk-around/tutorial	0.5
Communications Architecture and Evaluation	2.5
UAV Human Factors and Controls and Displays	2.0
UAV Flight Test Program Case History	1.5
UAV Airworthiness and Certification	1.5
UAV Sense and Avoid	1.5
UAV Flight Test Tutorial	2.0
UAV Data Reduction Tutorial	1.0
UAV FW Vol 10 FTT Briefings (Datalinks, Guidance, Navigation and Control)	2.0
Data Assignment	1.0

Total: 25.5

- c. Instructional Laboratory Hours

Laboratories	Hrs
Ground Control Station (GCS) Tutorial	2.0
Sensor Control Station (SCS) Tutorial	2.0
TM Room Familiarization	0.5
GCS Human Factors Evaluation Tutorial	2.0
SCS Human Factors Evaluation Tutorial	2.0
Mission Planning Tutorial	2.0

Total: 10.5

- d. Reports and Exams

Reports and Exams	#
Daily flight Report	1
Written Examination	1
Formal Oral report	1
Individual/Group Oral Exam/Review	1

Total: 4

e. Flying Hours

Flights	Hrs
Datalink Demonstration Flight	1.1
GNC Demonstration Flight	1.1
Project Data Flight	1.1

Total: 3.3

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

8. Individual/Group Oral Examination/Review:

One exam/review encompassing all academic lectures

Written reports:

Daily flight report

Oral report:

One formal UAV oral report

Graded Data Flights:

Project Flight

T&E 4206 Air-to-Air and Air-to-Ground Weapons Integration

Course Number and Name

T&E 4206 Air-to-Air and Air-to-Ground Weapons Integration

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credit practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapter 10.

Course Learning Outcomes

5. Anticipated Course Learning Outcomes

- a. Be familiar with:
 - MIL-STD-1760D/E
 - Weapon to aircraft interface
 - Weapon templates and safety footprints
 - Air drop testing
 - b. Understand:
 - Stores Management Systems
 - Error budgets
 - Weapons accuracy analysis
 - c. Know:
6.
 - Air-to-air weapons evaluations techniques and considerations
 - Air-to-ground weapons evaluations techniques and considerations
 - Weapon evaluations hazard analysis considerations

Topics to be Covered

- Air-to-Air and Air-to-Ground Weapons Introduction
- Weapons Systems Data Bus Architecture (MIL-STD-1760D/E Interface Standard for A/C Store Electrical Interconnection System)
- Stores Management System
- Introduction to MIL-HDBK-1763 Aircraft/Stores Compatibility Systems Engineering Data Requirements and Test Procedures

- Weapon Delivery Analysis and Ballistic Flight Testing (AGARD Volume 10)
- Targets and Instrumentation
- Air-to-Air Weapon Testing (FW and RW)
- Air-to-Ground Weapons Testing

Specific Course Information

a. Course Content

7. This one/two-week course is offered once per year on-campus, daily on a Monday through Friday basis. It consists of academic lecture and simulator exercises. The course is designed to provide an overview of MIL-STD-1760D/E, Interface Standard for Aircraft/Store Electrical Interconnection Systems as the baseline for Weapons Integration. Evaluation of Stores Management Systems (SMS) and Hazard Analysis considerations are covered. Error budgeting and analysis are key elements in undertaking ballistics evaluations.

b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction	1.0
Air-to-Air and Air-to-Ground Weapons Overview	2.0
Weapons Systems Data Bus Architecture	2.0
Stores Management Systems	2.0
Introduction to MIL-HDBK-1763	2.0
Weapon Safety Templates	2.0
Weapon Ballistics and Accuracy	2.0
Targets and Instrumentation	2.0
Air-to-Air Weapons Testing	2.0
Air-to-Ground Weapons Testing	2.0
Helicopter Weapons Testing	2.0
Air Drop Testing	2.0
Weapon Integration Test Program Examples	2.0
Weapons Flight Testing Tutorial	2.0
Falcon Simulator Overview	1.0
Air-to-Ground Vol 10 FTT Briefing	1.0

Total: 29.0

c. Instructional Laboratory Hours

Laboratories	Hrs
Air-to-Ground Tutorial	2.0
Air-to-Air Tutorial	2.0

Total: 4.0

d. Reports and Exams

Reports and Exams	#
Written Exam	1
Individual/Group Oral Exam/Review	1

Total: 2

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

8.

Individual/Group Oral Examination/Review:

One exam/reveiw encompassing all academic lectures

T&E 4207 Electro-Optics and Infrared Systems Flight Testing

Course Number and Name

T&E 4207 Electro-Optics and Infrared Systems Flight Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
3 credits practical (minimum 30 hours)

2. **Pre-requisites**

T&E 4001 & 4201

3. **Text Book**

4.
 - McShea, Robert E., 2014, *Test and Evaluation of Aircraft Avionics and Weapons Systems*, London, UK: SciTech Publishing, Chapter 7.
 - Holst, Gerald C., 2008, *Electro-Optical Imaging System Performance*, Sixth Edition, Oviedo, FL: JCD Publishing.
 - NTPS Faculty, 2019, *National Test Pilot School Professional Course Volume 10 Flight Test Techniques*, National Test Pilot School, Mojave, CA, Chapters 56 and 57.

5. **Course Learning Outcomes**

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - The history, evolution and application of electro-optic and infra-red systems
 - Electro-Optic and Infra-Red system components
- b. Understand:
 - Atmospheric propagation
 - Target signatures
 - Sources of radiation
 - Lasers and laser range finders
6. c. Know:
 - How to calculate spatial frequency
 - How to calculate range predictions
 - How to conduct electro-optic and infra-red systems evaluations

Topics to be Covered

- History, Evolution and Current Applications

- Electromagnetic Radiation Fundamentals
- Sources of EM Radiation
- Atmospheric Propagation of EM Radiation
- Target Signatures
- EO System Components
- Target Signatures
- Target Tracking
- Target Discrimination
- Range Predictions
- EO Systems Flight Test Techniques
- LASER Systems- Range Finders and Designators
- EO Weapon Systems and EW countermeasures

Specific Course Information

7. a. Course Content
 This one/three-week course is offered once per year on-campus, daily on a Monday through Friday basis. It consists of academic lecture, laboratory exercises and in-flight instruction. The course is designed to review basic Electro-optical (ultraviolet, visible and infrared) theory and then teach practical application of this theory. Electro-optical ground and flight test theory shall be explained and demonstrated. The first part of the course is designed to review radiation theory, while the remainder is arranged to review, in significant detail, typical electro-optical systems components, both passive and active electro-optical systems, and various countermeasures. Test plan formulation and the determination of the necessary test points for validating system capabilities are also addressed.
- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction	0.5
History, Evolution and Application	1.0
EM Radiation Fundamentals	1.0
EM Radiation Sources	1.0
Target Signatures	1.0
Atmospherics	1.0
EO System Components and Tutorial	3.0
Target Tracking	2.0
Target Discrimination and Range Predictions and Tutorial	3.0
Spatial Frequency Tutorial	2.0
EO Flight Testing Tutorial	2.0
EO Flight Testing	3.0
Laser Systems - Range Finders, Designators	2.0
Enhanced Vision Systems	1.0
EO Weapon Systems and EW countermeasures	1.5
EO Vol 10 FTT Briefings	2.0
Data Assignment	1.0

Total: 28.0

c. Instructional Laboratory Hours

Laboratories	Hrs
EO Ground Test Techniques Demonstration	2.0
Spatial Frequency	1.0
Enhanced Vision Systems	1.0
EO Simulator Tutorial	2.0
Total: 6.0	

d. Reports and Exams

Reports and Exams	#
Daily Flight Reports	4
Written Examination	1
Written Test Plan (Substantial)	1
Formal Oral Report	1
Individual/Group Oral Exam/Review	1
Total: 8	

e. Flying Hours

Flights	Hrs
EO FTT Demo	1.5
EVS Demo	1.0
EO Data (2)	3.0
FTT Review/Evaluation/AltMoC Sortie (EASA only)	1.0
Total: 6.5	

8.

