U.S. Naval Test Pilot School Command Brief

Presented to:

UND Space Studies Colloquium

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Presented by:

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Chief of Academics, USNTPS

Some Context- Test Pilots and Space

- Eisenhower decided in 1958 that the first astronauts would be *test pilots*
- *Why?*
  - *The Cold War created a concern about national security in space exploration*
  - *The requirements for Mercury involved three tasks; sequence monitoring, systems management, and attitude control*
  - *One of the psychological requirements was that "the astronaut should be able to function when out of familiar surroundings when usual patterns of behavior are impossible"*
  - *A combination of pure conjecture and real experience with high performance aircraft operations was to become the basis of the characteristics determined."*

(Santy, 1994)

Some Context- Test Pilots and Space

Naval Aviators

*"'**right stuff:'** an inexpressible blend of confidence, skill, and machismo. As Wolfe wrote it, test pilots' relationship to the right stuff was akin to the experience of believers in Protestant Calvinist predestination regarding salvation. Whether with redemption or the right stuff, a man could never know with confidence that he possessed it. He could only demonstrate—through sin or a split-second miscalculation—his lack of it. The astronaut was a single-combat warrior, carrying the weight of his nation's hopes into battle."*

Remembering Tom Wolfe and ***The Right Stuff,*** May 17, 2018
Margaret A. Weitekamp, Smithsonian Museum *Space History Department*

Original Astronauts In Space Suits
NASA Langley Research Center 1/10/1989 Image # EL–1996–00089

Naval Aviators in Space-Accomplishments

- **First American in Space**
- **First American to Orbit the Earth**
- **Naval Aviators were:**
  - *Seven of the twelve men to walk on the moon*
  - *The first and the last of the men to walk on the moon*
  - *The Commanders of the three Skylab missions*
  - *The first pilot/co-pilot crew to land the space shuttle*

- **90 Naval Test Pilots and Test Naval Flight Officers have served as Astronauts**

- **Doug Hurley (Col., USMC (Ret)) will be on the SpaceX crew 27 May**

Test Personnel Have Succeeded-Why?

- All of the early space missions were test and evaluation missions
- Gemini was a build up for Apollo
- All of the single digit Apollo missions were build ups for the landing
- Every mission had test objectives… some had emergencies
  - *Spacewalk challenges - Gemini*
  - *Rendezvous problem with Agena - stuck thruster*
  - *Apollo 11 overshoot of Landing-automated digital flight control system overloaded*
  - *Early shuttle landing software made the vehicle PIO-prone on short final*

All of the cases were reconciled by personnel trained to assess critical parameters, real-time in some cases, and execute a contingency based on technical knowledge and reasoning under stress – what knowledge, skills, and abilities led to this?

Test and Evaluation-Simplest Definition

In its most general sense, test and evaluation is that collection of activities which must be undertaken to **reveal the critical attributes** of the system so that they can be **compared to expectations** and **decisions can be made** regarding readiness for succeeding activities or processes

Reduce the risk to a level where the process can proceed

Required Knowledge and Skill

- **The definition implies one would have to be able to:**
  - Determine the critical attributes, both functional and physical
    - Define tasks and use cases – with *empathy for the user*
    - Derive a practical *model* that *identifies* the *variables* governing outcome
  - Determine a set of possible outcomes and successful expectations
    - Simulate (analytically or practically) exercising the variables in test events
    - *Analyze* the outcomes with respect to *risk* (probability and consequence)
    - Design in *contingencies* in case adverse outcomes are realized
  - Execute the tests and observe as both <u>user</u> and <u>engineer</u>
    - What is the craft doing? How am I compensating? Is it acceptable?
    - Requires the ability to *observe critical parameters, real-time,* and compensate
  - Analyze the differences between outcomes and expectations and decide on their significance
    - Determine how will it affect the goals of the mission/program
    - Identify the characteristics or parameters that are driving the problem
  - Help the decisionmakers assess the risk to proceed
    - Communicate a sound, logical risk product

48th Commanding Officer Mission

"The U.S. Naval Test Pilot School educates the WORLD'S FINEST Developmental Test pilots, flight officers, and engineers in the design, risk management, execution, and communication of aircraft and systems testing."

Frederick “Fritz” Trapnell

An engineering test pilot

Used his head as much as his “hands”

- "At present we simply specify that the airplane shall be perfect in all respects and leave it up to the contractor to guess what we really want... He does the best he can and then starts building new tails, ailerons, etc. until we say we are satisfied." CAPT Robert Hatcher, 1941

History

1945 USNTPS Established

1961 Rotary Wing Syllabus

1973 11 Month Syllabus

1975 Airborne Systems Syllabus

2014 Acquisition of UAS Platform

2018 Acquisition of C-26 platform

2019 Airborne and Unmanned Systems (AUS) combined Syllabus

2020 75 years of Test and Evaluation education

"...to fill a broad technical gap between flight training and test work..."

"...to maintain accuracy, standardization, and continuity in test work."

Overview

- What will the test personnel do?
  - Where they come from
  - What a graduate does
- How do they learn?
  - The thought process
  - Practical Lessons
- What do they learn?
  - The sub-disciplines
  - The skills
  - The dispositions
- Future Directions at USNTPS

Where do they come from?

•Military Student Profile:

- First Tour Navy Lieutenant or USMC Captain - 5-7 years experience
- Proven Performer with top Fitness Reports
- 1,000 Hours or more– Proven Aviator
- Technical Degree

They represent the current fleet/force aviator

•Selection Board Criteria:

- Professional/Flight/Academic Performance
- Career Timing
- Platforms to be Tested

Technically competent and tactically capable

•Selection of Civilian Engineers:

- 3-5 years test experience
- Likely career progression
- Needs of the Test Organization

The resulting Project Officer/Project Engineer teams are the backbone of the test force

What will they do?

- Work in small high-performance test teams:
  - Project Officer in charge of a test project
  - In a test squadron that provides support for all aspects of the test mission
  - Team composition is flat with expert civilian engineers and technicians
  - The Team, like the program, is under cost, schedule, and performance pressure

The team is not hierarchical; must use everyone's strength, develop the team

- Design, plan, and execute developmental test events:
  - Usually, expensive, one-of-a-kind test article
  - Must test to the limits of the aircraft without killing someone or destroying the aircraft
  - Testing to specification for contract satisfaction
  - More importantly, testing to mission standards to retire operational risk

Must answer the question,
"Was the system built correctly and did we build the correct system?"

