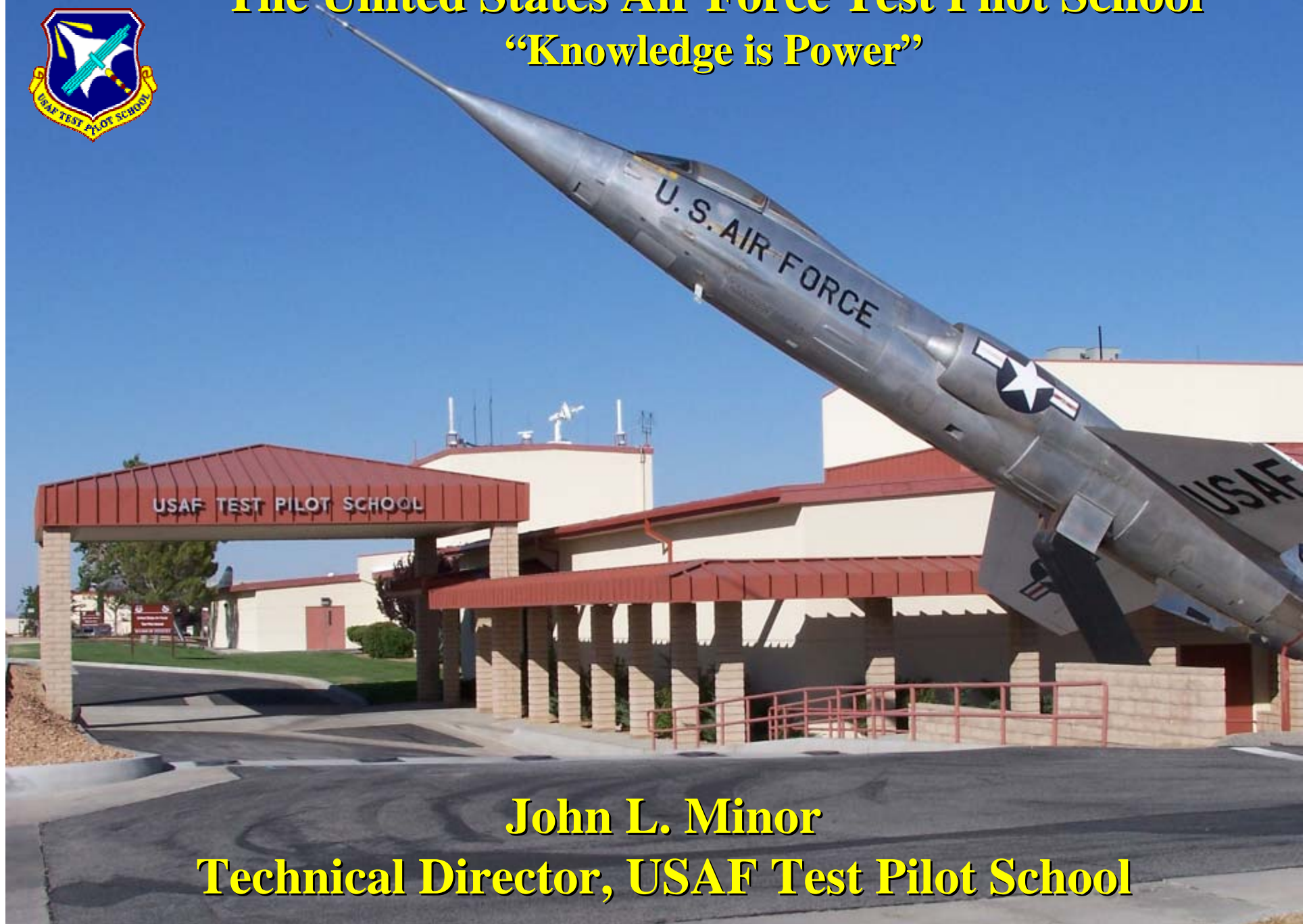


*Scientia est Virtus*



# The United States Air Force Test Pilot School

**“Knowledge is Power”**



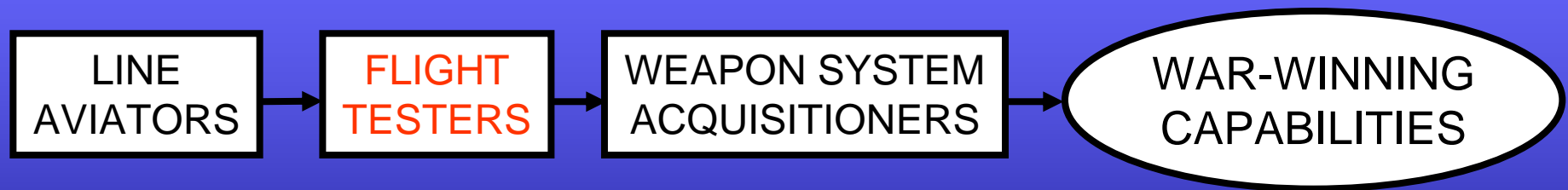
**John L. Minor**

**Technical Director, USAF Test Pilot School**

# USAF TPS Vision & Mission

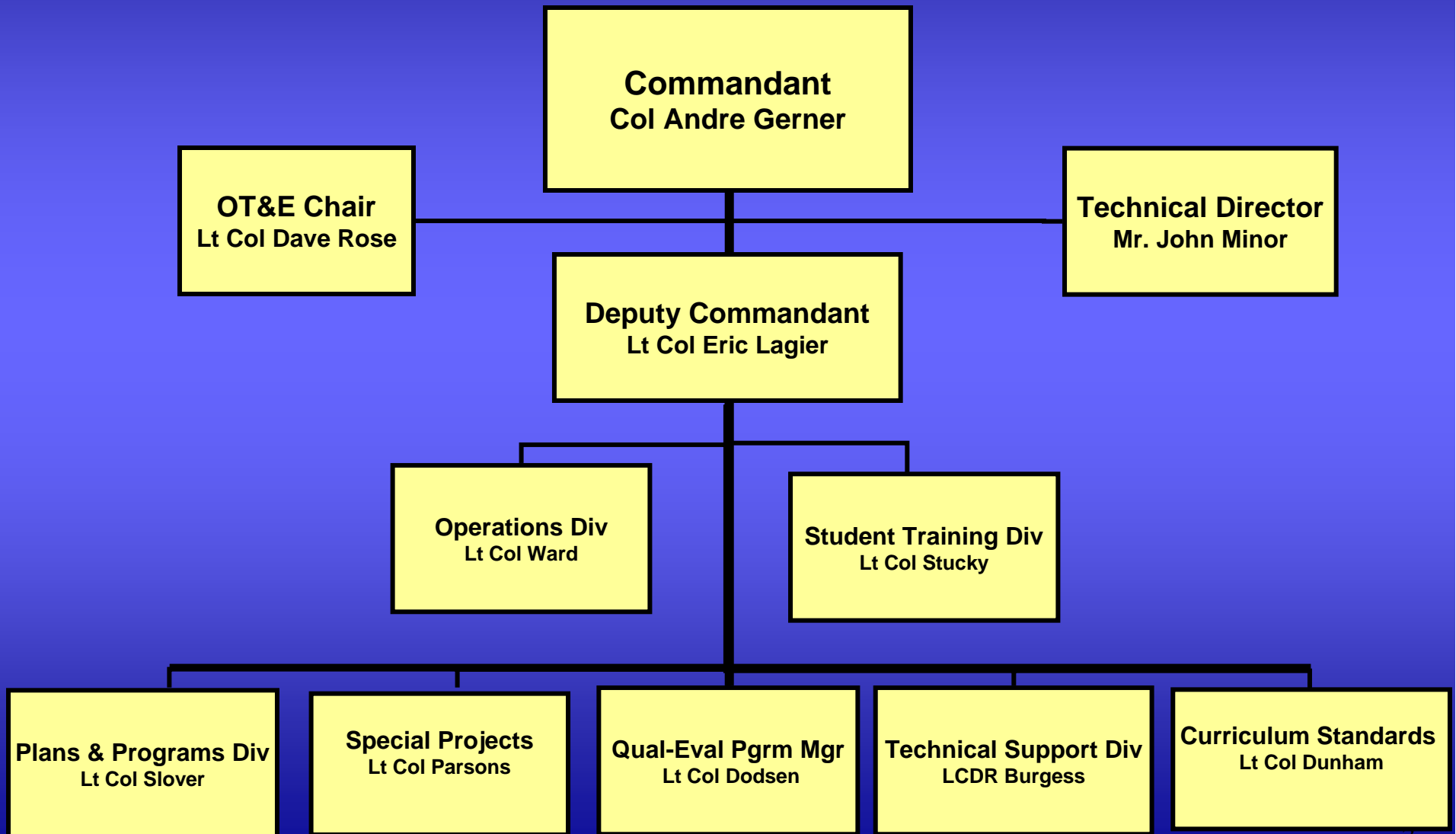


- **VISION:** *World's premiere educational & training center of excellence for theoretical and applied flight test engineering*
- **MISSION:** *Produce highly-adaptive critical-thinking flight test professionals to lead & conduct full-spectrum test & evaluation of aerospace weapon systems*



*Testers exert huge (often unseen) influence over weapon systems*

# USAF TPS Organization



# History



1940

1950

1960

1970

1980

1990

2000