Process of Evaluation

Written Examination:

One exam encompassing all academic lectures

Individual/Group Oral Examination/Review:

One exam/review encompassing all academic lectures

Written reports:

Daily flight report

EO Test Plan

Oral report:

One formal EO oral report

Graded Data Flights:

All EO Data Flights

T&E 4208 Night Vision Goggle and Helmet Mounted Display Testing

Course Number and Name

T&E 4208 NVG and HMD Testing

Credits and Contact Hours

1. 3 credits theory (minimum 30 hours)
1 credits practical (minimum 10 hours)

2. **Pre-requisites**

T&E 4001

3. **Text Books**

4.
 - Rash, Clarence E., 2000, *Helmet-Mounted Displays: Design Issues for Rotary Wing Aircraft*, Bellingham, WA: SPIE Press, Chapters 1 to 5, 7, 9 and 10.
 - Veelger, Mordekhai, 1998, *Helmet-Mounted Displays and Sights*, Boston, MA: Artech House Inc, Chapters 1, 3, 4, 5, 6, 8 and 9.
 - RTCA, 2001, *Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment: RTCA DO-275*, Washington, DC: RTCA Inc. Chapters 1 to 5.
 - Godfrey Geo, W., *NVG Fundamentals/Techniques: Night Vision Goggle Compatible Aircraft Lighting*, Clearwater, FL: Aerospace Lighting Institute, Inc., Chapters 3 to 11
 - Csorba, Illes P., 1985 *Image Tubes*, Indianapolis, IN: Howard W. Sams & Co., Chapters 2, 6, 8 to 10, 12 and 13.
- 5.

Course Learning Outcomes

Anticipated Course Learning Outcomes

- a. Be familiar with:
 - Night Vision Imaging Systems (NVIS) lighting specifications and Code of Federal Regulations (CFR) Title 14, NVG requirements.
 - HMD relay optics considerations
 - HMD head tracking systems
- b. Understand:
 - Night vision sensors and image sources
 - Image intensification technology
 - NVIS modification methods for interior and exterior lighting

- Biodynamics factors affecting HMD designs
 - NVIS to aircraft integration testing
 - Aeromedical and human factor considerations
- c. Know:
- Procedures for helmet mounting, aligning and adjusting the focus of NVG
 - Evaluate the NVG image for possible defects
 - Perform a qualitative evaluation of the NVG performance
 - Perform a ground and flight evaluation of a NVIS

Topics to be Covered

- 6.
- Introduction to HMD Systems
 - Sensors and Image Sources
 - Relay Optics
 - Biodynamics
 - Aeromedical and Human Factor Considerations
 - Head Tracking Systems
 - Image Intensification Technology
 - Introduction to NVGs
 - NVIS Modification Methods for Interior and Exterior Lighting
 - Aircraft Integration Testing
 - Ground Testing of NVIS Compatible Lighting
 - HMD and NVG Qualitative Ground Testing
 - HMD and NVG Flight Testing
- 7.

Specific Course Information

a. Course Content

This one/two-week course is offered twice a year on-campus (short course in the fall), daily on a Monday through Friday basis. It includes academic lectures, laboratory exercises and in-flight instruction. The course is designed to provide technical information and human factors considerations regarding Helmet Mounted Displays (HMDs), Night Vision Imaging System (NVIS) compatible lighting, and the integration of both into an aircraft. Emphasis is placed on hands-on test techniques to evaluate the total NVIS as integrated in fixed and rotary wing aircraft. The academic lectures are reinforced during laboratory demonstrations and through practical exercises performing both ground and flight-testing. This course enables the students to effectively plan and execute HMD and NVIS ground and flight tests.

- b. Academic Lecture Hours are shown in the following table, in the sequence typically scheduled. Course coordinators have latitude to vary the sequence if required.

Academic Subject	Hrs
Introduction to HMD Systems	1
Sensors and Image Sources	1
Relay Optics	1
Biodynamics	1
Aeromedical and Human Factors	2
Head Tracking Systems	1
Image Intensification Technology	2
Introduction to NVGs	1
NVIS Modification Methods for Interior and Exterior Lighting	2
Ground Testing of NVIS Compatible Lighting	2
Aircraft Integration Testing	1
HMD and NVG Qualitative Ground Testing	2
HMD and NVG Flight Testing	2

Total: 19

- c. Instructional Laboratory Hours

Laboratories	Hrs
Biodynamics	1
HMD Examples	1
NVG Video	1
HMD Specific Example (Top Owl)	1
NVG Fit, Align and Focus	1
NVG Performance & Image Defects	1
Aided Visual Acuity Evaluation	1
NVG Test Equipment	1
Display Lighting Evaluation	1
Daytime Readability	1
Nighttime Readability	1

Total: 11

- d. Student Laboratory Hours

Laboratories	Hrs
Test Aircraft Cockpit Survey	2
Daylight Readability Evaluation	1
Unaided Night Time Readability Evaluation	1
Aided Visual Acuity Evaluation	1
Aircraft Integration Evaluation	1
Biodynamics and Human Factors	1
NVG Performance and Image Defects	1
Aircraft Exterior Lighting Evaluation	1

Total: 9

e. Reports and Exams

Reports and Exams	#
Daily Flight Reports	1
Evaluation Oral Report	1
Written Exam	1

Total: 3

f. Flying Hours

Flights	Hrs
Introduction to NVGs	1.0
NVIS Flight Evaluation	1.0

Total: 2.0

Process of Evaluation

- 8. Written examination:
 - HMD and NVG Testing
- Oral report:
 - Report of test results from ground and flight test.
- Graded data flight:
 - NVIS Flight Evaluation

Appendix B

Short Course/On demand Module Descriptions

FAA Civil Flight Test Certification and Standardization

Initial Course

This course is for experienced flight test personnel who are new to FAA or CAA employment. This six-week course consists of classroom lectures, simulator and aircraft flying in both fixed and/or rotary wing aircraft. The course covers performance, propulsion, stability and control, and systems that are pertinent to certification to FAA (EASA) Regulations.

Each graduate will have a review of P&FQ and systems theory, hands on flight test experience, and data comparison to the existing certification regulations. They will be current in the covered FAA (EASA) flight test certification procedures for fixed and/or rotary wing aircraft.

Graduates of the Initial Civil Flight Test Certification and Standardization Course (T&E 4005) who are enrolled in the master's degree program can receive credits towards their master's degree.

Recurrent Course

The FAA two-week certification course is intended as a refresher for past graduates of the initial six-week FAA Flight Test Certification and Standardization Course. The course is specifically structured to refresh the necessary knowledge associated with certification of aircraft or aircraft components in accordance with FAA (EASA) regulations.

Short Courses

Pre-TPS Course

The Pre-TPS Course helps prepare the student academically for the mathematics and physical sciences required for the long course. It also introduces the student to aircraft performance and stability and control and airborne systems evaluation techniques they will soon utilize. The six-week course is divided into three two-week sections:

- Refresher in mathematics (trigonometry, calculus, differential equations) and physical sciences
- T&E 4008 Introduction to Systems Testing
- T&E 4007/4017 Introduction to Performance and Flying Qualities Flight Testing

Familiarization flights and local area orientation introduce the students to our aircraft and the surrounding test area, while also providing an opportunity to refresh flying skills.

This course, offered twice a year since 1976, has proven to be a very successful preparatory course for pilots and engineers prior to entering test pilot schools both in the US and abroad. Foreign students who speak English as a second language find the course particularly useful as an immersion course in technical English and as an exposure to a different culture. Supplemental English language training can also be arranged for those needing to enhance their English skills.

Operational Test and Evaluation (OT&E) Course

The course teaches basic flight test principles, concepts, and processes. Classroom instruction is reinforced by two demonstrations and two project flights designed to provide “hands-on” experience in flight testing. A final project further reinforces classroom instruction. The final project uses operational requirements/capability documents to plan, flight test, and report on how well an aircraft or system meets mission needs. Previous class projects have included fixed wing, rotary wing, air vehicle and avionics systems evaluations.

This course develops a “customer-centric” view of testing by providing an overview of current OT&E philosophies, processes, concepts and issues. Specifically, the course provides an understanding of how OT&E fits into the acquisition process, the interrelationships of DT&E and OT&E, how test objectives are derived from user requirements, and the importance of relating test results to mission requirements. The course is extremely beneficial to anyone involved in OT&E; to DT&E testers who interface with OT&E; and to Program Office personnel, Program Managers and Test Managers whose programs are subject to OT&E and who need to certify a system ready for OT&E. The course is continually updated based on customer feedback.