- Document deficient characteristics of the system under test:
  - Uses the judgement of an expert user to ascertain the mission impact
  - Provides the degree of mission impact to the Program Manager
  - Provide assistance in defining the solution

Their report of test results is a programmatic risk product for the program manager

Characteristics of a good Tester

- We need a Person
  - Who can lead and serve a team
  - Who is technically competent
  - Who is tactically proficient
  - Who is skilled in operating airborne systems
  - Who can think and reason under pressure
  - Who can assess risk
  - Who can look at the results of a test and honestly and logically provide an argument for corrective action or continuation
  - While remaining empathetic of the user and the goals of the program

I submit that those are the properties for which NASA and Space Systems Companies look

Overview

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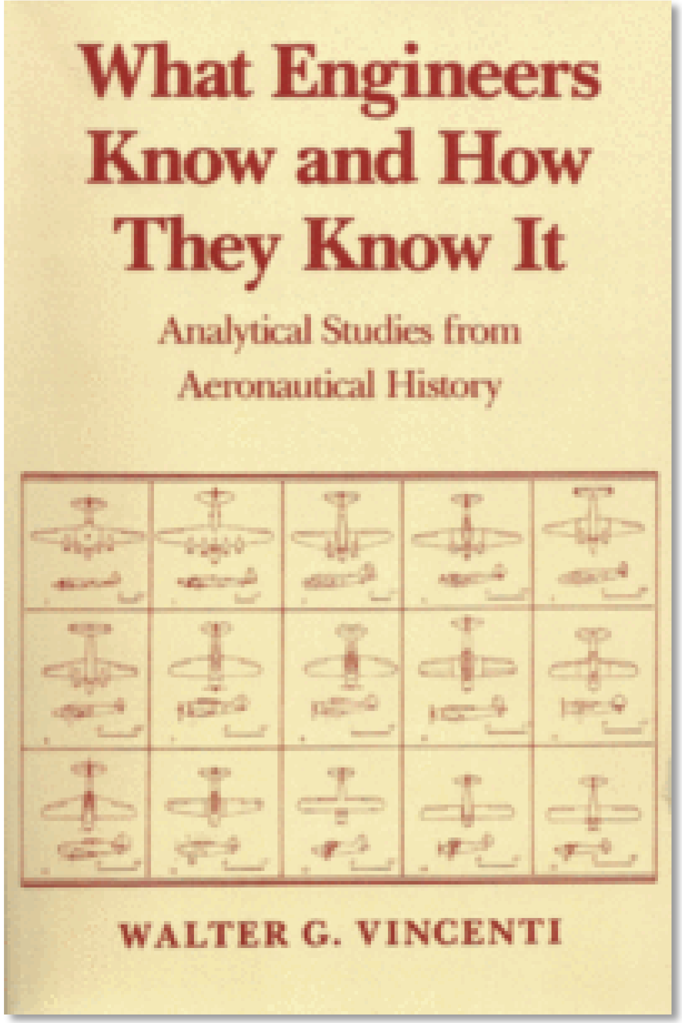
Training

AND

Education

An Epistemological View

- Some problems are **well-defined** in the technical sense (i.e., it is already known what is needed and how to specify what is required)
- Other problems are **poorly-defined** in the technical sense
- The TPS graduate must be able to:
  - Determine if a technical problem is well-defined or poorly-defined
  - If well-defined, master the existing body of knowledge and apply it to the problem
  - If poorly-defined, determine the fundamental questions and seek to systematically generate the required knowledge



(Vincenti, 1990)

(Slide by J.K. Tritschler)

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…some of the more "classical" elements of the TPS education focus on well-defined problems (e.g., aircraft performance and flying qualities)

In this context, a possible "narrow view" of the TPS grad:

- A "master practitioner"
- Capable of designing, executing, and reporting on tests conducted with well-established, time-tested flight test techniques safely and efficiently

(Slide by J.K. Tritschler)

An Epistemological View

- Some problems are **well-defined** in the technical sense (i.e., it is already known what is needed and how to specify what is required)
- **Other problems are poorly-defined in the technical sense**
- The TPS graduate must be able to:
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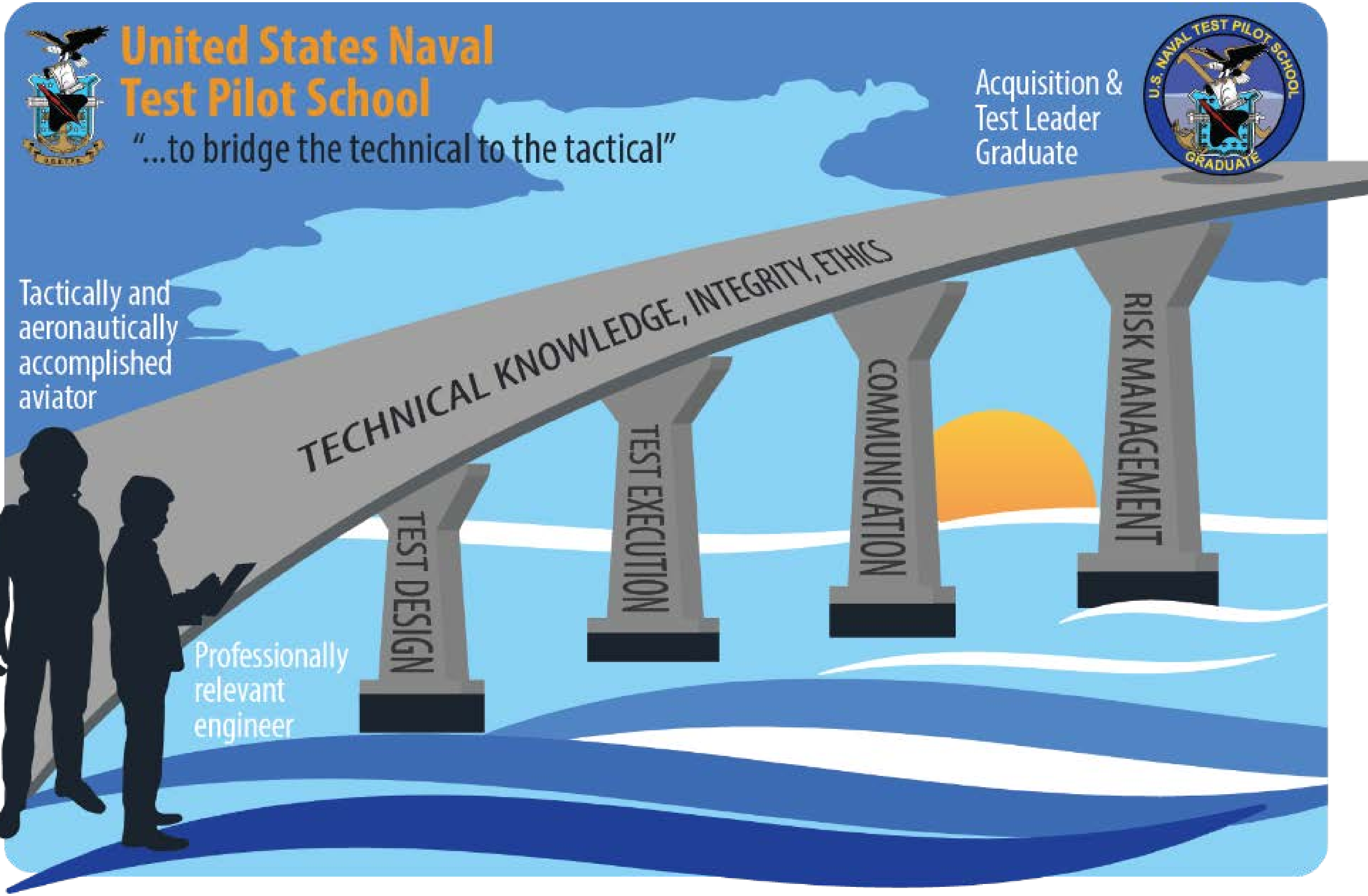
…we seek out opportunities to expose our students to poorly-defined problems (e.g., highly automated or autonomous systems)