2010

**1944 Established at Wright Field**

**1951 Moved to Edwards AFB**

**1961 Aerospace Research Pilot  
(ARP) Course Added  
Renamed USAF ARPS**

**1972 ARP Course Terminated  
Systems Phase Added  
Renamed USAF TPS**

**1973 FTE Program Initiated**

**1977 FTN Program Initiated**

**1990 TMP Phase Added**

**2000 Short Courses Added**

# USAF TPS Graduate Trivia




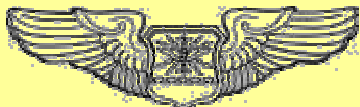

## *2,468 Total Graduates (1944-2004)*

- *Thomas D. White USAF Space Trophy* 11
- *David C. Schilling Award* 16
- *Mackay Trophy* 7
- *National Aviation Hall of Fame* 11
- *J. H. Doolittle Award* 11
- *Robert J. Collier Trophy* 17
- *Iven C. Kincheloe Award* 37
- *Harmon International Trophy* 16
- *Octave Chanute Award* 12
- *Lancaster Walk of Honor* 21
- *Aviator's Valor Award (Brig Gen Yeager & Senator Knight)* 2

# Eligibility Requirements



USAF-TPS

<b>Course</b>	<b>Time in Service</b>	<b>Education</b>	<b>Experience</b>	<b>Physical Qualification</b>
<b>PILOT</b> 	$\leq 10$ yr	<i>BS in Engineering, Math, or Physics</i>	<i>750 hr or IP (MWS)</i>  <i>12 mo AC in MWS</i>	<i>Annual Flying Class II</i>
<b>NAVIGATOR</b> 	$\leq 10$ yr	<i>BS in Engineering, Math, or Physics</i>	<i>500 hr or IN (MWS)</i>	<i>Annual Flying Class II</i>
<b>ENGINEER</b> 	$\leq 8$ yr	<i>BS in Engineering, Math, or Physics</i>  <i>Technical Masters highly desired</i>	$\geq 2$ yr experience in <i>13XX, 14NX, 21AX, 21CX, 21LX, 21MX, 33SX, 61SX, 62EX, 63AX</i>  <i>(civ: <math>\geq 2</math> yr in T&amp;E)</i>	<i>Annual Flying Class III</i>