The course is suitable for foreign government personnel and for civil airline pilots, engineers, and managers who are in a position to evaluate a new aircraft or systems for their government or company, who need to work with the manufacturer to define special mission or customer requirements, and who must evaluate resulting modifications to ensure an operationally viable aircraft.

Subjects Covered

- The Acquisition Process
- Performance and Handling Qualities Test
- DT&E / OT&E Philosophy and Processes
- Techniques
- User Requirements Process
- Overview and Laboratory Exercise
- OT&E test criteria development
- Test Crew Resource Management
- Test Planning and Data Concerns
- Crew Station Evaluation Techniques
- Risk Management and Test Safety
- Workload Assessment Techniques
- Reliability, Maintainability, and Availability
- OT&E Lessons Learned
- Testing Integrated Systems

Technical Pilot Course

This course introduces the student to the philosophy, procedures, and theory of acceptance / maintenance / production flight test. A review of basic aerodynamics and aircraft performance, plus risk management, upset recovery theory, aircraft pilot compatibility, an introduction to stability and control and acceptance / maintenance / production flight test procedures are accomplished prior to in-flight / simulator practical application exercises. During one of the inflight exercises, an actual aircraft acceptance flight test is performed to include a crew resource management exercise. A complete takeoff speed development and stability and control exercise for large jet aircraft is performed in the Simulator. At the completion of this course the student will have a basic knowledge of the Type Certificate Requirements / Process, and the role maintenance and acceptance flight test plays in ensuring that aircraft performance, flying qualities, and systems meet the critical Type Certificate Requirements.

Subjects Covered

- Subsonic Aerodynamics
- Certification Process/Documentation
- Takeoff and Land/Takeoff Speed Development
- Integrated Avionics
- Introduction to Stability and Control (S&C)
- Aircraft Subsystems
- Aircraft Design/Modification Effects on S&C
- Mach Effects on S&C
- Introduction to Variable Stability Simulation
- Upset Recovery Theory
- Transonic Aerodynamics
- Acceptance Test Checklist
- Flight Management System
- Flight Controls
- Crew Resource Management
- Warning Systems
- Ground Acceptance Inspection
- PIO Theory
- Stalls and High Angle of Attack
- Asymmetric Flight
- Introduction to Acceptance Testing
- Navigation Systems
- Aeroelasticity and Flutter Hazards
- Safety In Flight Test

On-Demand Courses

Upset Training Course

This course familiarizes the pilot with what to expect under upset conditions. It is well suited to those who have not flown in aircraft that are cleared for inverted flight or that can depart controlled flight.

Formation / Low Level / Chase Training Course

This course introduces the pilot to the special requirements of these unique flight conditions. The course would be beneficial to any pilot whose job requires formation, low-level, or chase flight.

Spin Training Course

This course familiarizes the pilot with the unique environment of an aircraft in a classic spin. Upright and inverted spins are demonstrated and practiced with both pro-spin and anti-spin control inputs. Different recovery techniques are practiced and evaluated.

Crew Resource Management for Flight Testers - Initial (3 Days)

This three-day short course is designed to introduce Flight Test aircrew and control room members the coordination concepts and procedures, the necessary attitude which recognizes the importance of good aircrew coordination for effective mission accomplishment, and the skills to implement the crew coordination procedures.

Crew Resource Management for Flight Testers - Refresher (1 Day)

This one-day short course is designed to review Flight Test aircrew and control room members the coordination concepts and procedures, the necessary attitude which recognizes the importance of good aircrew coordination for effective mission accomplishment, and the skills to implement the crew coordination procedures.

Aviation Safety Course (3 Days)

This three-day course is an introduction to flight safety, which is designed for those persons who are involved in flight operations and have had little or no Flight Safety training

Space Operational Test & Evaluation Course (3 Weeks)

The three-week Space Operational Test & Evaluation Course teaches basic flight test principles, concepts, and processes of Operational Test and Evaluation (OT&E). The course consists of classroom lectures, academic activities, and flight, simulator, and ground test sorties. These sorties cover: basic flight test principles, processes, practices and concepts; demonstrations and project flights; flight simulation training to reinforce space and flight test techniques; and Crew Resource Management. A student Final Project is the course capstone to further reinforce classroom instruction, and to logically carry a space test scenario from requirements analysis to test planning to test conduct to data analysis to a final test report. During the Space final project exercise, the

students plan, flight test, collect and analyze the test data, and report on space system performance in meeting the stated user operational requirements/capabilities.

The Space Operational Test Course is designed to provide an understanding of how Space Testing fits into the acquisition process, the interrelationships between Space Developmental Test & Evaluation (DT&E) and OT&E, and those concepts and issues specific to Space OT&E Testing. The NTPS philosophy behind the Space OT&E course is to teach a repeatable test process and provide a fundamental knowledge and practical understanding of the key subjects.

Subjects Covered

- Test Planning, Execution, Data Analysis and Reporting of OT&E Test Strategies
- How Space DT&E and OT&E fits into weapon system acquisition and engineering processes
- Space DT&E and OT&E test processes and procedures
- Key differences between DT&E and OT&E requirements, planning, execution
- Overview of Space OT&E test theory and standard flight test techniques
- Emphasis on User and Operational Requirements development and analysis
- Conduct, procedures and techniques of OT&E testing
- All aspects of Space test planning, execution, analysis, and reporting (PEAR)
- All aspects of flight test planning and mission execution
- Emphasis on testing relative to the User's mission and mission tasks
- Tools for effective Space OT&E test planning
- Generic flight test processes, concepts and practices
- Test Planning, Execution, Data Analysis and Reporting of OT&E Test Strategies
- How Space DT&E and OT&E fits into weapon system acquisition and engineering processes
- Space DT&E and OT&E test processes and procedures
- Key differences between DT&E and OT&E requirements, planning, execution
- Overview of Space OT&E test theory and standard flight test techniques
- Emphasis on User and Operational Requirements development and analysis
- Conduct, procedures and techniques of OT&E testing
- All aspects of Space test planning, execution, analysis, and reporting (PEAR)
- All aspects of flight test planning and mission execution
- Emphasis on testing relative to the User's mission and mission tasks
- Tools for effective Space OT&E test planning
- Generic flight test processes, concepts and practices

Appendix C

Academic Outcomes Cross Reference Tables

In the following pages are the cross reference tables to map the NTPS module academic outcomes with the ABET required academic outcomes, how the academic outcomes map to the NTPS program educational objectives, and how the academic outcomes are assessed.

Table C-1. Course Learning Outcomes vs. Program/Student Learning Outcomes

Course Learning Outcomes	Program/Student Learning Outcomes										
	a. An ability to apply knowledge of mathematics, science, and engineering	b. An ability to design and conduct experiments, as well as to analyze and interpret data	c. An ability to design a system, component, or process to meet desired needs with realistic process to meet desired needs with realistic	d. An ability to function on multi-disciplinary teams	e. An ability to identify, formulate and solve engineering problems	f. An understanding of professional and ethical responsibility	g. An ability to communicate effectively	h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	i. A recognition of the need for and an ability to engage in life-long learning	j. A knowledge of contemporary issues	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
4001											
Understand the roles and responsibilities of a TP and FTE				X		X		X	X	X	
Understand the purpose of flight test and evaluation						X		X			
Understand human factors considerations	X	X	X	X	X	X				X	X
Understand basic statistical concepts	X	X			X						
Understand mission planning and how to write test cards		X		X							
Understand safety considerations		X					X				
Familiar with computer based data analysis tools	X					X			X	X	X
Familiar with techniques to conduct crew station evaluation		X									
Understand format and content of technical reports				X		X	X				
Understand the importance of crew resource management in T&E		X		X		X		X			
4002											
Understand requirements process		X	X		X	X	X	X		X	X