In this context, a more fitting view of the TPS grad:

- **A "master thinker"**
- **Capable of assessing the maturity of new technologies**
- **Capable of designing, executing, and reporting on tests that generate the required knowledge to characterize the operational utility of those technologies**

(Slide by J.K. Tritschler)

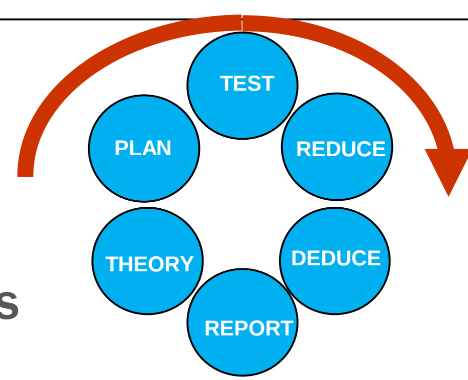

United States Naval
Test Pilot School
"...to bridge the technical to the tactical"
Acquisition &
Test Leader
Graduate
U.S. NAVAL TEST PILOT SCHOOL
GRADUATE
Tactically and
aeronautically
accomplished
aviator
TECHNICAL KNOWLEDGE, INTEGRITY, ETHICS
TEST DESIGN
TEST EXECUTION
COMMUNICATION
RISK MANAGEMENT
Professionally
relevant
engineer

The Approach

- **Define expectations**
  - Bound the problem
  - Establish the critical issues
- **Decompose the question**
  - System’s functional and physical as
  - Applied Math and Physics
  - Engineering theory
- **Gather evidence**
  - Plan the experiment (test)
  - Execute the test (on a system in flight)
- **Analyze and conclude**
  - Manage the data
  - Apply concepts, check theory
- **Communicate a compelling argument**
  - Apply logic, critical thinking, and communication skills

Defines Functional Areas

- Flight Test Engineering
- Flight Test Techniques
- Flight Test Planning
- Safety Planning/Risk Mgt
- Flight Test Execution
- Data Management
- Flight Test Evaluation
- Flight Test Reporting

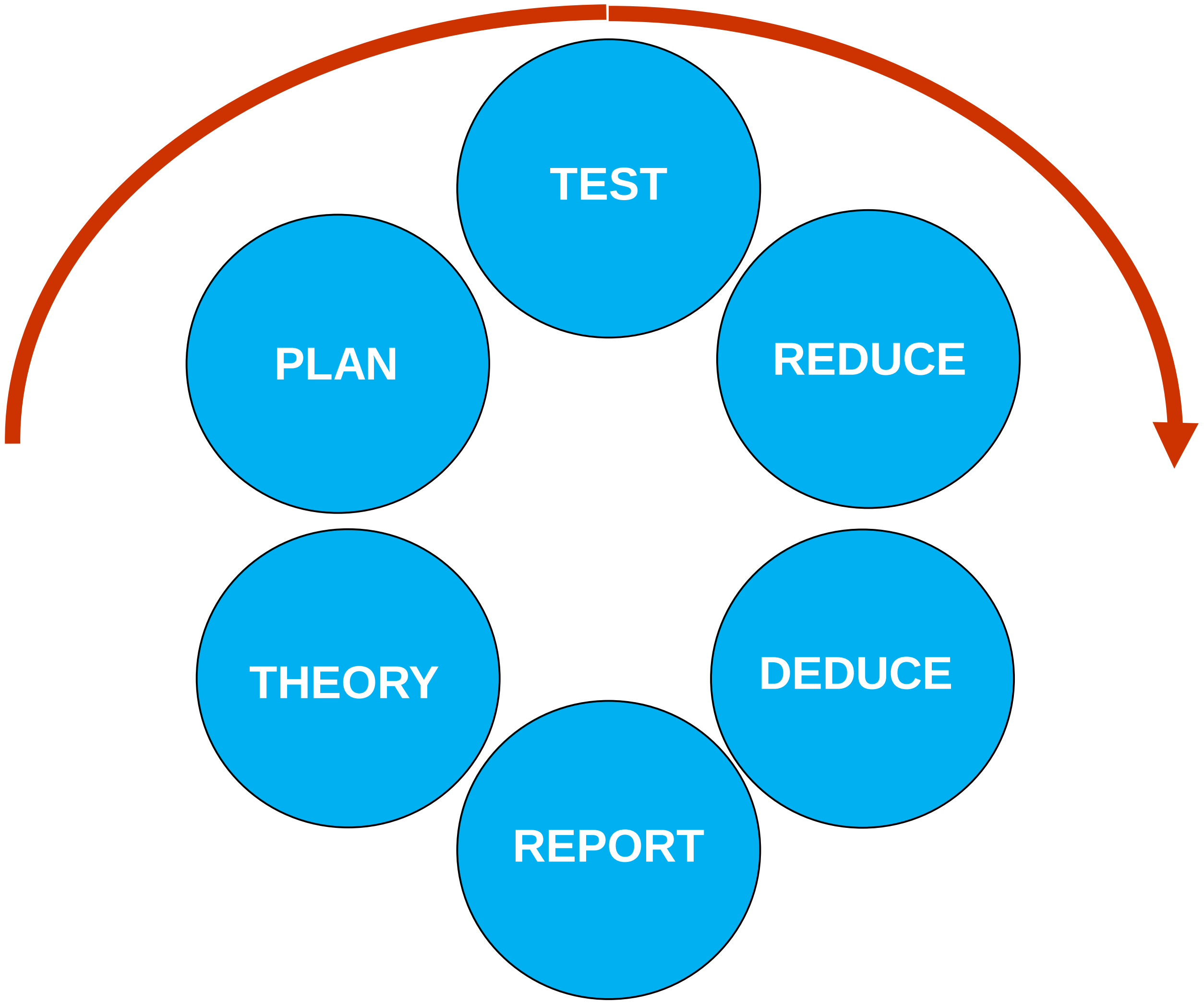


The Basis for Terminal Learning Objectives

- Education/Skill Requirements
  - Flight Test Engineering
  - Flight Test Techniques
  - Flight Test Planning
  - Safety Planning/Risk Mgt
  - Flight Test Execution
  - Data Management
  - Flight Test Evaluation
  - Flight Test Reporting

- Proficiency in each area is the goal of our program

The Approach



A Recursive Process

	Cockpit Eval	Hover Perf	Lvl Flt Perf	Clmb/Desc	AG Radar	EO/IR System	Long HQ	LatDir HQ	Low A/S	UAV Eval	Qual Eval	Final Project
Flight test engineering (theory)												
Flight test planning												
Safety Planning and Risk Management												
Establishment of Flight Test Techniques												
Flight test execution												
Data Management												
Evaluation/deduction from results												
Communication of results												

Why Critical Thinking and Communication?