# Current Student Stats



USAF-TPS

Class	Pilots	Navs/WSOs	Engineers	Aircraft	Services, Nations
<b>05B</b> Jul 05-Jun06 22 students	11  <b>BS GPA: 3.4</b> <b>MS GPA: 3.9</b> <b>Fly Hrs: 1520</b>	2  <b>BS GPA: 3.0</b> <b>MS GPA: n/a</b> <b>Fly Hrs: 1390</b>	9  <b>BS GPA: 3.5</b> <b>MS GPA: 3.8</b>	<b>F-15</b> <b>F-16</b> <b>C-130</b> <b>C-17</b> <b>B-52</b> <b>KC-135</b>	<b>USMC</b> <b>Japan</b> <b>Italy</b>
<b>06A</b> Jan 05-Dec06 24 students	12  <b>BS GPA: 3.46</b> <b>MS GPA: 3.93</b> <b>Fly Hrs: 1604</b>	2  <b>BS GPA: 3.45</b> <b>MS GPA: 3.50</b> <b>Fly Hrs: 1968</b>	10  <b>BS GPA: 3.50</b> <b>MS GPA: 3.65</b>	<b>A-10</b> <b>B-1</b> <b>B-52</b> <b>C-17</b> <b>C-141</b> <b>C-130</b> <b>F/A-18</b> <b>F-15</b> <b>F-16</b> <b>KC-135</b>	<b>USN</b> <b>Israel</b> <b>UK</b> <b>Civilian</b>

# International Students

(Current as of Class 06A)



<i>COUNTRY</i>	<i>#</i>	<i>LAST YR ATTENDED</i>	<i>COUNTRY</i>	<i>#</i>	<i>LAST YR ATTENDED</i>
<i>ARGENTINA</i>	<i>1</i>	<i>1964</i>	<i>JAPAN</i>	<i>13</i>	<i>2005</i>
<i>AUSTRALIA</i>	<i>3</i>	<i>1991</i>	<i>KOREA</i>	<i>5</i>	<i>1993</i>
<i>BELGIUM</i>	<i>2</i>	<i>2001</i>	<i>MALAYSIA</i>	<i>1</i>	<i>1981</i>
<i>BRAZIL</i>	<i>9</i>	<i>1986</i>	<i>NETHERLANDS</i>	<i>17</i>	<i>2003</i>
<i>CANADA</i>	<i>62</i>	<i>2005</i>	<i>NORWAY</i>	<i>12</i>	<i>2003</i>
<i>DENMARK</i>	<i>5</i>	<i>1981</i>	<i>SINGAPORE</i>	<i>8</i>	<i>2004</i>
<i>FRANCE</i>	<i>20</i>	<i>2005</i>	<i>SPAIN</i>	<i>9</i>	<i>2004</i>
<b><i>GERMANY</i></b>	<b><i>18</i></b>	<b><i>2002</i></b>	<i>SWEDEN</i>	<i>5</i>	<i>1991</i>
<i>GREECE</i>	<i>1</i>	<i>2001</i>	<i>SWITZERLAND</i>	<i>1</i>	<i>1982</i>
<i>INDIA</i>	<i>4</i>	<i>1991</i>	<i>TAIWAN</i>	<i>6</i>	<i>1997</i>
<i>ISRAEL</i>	<i>33</i>	<i>2006</i>	<i>THAILAND</i>	<i>1</i>	<i>1983</i>
<i>ITALY</i>	<i>59</i>	<i>2005</i>	<i>UNITED KINGDOM</i>	<i>9</i>	<i>2006</i>

**GRAND TOTAL 304**



# Curriculum



- *48 Weeks of Intensive Training*
- *4 Major Phases of Training*
  - *Performance*
  - *Flying Qualities*
  - *Systems*
  - *Test Management*
- *387 hrs academic instruction*
- *135 hrs flight training + 79 hrs ground school (pilots)*
- *20 scored academic tests*
- *21 graded written reports (15 written + 6 oral)*
- *Capstone Test Management Project*
- *Comprehensive Written & Oral Exams*