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Understand resource factors for T&E planning		X	X	X	X			X		X	X
Understand test management concepts			X		X	X		X		X	X
Understand role of M&S		X	X		X			X		X	X
Understand similarities and differences between OT&E and DT&E			X			X		X		X	X
Know how to develop COI/MOE/MOS/MOAs from user requirements	X	X	X	X	X		X	X		X	X
Familiar with budget tracking and the EVMS	X	X	X	X	X			X		X	X
4003											
Final project	X	X	X	X	X	X	X				X
4007											
Be familiar with Aircraft Control Systems	X	X	X		X	X			X	X	
Be familiar with Jet cruise	X	X	X	X		X	X	X			X
Be familiar with Mach effects on Stability and Control	X	X							X	X	
Be familiar with dimensional analysis	X	X							X	X	
Be familiar with drag polar	X	X		X	X	X		X			X
Be familiar with take-off and landings	X	X							X	X	
Be familiar with energy management	X	X							X	X	
Be familiar with subsonic aerodynamics	X	X							X	X	
Be familiar with closed loop handling qualities	X	X		X		X	X		X		X
Be familiar with aero-elasticity	X	X		X		X	X	X			X
Be familiar with standard atmosphere	X	X									
Be familiar with longitudinal non-linearities	X	X		X		X	X	X			X
Be familiar with light aircraft engine-out	X	X	X						X	X	
Be familiar with transonic aerodynamics	X	X							X	X	
Understand pitot-statics	X	X	X						X	X	
Understand propeller cruise	X	X		X	X	X	X	X			X
Understand Climb Performance	X	X		X		X	X	X			X
Understand Longitudinal Static Stability	X	X		X		X	X	X			X

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Understand Longitudinal Maneuvering Stability	x	x	x	x		x	x	x			x
Understand Lateral-Directional Static Stability	x	x	x	x	x	x	x	x			x
Understand Stalls	x	x		x		x	x	x			x
Understand Equations of Motion and Dynamics	x	x	x		x		x	x	x		
4008											
Be familiar with avionics flight test process, specifications and regulations	x				x						
Be familiar with areas to be considered in planning a mission and how to write test cards		x		x							
Be familiar with the format and content of technical reports, both written and oral				x		x	x				
Be familiar with risk management and safety considerations while planning and conducting a flight test program											x
Be familiar with human factors and workload evaluation	x		x								x
Be familiar with communications and navigation systems testing	x	x		x	x	x	x		x		x
Be familiar with data bus structure and TSPI	x		x								x
Be familiar with airborne radar testing		x		x	x	x	x	x	x	x	x
Be familiar with electro-optical and infrared systems testing		x		x	x	x	x	x	x	x	x
Be familiar with software development testing											x
Be familiar with Electromagnetic compatibility and interference	x	x	x	x	x	x	x		x		x
Understand the approach to safely and effectively execute ground and flight test of avionic systems	x	x		x	x	x	x		x		x

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Understand the techniques used to conduct a cockpit evaluation		x									
Understand the techniques for evaluating GNSS	x	x		x	x	x	x		x		x
Understand the techniques for evaluating systems for Required Navigation Performance (RNP) operations	x	x		x	x	x	x		x		x
Understand the techniques for evaluating workload	x		x								x
Understand the techniques for evaluating ground based NavAids	x	x	x	x	x	x	x	x	x		x
4017											
Be familiar with the standard atmosphere	x	x		x			x		x	x	x
Be familiar with the Height-Velocity diagram	x	x		x	x	x			x	x	x
Be familiar with takeoff and landing performance	x	x		x	x				x	x	x
Be familiar with rotor systems	x	x		x					x	x	x
Be familiar with flight control mechanical characteristics	x	x		x	x				x	x	x
Be familiar with CLHQ	x	x		x	x				x	x	x
Be familiar with low airspeed characteristics	x	x			x				x	x	x
Be familiar with AFCS	x	x		x	x				x	x	x
Understand pitot-static theory	x	x	x	x	x				x	x	x
Understand engine performance and assessment	x	x	x	x		x	x		x	x	x
Understand hover performance	x	x	x	x	x				x	x	x
Understand level flight performance	x	x	x	x	x				x	x	x
Understand Climbs & Descent Performance	x	x	x	x	x				x	x	x
Understand longitudinal static stability	x	x	x	x	x				x	x	x
Understand lateral-directional static stability	x	x	x	x	x				x	x	x
Understand longitudinal dynamic stability	x	x	x	x	x				x	x	x

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Understand lateral-directional dynamic stability	x	x	x	x	x				x	x	x
4101											
Familiar with dimensional analysis	x	x							x	x	
Familiar with subsonic aero principles	x	x							x	x	
Understand pitot static theory and PEC requirements	x	x	x						x	x	
Understand reciprocating engine and propeller theory	x	x	x						x	x	
Understand T/O and landing theory and requirements	x	x							x	x	
Understand standard atmosphere	x	x									
Know how to develop drag polar	x	x		x	x	x		x			x
Know how to measure and evaluate PEC	x	x	x	x	x	x	x	x			x
Know how to T&E cruise performance - prop aircraft	x	x		x	x	x	x	x			x
Know how to T&E T/O and landing performance	x	x		x	x	x	x	x			x
Know how to measure weight and C.G. of an aircraft	x	x		x	x	x	x	x			x
4102											
Familiar with transonic aerodynamics	x	x							x	x	
Familiar with supersonic aerodynamics	x	x							x	x	
Understand energy management concepts	x	x							x	x	
Understand turbine engine theory and test procedures	x	x	x		x	x			x	x	
Understand prediction and optimization of cruise performance	x	x	x	x	x	x	x	x			x
Understand advanced performance gathering techniques.	x	x	x			x					
Know climb performance theory and test methods	x	x		x		x	x	x			x
Know turn performance theory and test methods	x	x		x		x	x	x			x

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Know stall performance theory and test methods	x	x		x		x	x	x			x
Know how to T&E jet cruise performance	x	x	x	x		x	x	x			x
4103											
Familiar with aircraft trim systems	x	x							x	x	
Familiar with Mach effects on S&C	x	x							x	x	
Understand mechanical flight control systems	x	x	x		x	x			x	x	
Understand S&C regulatory requirements	x	x							x	x	
Understand flying qualities evaluation	x	x	x			x					
Understand how to determine engine out capability of an aircraft	x	x		x		x	x	x			x
Know how to determine longitudinal static stability of an aircraft	x	x		x		x	x	x			x
Know how to determine maneuvering stability of an aircraft	x	x	x	x		x	x	x			x
Know how to determine lat-dir static stability of an aircraft	x	x	x	x	x	x	x	x			x
Know how to determine flight path stability	x	x	x	x	x	x	x	x			x
4104											
Familiar with motion analysis and EOM	x	x	x		x		x	x	x		
Familiar with aircraft coupling	x	x	x		x		x		x		
Understand aircraft dynamics theory	x	x	x		x		x	x	x		
Understand regulatory dynamics requirements	x	x	x		x	x	x		x	x	x
Understand stall and spin requirements	x	x	x		x	x	x		x	x	x
Know spin theory and FTT's	x	x	x	x	x	x	x		x		x
Know how to determine stall characteristics	x	x	x	x		x	x		x		x
Know CLHQ testing	x	x		x		x	x		x		x
Know dynamics FTTs	x	x		x		x	x		x		x
4107											
Be familiar with icing regulations and FAA / EASA guidance materials	x					x	x	x	x	x	x

Course Learning Outcomes	Program/Student Learning Outcomes										
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.
Be familiar with icing Certification procedures and processes	x					x	x	x	x	x	x
Be familiar with 14 CFR Part 25 and 29 / CS 25 and 29 Icing Envelopes and the need and methods for converting them to other exposure distances	x	x				x	x	x	x	x	x
Understand the unique problems associated with airframe icing	x				x	x	x	x	x	x	x
Understand icing cloud formation	x	x				x	x	x	x	x	x
Understand data collection, reading, and data analysis procedures	x	x		x	x						x
Understand icing test principles and the reasons for dry air, simulated ice accretions and natural icing tests		x		x	x	x					x
Understand the requirement for measuring icing cloud parameters		x		x	x						x
4111											
Familiar with standard atmosphere and the associated tables	x	x				x	x	x	x	x	x
Familiar with the non-uniform induced velocity theory	x	x				x	x	x	x	x	x
Familiar with definitions of disk loading, power loading, solidity ratio and FM	x	x				x	x	x	x	x	x
Understand the fundamentals of dimensional analysis	x	x			x			x	x	x	x
Understand subsonic aerodynamics principles	x	x			x			x	x	x	x
Understand pitot static principles and PEC requirements	x	x	x		x			x	x	x	x
Understand momentum theory and blade element theory	x	x			x			x	x	x	x
Understand how to determine engine characteristics	x	x	x		x			x	x	x	x