- “Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action”-National Council for Excellence in Critical Thinking, 1987

- “The objective analysis and evaluation of an issue in order to form a judgment”
- Need a critical thinking model

A Critical Thinking Model

Paul, Elder, and Niewoehner

- Universal Structures of Thought
  - Whenever we think, we think for a purpose
  - What is my fundamental purpose?
  - Within a point of view
  - What is my point of view with respect to the issue?
  - Based on assumptions
  - What assumptions am I using in my reasoning ?
  - Leading to implications and consequences
  - What are the implications of my reasoning?
  - We use data, facts, and experiences
  - What data do I need to answer my question?
  - To make inferences or judgments
  - What are my most fundamental inferences or conclusions?
  - Based on concepts or theories
  - What is the most basic concept in the question?
  - To answer a question or solve a problem
  - What is the key question I am trying to answer?

(Niewoehner 2017)

Assessment Techniques

- **Academics**
  - Remember
  - Understand
  - Apply

In-class Academic Tests

An understanding of concepts and theories

- **Flight Exercises**
  - Analyze
  - Synthesize
  - Evaluate

Airborne Tests with Analysis and a Report of Results

An indication of their thought process

Analysis, Evaluation, Communication

- Present data that are complete, accurate, and precise
- Analyze data and interpret the results to draw correct conclusions
- Present a logical, compelling argument substantiated to the point that the reader cannot reach any other conclusion

We use oral and written reports as a tool to assess the student's ability to analyze, evaluate, and communicate

We grade their data, analysis, argument, and communication

Intellectual Standards for Engineering Reasoning

Clarity: *Understanding; the meaning can be grasped*

Accuracy: *Free from errors or distortions; true*

Precision: *Exact to the necessary level of detail*

Relevance: *Relating to the matter at hand*

Significance: *Significant to the matter at hand*

Depth: *Containing Complexities and multiple interrelationships*

Breadth: *Encompassing multiple viewpoints*

Logic: *The parts make sense together, no contradictions*

Fairness: *Justifiable, not self-serving or one-sided*

Concision: *Economy of thoughts words and images*

Suitability: *Seeking to be appropriate by selecting the right tone and presentation for the audience*

(Niewoehner 2017)

The goal is for the student to assess their product using these standards

Intellectual Standards for Engineering Reasoning

Intellectual Standards for Engineering Reasoning

An Aid to Authors and Graders of USNTPS Student Deliverables

Adapted from *The Thinkers Guide to Engineering Reasoning* by Dr. Richard Paul, Dr. Robert Neiwoehner, and Dr. Linda Elder

Standard:	Definition:	Questions Targeting the Standard:
Clarity	Understandable; the meaning can be grasped *Clarity is a gateway standard. If a statement is unclear, we cannot determine whether it is accurate or relevant. In fact, we cannot tell anything about it because we do not yet know what it is saying.*	• Could you elaborate further on that point? • Could you express that point more clearly in another way? • Could you give me an illustration or example? • Have the assumptions been clearly stated? • Have terms and symbols been clearly defined? • Do drawings/graphs/photos and supporting annotations clearly portray important relationships?
Accuracy	Free from errors or distortions; true *A statement can be clear but not accurate, as in "Most creatures with a spine are over 300 pounds in weight."*	• Is that really true? • How could we check that? • What is your confidence in that data? • Has the test equipment been calibrated? How or when? • How have simulation models been validated? • Have assumptions been challenged for legitimacy? • Are there hidden or unstated assumptions that should be challenged? • What if the environment is other than we had expected (e.g., hotter, colder, dusty, humid)?
Precision	Exact to the necessary level of detail *A statement can be both clear and accurate, but not precise, as in "The solution in the beaker is hot." (We don't know how hot it is.)*	• Could you give me more details? • Could you be more specific? • What are acceptable tolerances for diverse pieces of information? • What are the error bars or confidence bounds on experimental, handbook or analytical data? • Does the readability of the measurement justify this level of precision? • At what threshold do details or additional features no longer add value?
Relevance	Relating to the matter at hand *A statement can be clear, accurate, and precise, but not relevant to the question at issue. A technical report might mention the time of day and phase of the moon at which the test was conducted. This would be relevant if the system under test were a night vision device. It would be irrelevant if it were a microwave oven.*	• How is that connected to the question? • How does that bear on the issue? • Have all relevant factors been weighed? • Are there unnecessary details obscuring the dominant factors? • Has irrelevant information been included? • Have features and capabilities (and hence costs) been included which the customer neither needs nor wants?
Significance	Significant to the matter at hand *Our speech or writing can be clear, accurate, precise, and relevant, yet focus on insignificant conclusions or details rather than the most important features.*	• Does one detail of many overwhelm the others in importance or influence? • Are insignificant details presented that obscure recognition of first-order factors or effects before working down to the more subtle? • Is that dealing with the most significant factors? • Are insignificant details presented that compromise the overall conclusion?

Intellectual Standards for Engineering Reasoning

(Continued)

Standard:	Definition:	Questions Targeting the Standard:
Depth	Containing complexities and multiple interrelationships *A statement can be clear, accurate, precise, and relevant, but superficial. For example, the statement, "Radioactive waste from nuclear reactors threatens the environment," is clear, accurate, and relevant. Nevertheless, more details and further reasoning need to be added to transform the initial statement into the beginnings of a deep analysis.*	• How does your analysis address the complexities in the question? • Have important interrelationships been fully identified and studied? • How are you taking into account the issues in the question? • Does this analytical model have adequate complexity and detail, given its counterpart in reality?
Breadth	Encompassing multiple viewpoints *A line of reasoning may be clear, accurate, precise, relevant, and deep, but lack breadth (as in an argument from either of two conflicting theories, both consistent with available evidence).*	• Do we need to consider another point of view? • Is there another way to look at this question? • What would this look like from the point of view of a conflicting theory, hypothesis, or conceptual scheme? • Have the full range of options been explored? • Have interactions with other systems been fully considered?
Logic	The parts make sense together, no contradictions *When we think, we bring a variety of thoughts together into some order. The thinking is "logical" when the conclusion follows from the supporting data or propositions. The conclusion is "illogical" when it contradicts proffered evidence, or the arguments fail to cohere.*	• Does this really make sense? • Does that follow from what you said? How does that follow? • But earlier you implied this and now you are saying that. I don't see how both can be true. • Are the evaluation conclusions supported by logical analysis?
Fairness	Justifiable, not self-serving or one-sided *Fairness is particularly at play where more than one viewpoint is relevant to understanding and reasoning through an issue (conflicting conceptual systems), or where there are conflicting interests among stakeholders. Fairness gives all relevant perspectives a voice, while recognizing that not all perspectives may be equally valuable or important.*	• Have other points of view been considered (contractor, program office, fleet user, maintenance, public citizens, etc.)? • Are vested interests inappropriately influencing the evaluation? • Are divergent views within the evaluation team given fair consideration? • Have the environmental/safety impacts been appropriately weighed? • Have we thought through the ethical implications in this decision?
Concision	Economy of thought, words, and images enhance clarity by preventing self-generated noise	• Would fewer words work? • Could all related graphs be overlaid or placed on one page to improve the insight into trends and encourage direct comparison? • Are relevant visual perspectives efficiently presented?
Suitability	Seeking to be fitting or appropriate by selecting the right tone and presentation for the intended audience	• Does this convey the appropriate tone? • Is the level of detail appropriate for the intended audience? • Is the language patronizing or condescending? • Is the language overly complex or specialized? • Are the elements appropriately placed to maximize communication?

Intellectual Ethics-Dispositions

Intellectual Humility: *Thoughtful acknowledgement of the limitations of our own knowledge*

Intellectual Integrity: *hold ourselves to the same standards we expect other to honor*

Intellectual Courage: *Accepts risk for one's intellectual judgements and opinions*

Intellectual Empathy: *Awareness of the need to actively entertain views that differ from our own*

Intellectual Perseverance: *Compels us to work through intellectual complexities despite frustration inherent in the task*

Confidence in Reason: *Our highest interests are best served by giving the freest play to reason*

Intellectual Autonomy: *healthy skepticism that wants to wants to evaluate the data and form one's own conclusion*

Fair-mindedness: *Purposely treat all viewpoints by the same standards*

Intellectual Curiosity: *Propels the thinker towards further learning* **(Niewoehner 2017)**

Dr. Niewoehner and the staff share their career reflections of these dispositions
Students are asked to reflect on their dispositions during their group projects

Overview

- What will the test personnel do?
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  - The dispositions
- Future Directions at USNTPS

What do they learn?

- The basic question: Can the craft attain and hold a trajectory in a manner that accommodates the mission?
- Mission context
  - Transport forces?
  - Deliver a weapon?
  - Provide a platform to position a sensor?
- Three practical engineering sub-disciplines developed over 75 years
  - Performance (power available vs power required)
  - Flying Qualities
  - Airborne Systems Performance
- The test and evaluation process; plan, execute, observe, analyze, communicate
- Risk Management and Hazard Analysis

The Learning Objectives span cognitive, psychomotor, and affective domain
"Must be able to fly what you planned and *really* observe"

Course of Instruction

Each student executes approximately 120 flight hours and 530 academic hours

Command totals:
Flight hours: ~6,700 per year
Sorties: ~4,500 per year

Classroom

- Mathematics
- Engineering
- Aircraft Performance
- Aircraft Stability & Control

Lab and Simulation

- Aerodynamics
- Thermodynamics
- Electro-optics
- RADAR Theory
- Advanced Topics

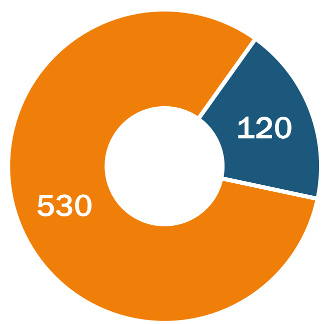
Exercise Brief

Flight Demonstration

Exercise and Data Flights

Technical Report

Review and Debrief



GROUND — THEORY

FLIGHT — APPLICATION

REPORT — ASSESS

Academics

Common Academic Courses

- *Math/Calculus*
- *Mechanics*
- *Intro to Airborne Systems*
- *Pitot Statics*
- *Report Writing*
- *Human Systems Interface*
- *Control Systems*
- *Statistics & data analytics*
- *Subsonic Aero*
- *1st & 2d Order Systems*
- *Dynamic Systems Analysis Techniques*
- *Airborne Electro-Optical Systems*
- *Thermodynamics*
- *Avionics Architecture*
- *Low Observable – EO*
- *VSTOL Aircraft*

Fixed-wing and Airborne and UA Systems

- *Airplane Performance (Jet & Turbo-Prop)*
- *Airborne Radar Systems*
- *Airplane Stability & Control*
- *High AoA*
- *Airplane Dynamics*
- *High Speed Aerodynamics*
- *Loads & Structures*
- *Special Topics in Flight Mechanics*
- *Propulsion Systems*
- *Shipboard Interface*
- *Airborne Navigation Systems*
- *Special Topics in Airborne Systems*

Rotary-wing Aircraft

- *Helicopter Performance & Aero*
- *Helicopter Rotor Systems*
- *Helicopter Stability & Control*
- *Turbo-prop Performance*
- *Helicopter Dynamics*
- *Airborne Radar Systems*
- *Airplane Stability & Control*
- *Propulsion Systems*
- *Flight Loads*
- *Dynamic Interface*
- *Airborne Navigation Systems*
- *Human Systems Interface*
- *Special Topics in Flight Mechanics*

530 hours
25 Tests and exams
7 labs and simulations

Hazard Analysis and Risk Management

The Why-

It (like testing space systems) is inherently risky

- Program Manager Asks
  - "Can you find me the answer....
  - ...to the limits of the aircraft/system....
  - ...without killing somebody or destroying the test article, which is one of a kind?"

- "Explain your approach and how much safety risk I need to assume"
- Bravado won't work – the Affective domain
- The approach must be organic to the test plan
  - Build up
  - Contingencies
  - Real-time, critical parameter analysis

"Walk to the edge of the cliff, peer over the side, come back and tell us what you saw"

Understand the Facets of Risk

- Technical
- Supportability
- Programmatic
- Cost
- Schedule

Technical →

- Physical Properties
- Material Properties
- Radiation Properties
- Testing/Modeling
- Integration/Interface
- Software Design
- Safety
- Requirement Changes
- Fault Detection
- Operating Environment
- Proven/Unproven Technology
- System Complexity
- Unique/Special Resources

- Safety

Safety →

- Human error
- System failure–mechanical, etc.
- Environmental conditions

(Slide by James Casler)

Manage Risk through a Process

- Risk Management
  - Risk Planning
  - Risk Identification
  - Risk Characterization
  - Risk Analysis
  - Risk Mitigation
  - Risk Tracking

(Slide by James Casler)

Identify Hazards and Plan Contingencies

Test Hazard Analysis: Example Formats

Hazardous Condition	Cause	Effect (Severity)	Risk Assessment	Precautionary Measure	Corrective Action	Hazard Level
Description of the hazard	What is the cause of the hazard	What is the effect if the hazard occurs? Actually list what will happen, not the severity code	Probability and consequence of occurrence and why? If low probability, so state.	Risk Handling. What will be done to eliminate or control the hazard?	What will be done if hazard effect is realized?	Codes for Severity and Probability