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Understand how power required to hover and VC is affected by helicopter parameters and atmospheric properties.	x	x	x		x		x	x		x	x
Know how Coefficient of Power and Coefficient of Thrust are used for determining hover ceiling.	x	x	x		x	x					x
Know how to measure and evaluate pitot static position errors	x	x	x	x		x	x				x
Know how to test and evaluate hover performance of rotary wing aircraft	x	x	x	x	x	x	x				x
Know how to evaluate turbine engine performance	x	x	x	x		x	x				x
Know how to measure the weight and center of gravity of an aircraft	x	x	x	x	x	x	x				x
4112											
Understand transonic aerodynamics principles	x	x						x	x	x	x
Understand autorotational descent performance	x	x			x			x	x	x	x
Familiar with FADEC testing	x	x	x			x	x	x	x	x	x
Know climb and descent performance theory and test methods	x	x	x	x	x	x	x				x
Know take-off/landing performance theory and test methods	x	x	x	x	x	x	x				x
Know height-velocity theory and test methods	x	x	x	x	x	x	x				x
Know level flight performance theory and test methods	x	x	x	x	x	x	x				x
Know how to predict significant airspeeds from level performance data	x	x	x	x	x	x	x				x
Know the effects of engine failure	x	x	x	x	x	x	x				x
4113											
Understand mechanical flight control systems	x	x			x			x	x	x	x
Understand fundamentals of EOM	x	x					x	x	x	x	x

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Understand helicopter trim systems	x	x			x			x	x	x	x
Understand closed loop handling qualities	x	x	x					x	x	x	x
Understand the applicable Mil and CFR/CS regulatory requirements	x	x				x	x	x	x	x	x
Understand rotor characteristics	x	x						x	x	x	x
Know how to determine the critical azimuth in the low airspeed envelope	x	x	x	x		x	x				x
Know how to determine the longitudinal static stability using appropriate FTT	x	x	x	x	x	x	x				x
Know how to determine maneuvering stability using appropriate FTT	x	x	x	x	x	x	x				x
Know how to determine lateral-directional static stability using appropriate FTT	x	x	x	x	x	x	x				x
4114											
Understand fundamentals of helicopter motion analysis	x	x					x	x	x	x	x
Understand the regulatory requirements pertaining to helicopter dynamics	x	x	x			x		x	x	x	x
Familiar with AFCS flight testing	x	x	x	x			x	x	x	x	x
Understand ADS-33 closed loop handling qualities testing and techniques	x	x	x	x		x	x		x	x	x
Know the FTT to quantitatively and qualitatively determine helicopter dynamics	x	x	x	x	x	x	x				x
Understand rotary wing control and gust response	x	x			x	x	x		x	x	x
Familiar with MATLAB applications	x	x	x		x		x		x		x
4105											
Familiar with block diagrams concepts	x	x		x	x		x		x	x	x
Familiar with the generic structure of a control system	x	x		x	x		x		x	x	x
Familiar with the poles and zeros formalism	x	x		x	x		x		x	x	x

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Familiar with application of Pre-Filters	x	x		x	x		x		x	x	x
Familiar with the response feedback technique for stability augmentation	x	x		x	x		x		x	x	x
Familiar with effects of common aircraft parameters on stability	x	x		x	x		x		x	x	x
Familiar with dynamic inversion concept	x	x		x	x		x		x	x	x
Familiar with general design criteria	x	x		x	x		x		x	x	x
Understand the relationship between poles location and dynamic stability	x	x	x	x			x		x	x	x
Understand the relationship between transfer function and frequency response	x	x	x	x			x		x	x	x
Understand the meaning of gain and phase margins	x	x	x	x			x		x	x	x
Understand the approach of flight testing an augmented aircraft	x	x	x	x			x		x	x	x
How to apply Laplace in EOM solution	x	x	x	x	x		x		x	x	x
Know to construct and interpret Bode plots	x	x	x	x	x		x		x	x	x
Know to implement RL analysis to assess CL stability of a system	x	x	x	x	x		x		x	x	x
Know how to use software to solve for basic stability augmentation problems	x	x	x	x	x		x		x	x	x
4106											
Understand properties of aircraft materials	x	x	x		x						x
Understand how to perform basic structural aircraft analysis	x	x	x		x						x
Understand structural loads and flutter ground test methods	x	x	x		x						x
Familiar with aero-elastic effects on aircraft	x	x	x		x						x
Know FTTs needed to determine aircraft flight loads		x		x			x				x
Know FTTs needed to demonstrate aircraft is flutter free		x		x			x				x

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Know the theory and methods to clear stores for carriage	x	x	x		x	x		x			x
Know the theory and methods to clear stores for separation	x	x	x		x	x		x			x
4116											
Familiar with properties of material used in RW aircraft structures	x	x	x		x		x				
Familiar with Flight Test Instrumentations (FTI) used for RW aircraft loads and vibration testing		x	x		x				x	x	x
Familiar with the basic concepts and methods to alleviate inherent vibrations in RW aircraft	x	x	x		x		x		x	x	
Familiar with the regulatory requirements pertaining to RW aircraft vibration levels.	x	x	x		x	x	x			x	x
Understand the principal of operation of a strain-gauge	x	x	x	x	x				x		x
Understand the method of transforming in-plane stresses & strains	x	x	x	x	x		x			x	x
Understand the mechanism that governs the manifestation of main & tail rotor alternating loads as discrete fuselage vibrations.	x	x	x	x	x		x		x	x	x
Know the FTT used to conduct a RW aircraft vibration survey		x		x	x	x	x	x	x	x	x
Know the practicality of decomposing a time-based measured signal into its frequency content using a FFT algorithm in MATLAB	x	x	x	x	x		x		x	x	x
4201											
Understand the unique problems associated with Avionics Testing	x		x								x
Basic knowledge of the 1553 data bus architectures	x		x								x

Course Learning Outcomes	Program/Student Learning Outcomes										
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.
Understand other types of Data Busses (ARINC,CAN,TCP/IP,AFDX)	x		x								x
Know Workload data collection, and data analysis procedures	x	x	x	x							x
Understand software test and configuration management principles											x
Familiar with avionic systems data bus specifications and regulations (1553B, ARINC,CAN,TCP/IP,AFDX)											x
Know workload evaluation on avionic systems	x		x								x
Familiar with Cyber security impact on avionics flight testing	x		x					x			x
Familiar with Electrical, Electromagnetics and logic circuits as they relate to Avionics testing											x
4202											
Understand the approach to safely and effectively execute ground and flight test of communication and navigation systems	X	X		X	X	X	X		X		X
Understand the fundamentals behind GNSS and GNSS Augmentation Systems			X					X	X	X	
Understand the techniques for evaluating GNSS	X	X		X	X	X	X		X		X
Understand the techniques for evaluating systems for Required Navigation Performance (RNP) operations	X	X		X	X	X	X		X		X
Understand the technique for evaluating and Integrated Navigation Systems	X	X		X	X	X	X		X		X
Be familiar with the techniques for evaluating radio communications intelligibility	X	X		X	X	X	X		X		X
Be familiar with the fundamentals and technique for evaluating EMI/EMC	X	X	X	X	X	X	X		X		X

Course Learning Outcomes	Program/Student Learning Outcomes										
a. An ability to apply knowledge of mathematics, science, and engineering	b. An ability to design and conduct experiments, as well as to analyze and interpret data	c. An ability to design a system, component, or process to meet desired needs with realistic process to meet desired needs with realistic	d. An ability to function on multi-disciplinary teams	e. An ability to identify, formulate and solve engineering problems	f. An understanding of professional and ethical responsibility	g. An ability to communicate effectively	h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	i. A recognition of the need for and an ability to engage in life-long learning	j. A knowledge of contemporary issues	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	
Be familiar with the fundamentals and technique for evaluating ground based NavAids	X	X	X	X	X	X	X	X		X	
Be familiar with the fundamentals of Inertial Navigation Systems	X		X					X			
Be familiar with the fundamentals of Integrated Navigation Systems	X		X					X			
Be familiar with the fundamentals of Data Link Communications and Tactical Datalinks	X		X				X	X			
Be familiar with the fundamentals of IFF and ADS-B	X		X				X	X			
4203											
Understand civil cert process	x				x						
Understand CFR/EASA CS requirements	x				x						
Familiar with type certification process	x				x						
Familiar with complex systems and their unique requirements	x				x						
Familiar with human factors impact on avionics systems	x	x	x		x						
Familiar with techniques for evaluating cockpit controls and displays		x		x	x	x	x	x	x	x	
Familiar with FMS and the impact on cockpit automation		x	x	x	x					x	
Familiar with evaluation of automatic autopilots and flight directors		x	x	x	x	x	x	x	x	x	
Familiar with civil certification of GPS		x		x	x	x	x	x	x	x	
Familiar with design and test of proximity systems		x		x	x	x	x	x	x	x	
Familiar with requirements and methods for RVSM		x	x	x	x	x	x	x	x	x	
4204											
Understand theory, FTTs and data analysis for RADAR and EW	x				x						

Course Learning Outcomes	Program/Student Learning Outcomes										
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.
Familiar with basic RADAR and EW fundamentals	x		x		x						
Familiar with millimeter-wave RADAR	x	x		x	x						x
Familiar with RADAR modes of operation			x		x						x
Understand RADAR and EW test methods		x			x	x	x	x	x	x	x
Understand RADAR and EW test considerations		x			x	x	x	x	x	x	x
4205											
Understand the fundamental differences in ground/flight testing of a UAV versus a manned aircraft										X	X
Understand the requirements and technique for assessing human factors on UAV Ground Control Stations (GCS)										X	X
Understand the fundamentals behind UAV data link communications	X										X
Understand the primary modes employed for controlling an UAV to include RPV and CDV operations	X										X
Understand the concept of sense and avoid systems and their importance to UAV operations										X	X
Understand the current state of Airworthiness Requirements (Civil and Military) for UAVs										X	X
Familiar with the techniques and data analysis for an UAV data link ground/flight test		X	X		X		X				X
Familiar with the techniques for an UAV autopilot functionality and limit protection flight test		X		X	X		X				X

Course Learning Outcomes	Program/Student Learning Outcomes										
	a. An ability to apply knowledge of mathematics, science, and engineering	b. An ability to design and conduct experiments, as well as to analyze and interpret data	c. An ability to design a system, component, or process to meet desired needs with realistic process to meet desired needs with realistic	d. An ability to function on multi-disciplinary teams	e. An ability to identify, formulate and solve engineering problems	f. An understanding of professional and ethical responsibility	g. An ability to communicate effectively	h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	i. A recognition of the need for and an ability to engage in life-long learning	j. A knowledge of contemporary issues	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
Familiar with the development of a structured test plan/cards for an UAV ground/flight test		X	X	X	X		X				X
Familiar with the fundamentals of safety planning and risk mitigation for UAV ground/flight test		X	X	X	X		X				X
Familiar with the approach to safely and effectively executing an UAV flight test sortie		X		X	X		X				X
4206											
Understand stores management systems	x		x		X						
Understand error budgets	x			x	x						x
Understand weapons accuracy analysis	x		x	x	x	x	x	x	x	x	x
Understand specific air-to-air weapons evaluations		x		x	x	x	x	x	x	x	x
Understand specific air-to-ground weapons evaluations		x		x	x	x	x	x	x	x	x
Understand safety footprints and hazard analysis	x	x			x	x	x	x	x	x	
Familiar with Mil-Std-1760D/E	x	x	x		x						
Familiar with weapons to aircraft interface		x	x	x	x						x
4207											
Understand theory, FTTs and data analysis for EO systems	x	x			x						
Understand atmospheric propagation	x		x		x						
Understand target signatures	x		x		x						
Understand sources of radiation	x		x		x						
Understand spatial frequency and range predictions	x		x	x	x						x
Understand EO and IR test techniques		x		x	x	x	x	x	x	x	x
Understand lasers and laser range finders				x	x						x
Familiar with history of EO and IR systems				x	x						x

Course Learning Outcomes	Program/Student Learning Outcomes										
4208	a. An ability to apply knowledge of mathematics, science, and engineering	b. An ability to design and conduct experiments, as well as to analyze and interpret data	c. An ability to design a system, component, or process to meet desired needs with realistic process to meet desired needs with realistic	d. An ability to function on multi-disciplinary teams	e. An ability to identify, formulate and solve engineering problems	f. An understanding of professional and ethical responsibility	g. An ability to communicate effectively	h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	i. A recognition of the need for and an ability to engage in life-long learning	j. A knowledge of contemporary issues	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
Understand NVG design and human factors principles			x	x	x						x
Understand human factors in HMD design	x		x		x						
Understand approaches to HMD design	x		x		x					x	
Understand night vision image intensification.				x	x						x
Understand NVG compatible interior and exterior lighting		x		x	x	x	x	x	x	x	x
Understand HMD aircraft integration issues		x		x	x	x	x	x	x	x	x
Understand NVIS aircraft integration	x				x						
Familiar with NVG lighting specifications	x		x	x	x						x
Familiar with variations in HMD designs		x	x	x	x						x
Understand HMD ground and flight test procedures	x	x		x	x					x	x

Table C-2. Program/Student Learning Outcomes vs. Program Learning Objectives

Program/Student Learning Outcomes	Program Learning Objectives				
	1. Demonstrate increasingly highly specialized skills required to execute safety critical tests in flight and in the control room.	2. Successfully integrate the roles of a Test Pilot and Flight Test Engineer throughout the aircraft/system design, development, and testing process.	3. Validate the airworthiness and mission capability of an air vehicle and/or system.	4. Attain positions with increasing responsibilities in managing developmental flight test projects.	5. Advance the flight test and evaluation discipline through reports, professional papers, journal articles, and/or symposia presentations.
a. An ability to apply knowledge of mathematics, science, and engineering	X				
b. An ability to design and conduct experiments, as well as to analyze and interpret data	X		X		
c. An ability to design a system, component, or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	X				
d. An ability to function on multi-disciplinary teams	X	X		X	
e. An ability to identify, formulate and solve engineering problems	X	X	X		
f. An understanding of professional and ethical responsibility		X		X	X
g. An ability to communicate effectively	X			X	X
h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context		X	X		
i. A recognition of the need for and an ability to engage in life-long learning					X
j. A knowledge of contemporary issues	X		X		X
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	X		X		

Table C-3. Course Learning Outcomes vs. Assessment Method

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
4001						
Understand the roles and responsibilities of a TP and FTE						X
Understand the purpose of flight test and evaluation						X
Understand human factors considerations					X	
Understand basic statistical concepts	X					
Understand mission planning and how to write test cards						X
Understand safety considerations						X
Familiar with computer-based data analysis.						X
Familiar with techniques to conduct crew station evaluation					X	
Understand format and content of technical reports					X	
Understand the importance of crew resource management in T&E						X
4002						
Understand requirements process				X		
Understand resource factors for T&E planning						X
Understand test management concepts						X
Understand similarities and differences between OT&E and DT&E						X
Understand the purpose of RML&A tests				X		
Know how to develop COI/MOE/MOS/MOAs from user requirements				X		
Familiar with budget tracking and the EVMS						X
4003						
Final project				X	X	
4007						
Be familiar with Aircraft Control Systems						X
Be familiar with Jet cruise						X
Be familiar with Mach effects on Stability and Control						X
Be familiar with dimensional analysis						X
Be familiar with drag polar						X
Be familiar with take-off and landings						X
Be familiar with energy management						X
Be familiar with subsonic aerodynamics						X
Be familiar with closed loop handling qualities						X
Be familiar with aero-elasticity						X
Be familiar with standard atmosphere						X
Be familiar with longitudinal non-linearity's						X
Be familiar with light aircraft engine-out						X
Be familiar with transonic aerodynamics						X
Understand pitot-statics		X				
Understand propeller cruise						X