HAZARD SEVERITY		HAZARD PROBABILITY			
		LIKELY TO OCCUR	PROBABLY WILL OCCUR	MAY OCCUR	UNLIKELY TO OCCUR
		A	B	C	D
Catastrophic	I				
Critical	II				
Marginal	III				
Negligible	IV				

We Fly to Gain Knowledge

Table 7-1. Summary of Knowledge Categories and Generating Activities

Activities \ Categories	Fundamental design concepts	Criteria and specifications	Theoretical tools	Quantitative data	Practical considerations	Design instrumentalities
Transfer from science			X	X		
Invention	X					
Theoretical engineering research	X	X	X	X		X
Experimental engineering research	X	X	X	X		X
Design practice		X			X	X
Production				X	X	X
Direct trial (including operation)	X	X	X	X	X	X

(Vincenti, 1990)

- Traditionally, different *activities* (undertaken by different "sub-communities") will generate different *categories* of knowledge
- *Flying* is the *direct trial* and the only one that generates *all categories of knowledge*

(slide by Tritschler)

Fixed-Wing Syllabus

USNTPS is home to the newest and oldest fixed-wing aircraft in the USN inventory with five different type, model, and series.

10 T-38C Talon

~1100 hours per year

Primary FW student trainer

EXERCISES
- Flying Qualities and Performance
- Transonic/Supersonic Evaluation

6 T-6B Texan-II

~1000 hours per year

Primary FW student trainer (NATOPS qual)

EXERCISES
- Flying Qualities and Performance
- Flight Test Technique Demonstration
- Out-Of-Control Flight/ Spin Evaluation

2 X-26A Frigate Glider

~40 hours per year

EXERCISES
- High Lift/Drag Evaluation
- Un-powered Flying Qualities
- Aerobatics

2 U-6A Beaver

1 NU-1B Otter

~250 hours per year

EXERCISES
- Lateral-Directional Flying Qualities
- Qualitative Evaluation
- Glider Tow (U-6A)

All aircraft are USN

Rotary-Wing Syllabus

Four different type, model, and series.

5 H-72 Lakota

~1000 hours per year

Primary RW student trainer (NATOPS qual)

EXERCISES

- Highly augmented flight controls
- Flying Qualities and Performance

USN aircraft

5 OH-58C Kiowa Warrior

~500 hours per year

EXERCISES

- Flying Qualities and Performance
- Auto-rotational Landing Evaluation
- Height-Velocity Demonstration

USN aircraft

1 H-60A Blackhawk 4 H-60L

~900 hours per year

Primary RW student trainer (NATOPS qual)

EXERCISES

- Flying Qualities and Performance
- High Altitude Performance

USA aircraft

3 C-12C Huron

~500 hours per year

FW, RW, and SYS trainer

EXERCISES

- Multi-Engine Flying Characteristics
- Asymmetric Power Demonstration
- Navigation Systems Evaluation

USA aircraft

Airborne/Unmanned Systems Syllabus

Four different type, model, and series.

4 F/A-18F Super Hornet

~300 hours per year

Primary AUS trainer, FW/RW demos

EXERCISES

- APG-73 radar/ATFLIR
- A/A Radar Evaluation
- A/G Weapons Delivery Evaluation
- AFCS Demonstration
- High AOA/Departure Demonstration

USN aircraft

1 ASTARS-III Flying Classroom

375 hours per year

Primary AUS trainer, FW/RW demos

EXERCISES

- APG-68 radar/MX-15 FLIR/ AIS/LTN-92 INS/HUD

Evaluation

- Integrated Systems
- A/G and A/A Radar
- FLIR

USNTPS aircraft

UNMANNED

1 Aero-M UAS

1 X-8M

~25 hours per year

FW/RW/AUS training asset

EXERCISES

- UAS Evaluation
- Navigation System Evaluation

USNTPS aircraft

Airborne Systems Training and Research Support – III (ASTARS-III) Laboratory

Qualitative Evaluation Platforms

Qualitative evaluation platforms increase the adaptability of test pilots and aircrew and expose them to a varying range of performance, flying qualities, and weapons systems performance

TPS regularly provides opportunity for staff and students to fly unique and interesting aircraft

Final Exercise/Capstone Project

Developmental Test/Evaluation Phase IIA ("DT-II")

Students complete DT-II in an unfamiliar aircraft/ system. The exercise combines all elements learned in curriculum

Test Planning

- (1) Week (100+ page test plan)
- Instructor graded and reviewed
- Executive out-brief

Execution

- Ground Test
- 4 flights or 6 flight hours

Data Analysis/Reporting

- 9 day preparation
- 150+ page technical report

Instructor debrief

Overview

- What will the test personnel do?
  - Where they come from
  - What a graduate does
- How do they learn?
  - The thought process
  - Practical Lessons
- What do they learn?
  - The sub-disciplines
  - The skills
  - The dispositions
- Future Directions at USNTPS

Research Cell

- The purpose of the **USNTPS Research Cell** is to **conduct research** and **foster collaborations** that grow the USNTPS knowledge base in critical areas. These activities will support the **development of new test and evaluation doctrine** and the **creation of new curriculum training** to better prepare USNTPS graduates to anticipate tomorrow's technical challenges.

(slide by Tritschler)

Research as a Teaching Tool

For instance the application of highly automated or autonomous systems is presently a poorly-defined problem (i.e., it is not well established what is needed and how to specify what is required)

(slide by Tritschler)

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...thus new engineering knowledge must be generated:

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2. Identification of criteria
3. Development of instruments and techniques
4. Growth of opinion
5. Scheme for research
6. Measurement of characteristics
7. Assessment of results

(Vincenti, 1990)

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"knowledge generation" for automated or autonomous systems presently falls into these categories—thus an inventory of well-established, time-tested flight test techniques for highly automated or autonomous systems does not presently exist

(slide by Tritschler)

Some Current Research Projects

- Hover Performance over Sloped Ground Planes
- Mission Task Element Development for Small UAS with First Person View Cueing
- High-Speed MTE Development for Future Vertical Lift
- Research & Development for Efficient Flight Test and (SYS ID) Modeling Methods
- Modernizing On-Aircraft Electro-Optical/Infrared Systems Resolution Measurement

Conclusions and Implications

Many of the challenges of fielding modern space systems are congruent with those of fielding a modern aircraft

Those challenges will be met successfully by personnel with the knowledge, skills, and attitudes of test professional

NASA and Space Systems companies will look toward the Test Pilot Schools, as well as other sources, for personnel with the knowledge and skill to test and operate modern space vehicles

As such, US Naval Test Pilot School and the other Test Pilot Schools will continue to have a positive effect on the development of space systems and space exploration

USNTPS

From Knowledge, Air Power
Ex Scientia, Aeris Potentia

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- Vincenti, W. G. (1990). *What Engineers Know and How They Know It*., The Johns Hopkins University Press, Baltimore, MD
- Niewoehner, R. J. (2017). *Engineering Our Thinking*. Sentia, Austin, TX

BACKUP SLIDES

Short Course Curriculum

Designed for aircrew, engineers, and scientists, short course curriculum provides a basis for safe and effective test project planning, test execution, and reporting. Students complete guided exercises with demonstration flights and ground simulators