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Understand climb performance		X				
Understand Longitudinal Static Stability		X				
Understand Longitudinal Maneuvering Stability		X				
Understand Lateral-Directional Static Stability		X				
Understand Stalls		X				
Understand Equations of Motion and Dynamics						X
4008						
Be familiar with avionics flight test process, specifications and regulations		X				
Be familiar with areas to be considered in planning a mission and how to write test cards		X				
Be familiar with the format and content of technical reports, both written and oral		X				
Be familiar with risk management and safety considerations while planning and conducting a flight test program		X				
Be familiar with human factors and workload evaluation		X				
Be familiar with communications and navigation systems testing		X				
Be familiar with data bus structure and TSPI						X
Be familiar with airborne radar testing						X
Be familiar with electro-optical and infrared systems testing						X
Be familiar with software development testing						X
Be familiar with Electromagnetic compatibility and interference						X
Understand the approach to safely and effectively execute ground and flight test of avionic systems		X				
Understand the techniques used to conduct a cockpit evaluation		X				
Understand the techniques for evaluating GNSS		X				
Understand the techniques for evaluating systems for Required Navigation Performance (RNP) operations		X				
Understand the techniques for evaluating workload		X				
Understand the techniques for evaluating ground based NavAids		X				
4017						
Be familiar with the Standard Atmosphere						X
Be familiar with various types of Rotor Systems						X
Be familiar with Low Airspeed Characteristics						X
Be familiar with the Height-Velocity Diagram						X
Be familiar with Takeoff and Landing Performance						X
Be familiar with Flight Control Mechanical Characteristics						X
Be familiar with Closed Loop Handling Qualities (CLHQ)						X

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Be familiar with Low Airspeed Handling Characteristics						X
Be familiar with Automatic Flight Control System (AFCS) Testing						X
Understand Pitot-Static Theory				X		
Understand Engine Performance and Assessment				X		
Understand Hover Performance				X		
Understand Level Flight Performance				X		
Understand Forward Flight Climb and Autorotational Descent Performance				X		
Understand Longitudinal and Lateral-Directional Static Stability				X		
Understand Longitudinal and Lateral-Directional Dynamic Stability				X		
Understand level flight performance		X				
Understand climb/descent performance		X				
4101						
Familiar with dimensional analysis						X
Familiar with subsonic aero principles	X	X				
Understand pitot static theory and PEC requirements	X	X				
Understand reciprocating engine and propeller theory						X
Understand T/O and landing theory and requirements						X
Understand standard atmosphere	X	X				X
Know how to develop drag polar	X	X				
Know how to measure and evaluate PEC	X	X	X	X	X	
Know how to T&E cruise performance - prop aircraft	X	X	X	X	X	
Know how to T&E T/O and landing performance			X	X	X	
Know how to measure weight and C.G. of an aircraft						X
4102						
Familiar with transonic aerodynamics						X
Familiar with supersonic aerodynamics	X					
Understand energy management concepts	X					
Understand turbine engine theory and test procedure	X	X				
Understand prediction and optimization of cruise performance	X	X				
Understand advanced performance gathering techniques						X
Know climb performance theory and test methods	X		X	X	X	
Know turn performance theory and test methods	X		X	X	X	
Know stall performance theory and test methods			X	X	X	
Know how to T&E jet cruise performance	X		X	X	X	
4103						
Familiar with aircraft trim systems		X				
Familiar with Mach effects on S&C		X				
Understand mechanical flight control systems		X				

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Understand S&C regulatory requirements	X					
Understand flying qualities evaluation	X					
Know how to determine engine out capability	X					
Know how to determine longitudinal static stability	X		X	X	X	
Know how to determine maneuvering stability	X		X	X	X	
Know how to determine lat-dir stability	X		X	X	X	
Know how to determine flight path stability	X		X	X	X	
4104						
Familiar with motion analysis and EOM	X					
Understand aircraft dynamics theory	X					
Understand regulatory dynamics requirements	X		X	X	X	
Familiar with aircraft coupling						X
Know spin theory and FTTs	X					
Understand stall and spin requirements	X		X	X	X	
Know CLHQ testing	X	X				
Know how to determine stall characteristics	X					
Know dynamics FTTs	X		X	X	X	
4107						
Be familiar with icing regulations and FAA / EASA guidance materials	X					
Be familiar with icing Certification procedures and processes	X					
Be familiar with 14 CFR Part 25 and 29 / CS 25 and 29 Icing Envelopes and the need and methods for converting them to other exposure distances	X					
Understand the unique problems associated with airframe icing	X					
Understand icing cloud formation	X					
Understand data collection, reading, and data analysis procedures					X	
Understand icing test principles and the reasons for dry air, simulated ice accretions and natural icing tests	X				X	
Understand the requirement for measuring icing cloud parameters	X					
4111						
Familiar with standard atmosphere and the associated tables	X	X				
Familiar with the non-uniform induced velocity theory	X	X				
Familiar with definitions of disk loading, power loading, solidity ratio and FM	X	X		X	X	
Understand the fundamentals of dimensional analysis	X	X				
Understand subsonic aerodynamics principles	X	X				
Understand pitot static principles and PEC requirements	X	X		X	X	
Understand momentum theory and blade element theory	X	X		X	X	

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Understand how to determine engine characteristics	X	X		X	X	
Understand how power required to hover and VC is affected by helicopter parameters and atmospheric properties.	X	X				
Know how Coefficient of Power and Coefficient of Thrust are used for determining hover ceiling.	X	X		X	X	
Know how to measure and evaluate pitot static position errors	X	X		X	X	
Know how to test and evaluate hover performance of rotary wing aircraft	X	X		X	X	
Know how to evaluate turbine engine performance	X	X		X	X	
Know how to measure the weight and center of gravity of an aircraft	X	X				
4112						
Understand transonic aerodynamics principles	X	X				
Understand autorotational descent performance	X	X		X	X	
Familiar with FADEC testing		X				X
Know climb and descent performance theory and test methods	X	X		X	X	
Know take-off/landing performance theory and test methods	X	X		X	X	
Know height-velocity theory and test methods	X	X		X	X	
Know level flight performance theory and test methods	X	X		X	X	
Know how to predict significant airspeeds from performance data	X	X		X	X	
Know effects of engine failure	X	X				
4113						
Understand mechanical flight control systems	X	X		X	X	
Understand fundamentals of EOM	X	X				
Understand helicopter trim systems	X					
Understand closed loop handling qualities	X		X	X	X	
Understand the applicable Mil and FAR regulatory requirements	X	X				
Understand rotor system characteristics	X	X				
Know how to determine the critical azimuth in the low airspeed envelope	X	X		X	X	
Know how to determine the longitudinal static stability using appropriate FTT	X	X		X	X	
Know how to determine maneuvering stability using appropriate FTT	X	X		X	X	
Know how to determine lateral-directional static stability using appropriate FTT	X	X		X	X	
4114						
Understand fundamentals of helicopter motion analysis	X	X				
Understand helicopter dynamics theory	X	X				

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Understand the regulatory requirements pertaining to helicopter dynamics	X	X		X	X	
Familiar with AFCS flight testing		X				
Understand ADS-33 closed loop handling qualities testing and techniques		X				
Know the FTT to quantitatively and qualitatively determine aircraft dynamics		X	X			
Understand rotary wing control and gust response	X			X		
Familiar with Data analysis software applications	X					
4105						
Familiar with block diagrams concepts	X					
Familiar with the generic structure of a control system	X					
Familiar with the poles and zeros formalism	X					
Familiar with application of Pre-Filters	X					
Familiar with the response feedback technique for stability augmentation	X					
Familiar with effects of common aircraft parameters on stability	X					
Familiar with dynamic inversion concept	X					
Familiar with general design criteria	X					
Understand the relationship between poles location and dynamic stability	X					
Understand the relationship between transfer function and frequency response	X					
Understand the meaning of gain and phase margins	X					
Understand the approach of flight testing an augmented aircraft	X					
How to apply Laplace in EOM solution	X					
Know to construct and interpret Bode plots	X					
Know to implement RL analysis to assess CL stability of a system	X					
Know how to use MATLAB to solve for basic stability augmentation problems	X					
4106						
Understand properties of aircraft materials	X					
Understand how to perform basic structural aircraft analysis	X					
Understand structural loads and flutter ground test methods	X		X	X	X	
Familiar with aero-elastic effects on aircraft	X		X	X	X	
Know FTTs needed to determine aircraft flight loads	X		X	X	X	
Know FTTs needed to demonstrate aircraft is flutter free	X		X	X	X	
Know the theory and methods to clear stores for carriage	X					

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Know the theory and methods to clear stores for separation	X					
4116						
Familiar with properties of material used in RW aircraft structures	X	X		X		
Familiar with FTI used for RW aircraft loads and vibration testing	X	X		X	X	
Familiar with the basic concepts and methods to alleviate inherent vibrations in RW aircraft	X	X		X	X	
Familiar with the regulatory requirements pertaining to RW aircraft vibration levels	X	X		X	X	
Understand the principal of operation of a strain-gauge	X	X		X	X	
Understand the method of transforming in-plane stresses and strains	X	X				
Understand the mechanism the governs the manifestation of main & tail rotor alternating loads as discrete fuselage vibrations.	X	X	X	X	X	
Know the FTT used to conduct a RW aircraft vibration survey	X	X	X	X	X	
Know the practicality of decomposing a time-based measured signal into its frequency content using a FFT algorithm in MATLAB				X	X	
4201						
Know workload evaluation on avionic systems	X					
Know workload data collection and date analysis on avionic systems	X					
Know MIL-STD-1553B data bus architecture	X					
Understand software test and configuration management principles.	X					
Understand unique problems associated with Avionics Testing	X					
Understand other types of data busses (ARINC,CAN,TCP/IP,AFDX)	X					
Familiar with Electrical, Electromagnetics and logic circuits as they relate to avionics flight testing	X					
Familiar with Cyber security impacts on avionics flight testing	X					
Familiar with avionics system databus specifications and regulations (1553B,ARINC,CAN,TCP/IP,AFDX)	X					
4202						
Know the techniques for evaluating radio communication intelligibility	X					
Know the technique for evaluating GNSS as installed on an aircraft	X					
Know the technique for evaluating systems for Required Navigation Performance (RNP) operations	X					

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Know the technique for evaluating ground based NavAids	X					
Understand the fundamentals behind GNSS and GNSS augmentation systems	X					
Be familiar with the fundamentals of Antennas	X					
Be familiar with the fundamentals of EMI/EMC	X					
Be familiar with the fundamentals of Inertial Navigation Systems	X					
Be familiar with the fundamentals of Integrated Navigation Systems	X					
Be familiar with the fundamentals of Data Link Communications and Tactical Datalinks	X					
Be familiar with the fundamentals of Transponders and ADS-B	X					
4203						
Understand civil cert process	X					
Understand CFR/EASA CS requirements	X					
Familiar with type certification process	X					
Familiar with complex systems and their unique requirements	X					
Familiar with human factors impact on avionics systems	X					
Familiar with techniques for evaluating cockpit controls and displays	X					
Familiar with FMS and the impact on cockpit automation	X					
Familiar with evaluation of automatic autopilots and flight directors	X					
Familiar with civil certification of GPS	X					
Familiar with design and test of proximity systems	X					
Familiar with requirements and methods for RVSM	X					
4204						
Understand theory, FTTs and data analysis for RADAR and EW	X					
Familiar with basic RADAR and EW fundamentals	X					
Familiar with millimetric wave RADAR	X					
Familiar with RADAR modes of operation	X					
Understand RADAR and EW test methods	X					
Understand RADAR and EW test considerations	X					
4205						
Understand the fundamental differences in ground/flight testing of an UAV versus a manned aircraft	X					
Understand the requirements and technique for assessing human factors on UAV Ground Control Stations (GCS)	X			X		
Understand the fundamentals behind UAV data link communications	X					

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Understand the primary modes employed for controlling an UAV to include RPV and CDV operations	X					
Understand the concept of sense and avoid systems and their importance to UAV operations	X					
Understand the current state of Airworthiness Requirements (Civil and Military) for UAVs	X					
Familiar with the techniques and data analysis for an UAV data link ground/flight test				X		
Familiar with the techniques for an UAV autopilot functionality and limit protection flight test				X		
Familiar with the development of a structured test plan/cards for an UAV ground/flight test				X		
Familiar with the fundamentals of safety planning and risk mitigation for UAV ground/flight test				X		
Familiar with the approach to safely and effectively executing an UAV flight test sortie				X		
4206						
Understand stores management systems	X					
Understand error budgets	X					
Understand weapons accuracy analysis	X					
Understand specific air-to-air weapons evaluations	X					
Understand specific air-to-ground weapons evaluations	X					
Understand safety footprints and hazard analysis	X					
Familiar with Mil-Std-1760D/E	X					
Familiar with weapons to aircraft interface	X					
4207						
Understand theory, FTTs and data analysis for EO systems	X					
Understand atmospheric propagation	X					
Understand target signatures	X					
Understand sources of radiation	X					
Understand spatial frequency and range predictions	X					
Understand EO and IR test techniques	X					
Understand lasers and laser range finders	X					
Familiar with history of EO and IR systems	X					
4208						
Understand NVG design and human factors principles	X		X	X		
Understand human factors in HMD design	X					
Understand approaches to HMD design	X					
Understand night vision image intensification.	X		X	X		
Understand NVG compatible interior and exterior lighting	X		X	X		
Understand HMD aircraft integration issues	X		X	X		
Understand NVIS aircraft integration	X		X	X		

Course Learning Outcomes	Assessment Method					
	a. Written Examination	b. Oral Examination	c. Graded Flight	d. Oral Presentation	e. Written Report	f. Pass/Fail (No Assessment)
Familiar with NVG lighting specifications	X		X	X		
Familiar with variations in HMD designs	X					
Understand HMD ground and flight test procedures	X		X	X		

Appendix D

Course Coordinator List

Professional Course	
Module	Name
<i>Core Modules</i>	
T&E 4001 – Fundamental of Flight Test	Jeremy Sequeira
T&E 4002 – Test Management and Operational Test and Evaluation	John Norton
T&E 4003 – Capstone Project	Jason Paquin
<i>Performance & Flying Qualities Modules</i>	
T&E 4007 – Introduction to Fixed Wing P&FQ Flight Testing	Matteo Brambilla
T&E 4017 – Introduction to Rotary Wing P&FQ Flight Testing	Andrea Pingitore
T&E 4101 – FW Performance Flight Testing I	Adam Francki
T&E 4102 – FW Performance Flight Testing II	Jason Paquin
T&E 4103 – FW Flying Qualities Flight Testing I	Adam Francki
T&E 4104 – FW Flying Qualities Flight Testing II	Jason Paquin
T&E 4105 – Modern Flight Control Systems	Ilan Arush
T&E 4106 – FW Loads, Flutter & Stores Certification	Jason Paquin
T&E 4107 – Civil Aircraft Icing Certification	Fabian Machado
T&E 4111 – RW Performance Flight Testing I	Ilan Arush
T&E 4112 – RW Performance Flight Testing II	Ilan Arush
T&E 4113 – RW Flying Qualities Flight Testing I	Ilan Arush
T&E 4114 – RW Flying Qualities Flight Testing II	Ilan Arush
T&E 4116 – RW Loads & Vibrations	Ilan Arush
<i>Systems Modules</i>	
T&E 4008 – Introduction to Systems Testing	Bruce Wilder
T&E 4201 – Avionics Systems Flight Testing	Bruce Wilder
T&E 4202 – Communications, Navigation and GNSS Flight Testing	Jeremy Sequeira
T&E 4203 – Part 23/25/27/29 Avionics Certification Flight Testing	Adam Francki
T&E 4204 – Flight Test of RADAR and EW Systems	Bruce Wilder
T&E 4205 – UAV Systems Test	Jeremy Sequeira
T&E 4206 – Air-to-Air and Air-to-Ground Weapon Integration	Bruce Wilder
T&E 4207 – Electro-Optics and Infrared Systems Flight Testing	Jason Paquin
T&E 4208 – Helmet Mounted Displays & NVG Testing	Andrea Pingitore

Short Courses

FAA Civil Flight Test Certification and Standardization	Fabian Machado
Mathematics/Physics Pre-TPS	Juan Rodriguez
Introduction to Fixed Wing P&FQ Flight Testing	Matteo Brambilla
Introduction to Rotary Wing P&FQ Flight Testing	Andrea Pingitore
Introduction to Systems Testing	Bruce Wilder
Operational Test and Evaluation (OT&E)	Scott Marshall
Technical Pilot Course	Adam Francki

On-Demand Courses

Upset Training	TBA
Formation/Low-Level/Chase Training	Matteo Brambilla
Spin Training	Fabian Machado
Crew Resource Management for Flight Testers – Initial (3-day)	Russ Stewart
Crew Resource Management for Flight Testers – Refresher (1-day)	Russ Stewart
Aviation Safety – Initial (3-Day)	Russ Stewart



Ilan Arush, CAO

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