- *~200 students per year*
- *Two week duration*
- *Specialized courses delivered to:*
  - China Lake and Pt. Mugu
  - Lockheed-Martin
  - Finland and Spain

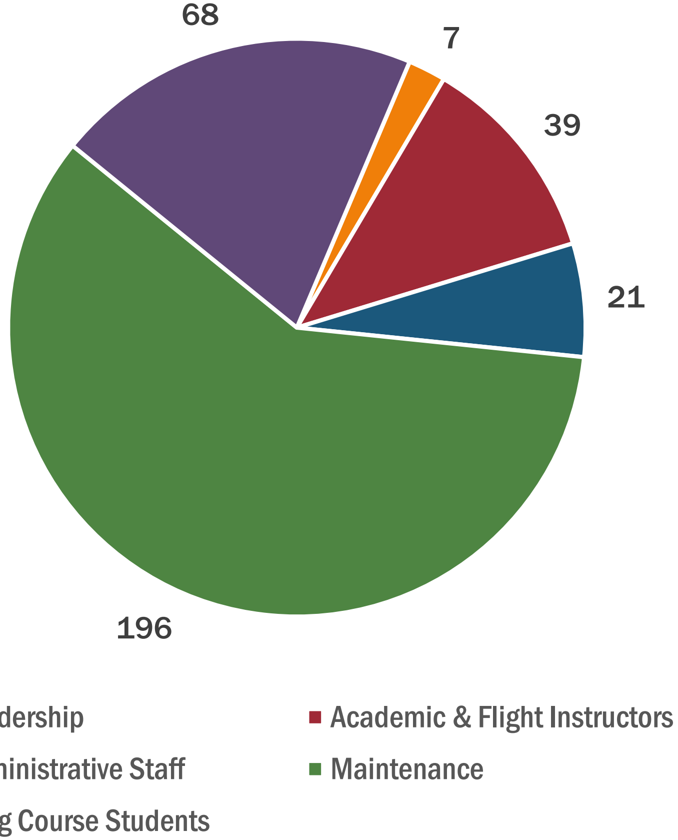
Introduction to Unmanned Aerial Systems Flight Test

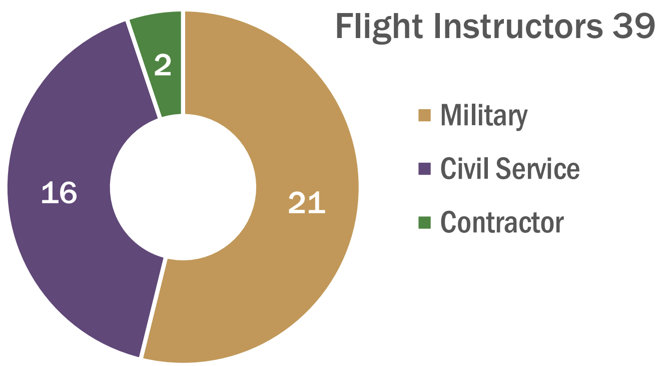
Annual Offerings (8-10):

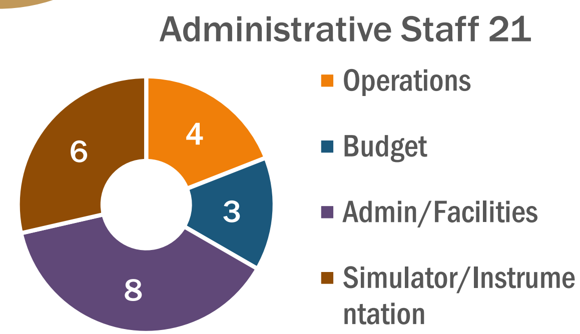
Introduction to Aircraft and Systems T&E
Introduction to Fixed Wing Flying Qualities
Introduction to Rotary Wing Flying Qualities and Performance
Introduction to Unmanned Aerial Systems Flight Test

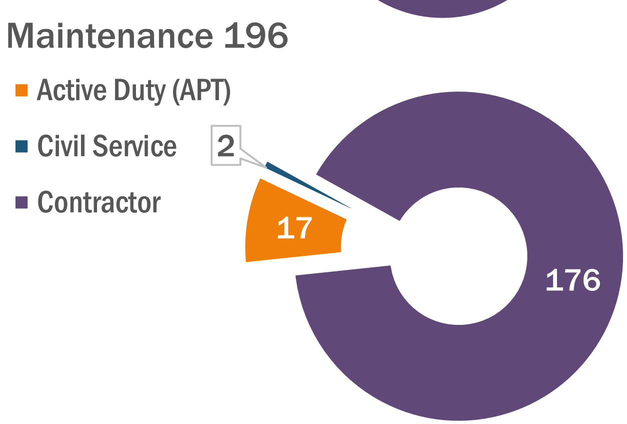
Command Profile

At any given time, USNTPS is populated by a mix of domestic and international leadership, instructors, support staff, and long course students.
A typical year consists of:









February 2019

Partnerships

USNTPS partners with domestic and international organizations through instructor, student, and aircraft exchanges

U.S. Air Force Test Pilot School

- Est. 1944. Moved to Edwards AFB, CA 1951
- FW only curriculum
- 2 Classes per year
- 1 USN staff instructor
- 1 USN and 1 USMC exchange student per year

U.S. Naval Test Pilot School

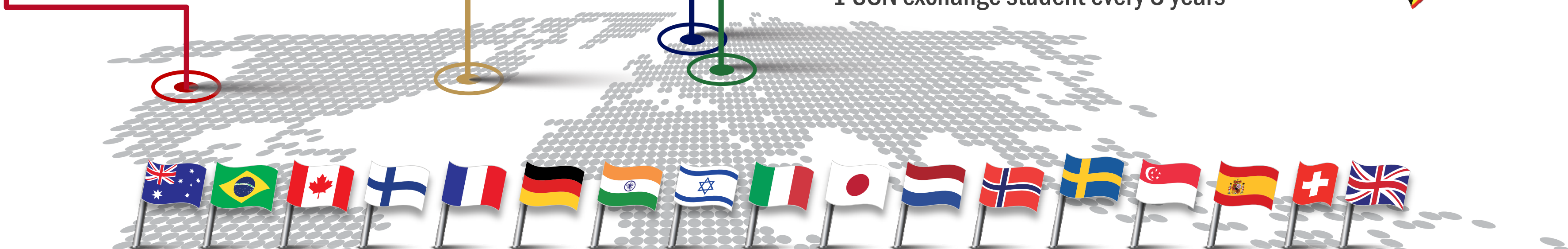
- Est. 1945. NAS Patuxent River, MD
- FW, RW, and AUS curricula
- 2 Classes per year (72 students)
- 1 UK, 2 USA, 1 USAF staff instructor
- 1 UK exchange student per year
- 2 USAF exchange students per year

Empire Test Pilots' School (ETPS)

- Est. 1943. Boscombe Down, UK
- FW and RW curricula
- 1 Class per year
- 1 USN staff instructor
- 1 USN exchange student in each class

École du Personnel Navigant d'Essais et de Réception (EPNER)

- Est. 1946. Moved to Istres Le Tube AB, FR 1962
- FW and RW curricula
- 1 Class per year
- 1 USN exchange student every 3 years



International Partners

Australia	Finland	India	Japan	Sweden	Switzerland
Brazil	France	Israel	Netherlands	Singapore	United Kingdom
Canada	Germany	Italy	Norway	Spain	

Long Course Student Profile

Two Classes Annually

Students 72 per year (36 per class)

Three Curricula

Fixed Wing (pilot/engineer)

Rotary Wing (pilot/engineer)

Airborne/Unmanned Systems (NFO/engineer)

11 Months in Duration

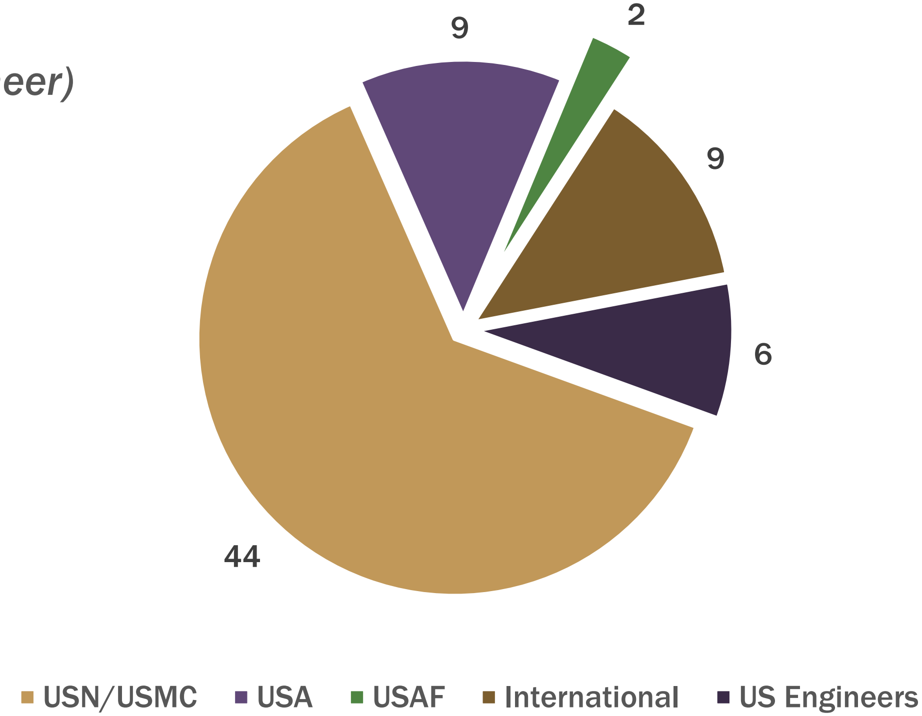
Pre-arrival training

- T-6B (Whiting Field, FL)
- T-38C (Randolph AFB, TX)
- H-72/H-60 (WAATS, AZ)

Academic hours: 530

Annual Student Distribution

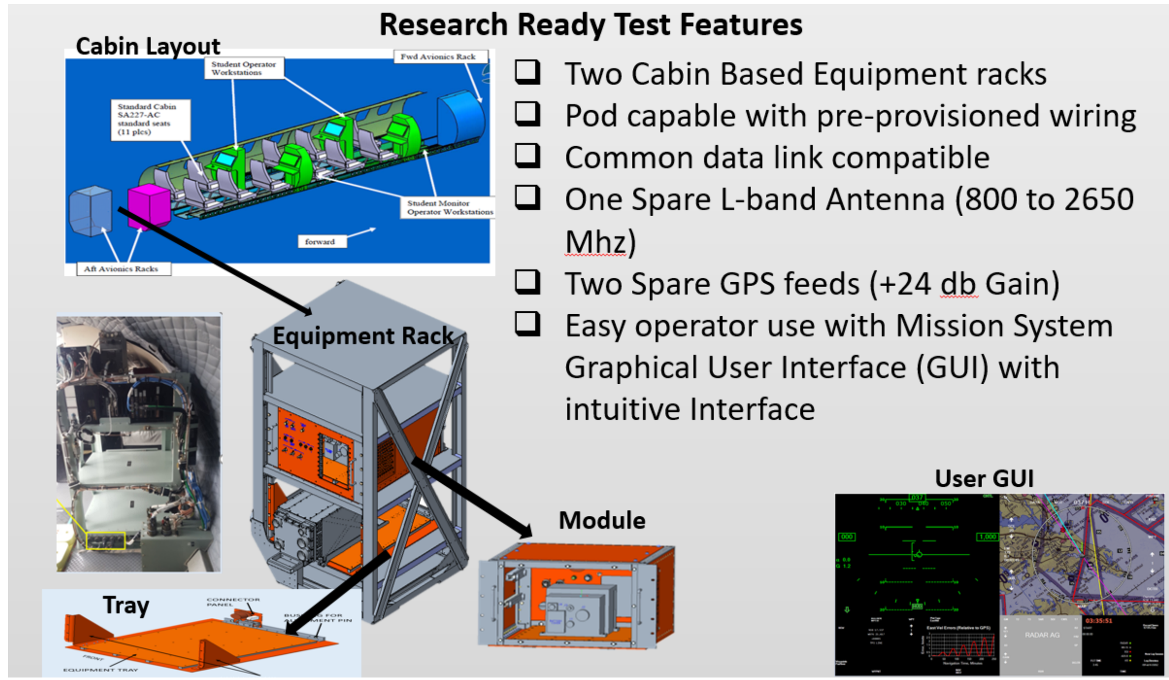
Every TPS class is a diverse mix of US military services, civilian, and international students



Emerging Capabilities

Academics/Doctrine

- *T&E Application to Unmanned Aerial Systems*
- *Capabilities Based Test & Evaluation*
  - **System-of-Systems**
  - **Live-Virtual-Constructive**
- *Cyber classes and desktop demo*
- *ASTARS-III Research capability*
- *Critical Thinking Instruction*
  - **Intellectual ethics training**
  - **Leadership lecture series**



Training Aids

- *Next Generation Threat System (NGTS)*
  - **Simulator air-to-air model**
  - **Surface to air model**
- *Learning Management System*

Post Graduation Opportunities

USNTPS has established relationships with the Naval Postgraduate School, Johns Hopkins University, George Washington University, and the Florida Institute of Technology.

These relationships enable USNTPS students to receive credit toward advanced degree programs/Master of Science degrees in disciplines such as Systems Engineering, Aerospace Engineering, and Technical Management.

>4,460
Graduates since 1945
322 International

USNTPS is considered a gateway into the NASA Astronaut Program. Nearly two-thirds of astronauts are graduates of a Test Pilot School.
90 U.S. astronauts graduated from USNTPS

February 2019