# Core Curriculum Aircraft

F-16



T-38



NF-16D VISTA



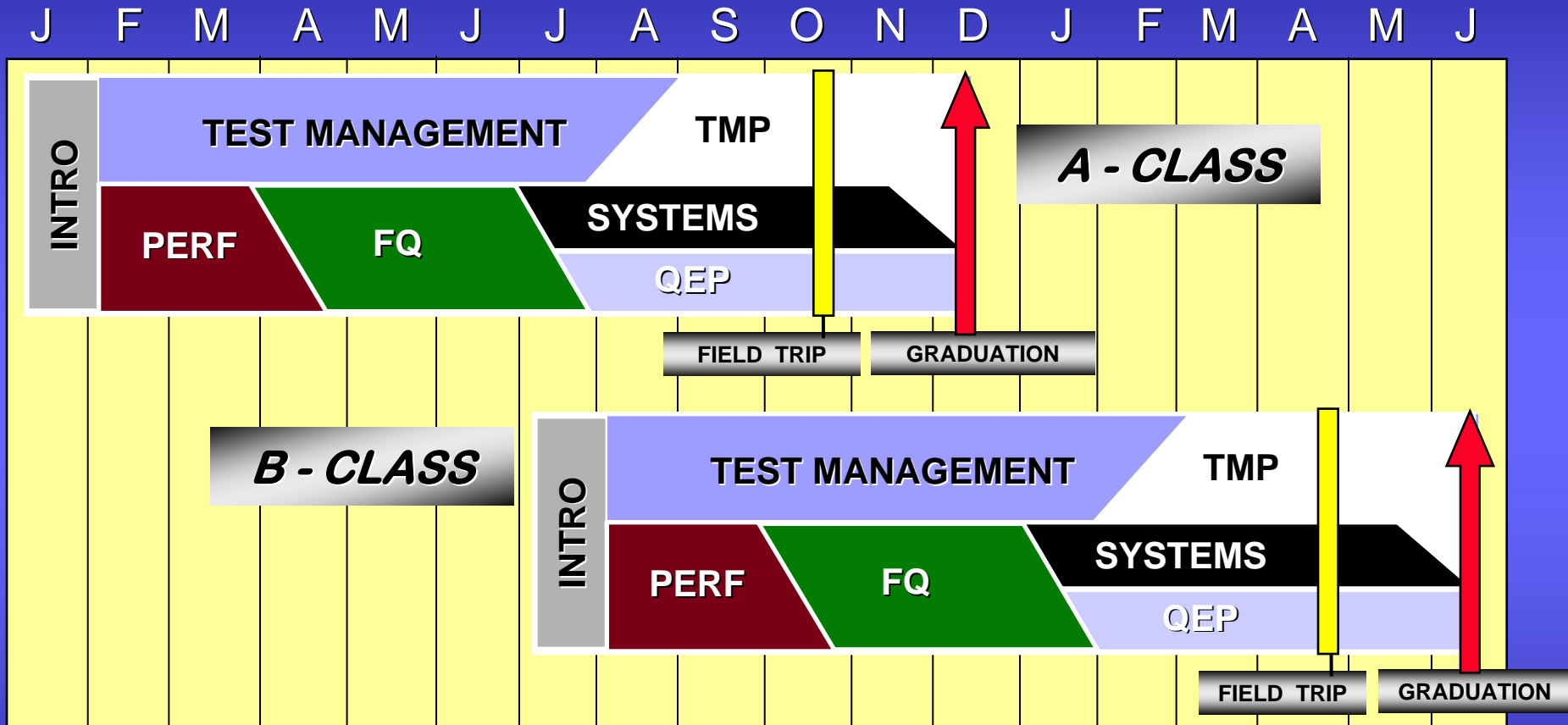
C-12



ASK-21



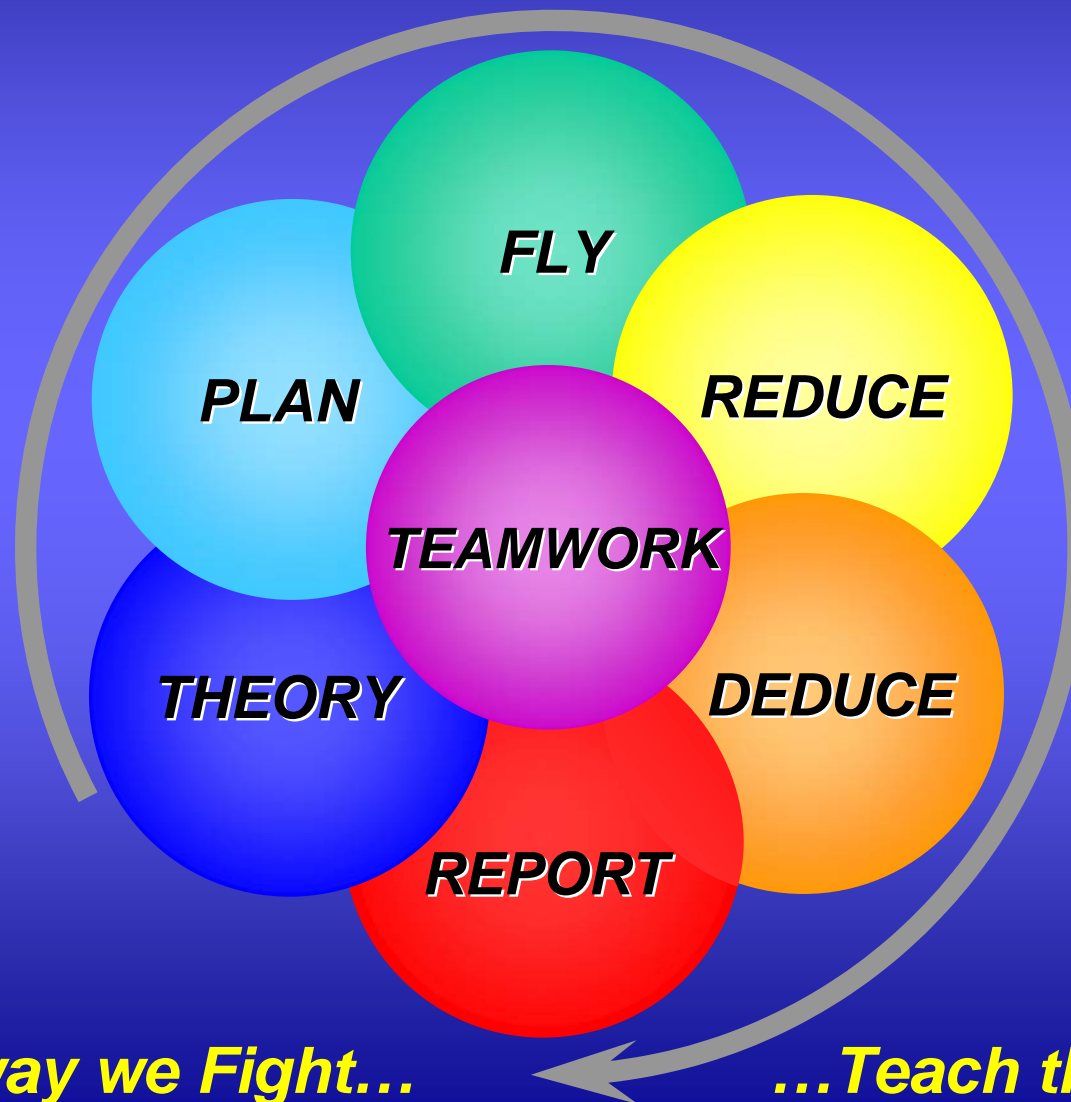
# Master Schedule



- PERF** = Performance
- FQ** = Flying Qualities
- TMP** = Test Management Project
- QEP** = Qualitative Evaluation Program

# Learning Paradigm

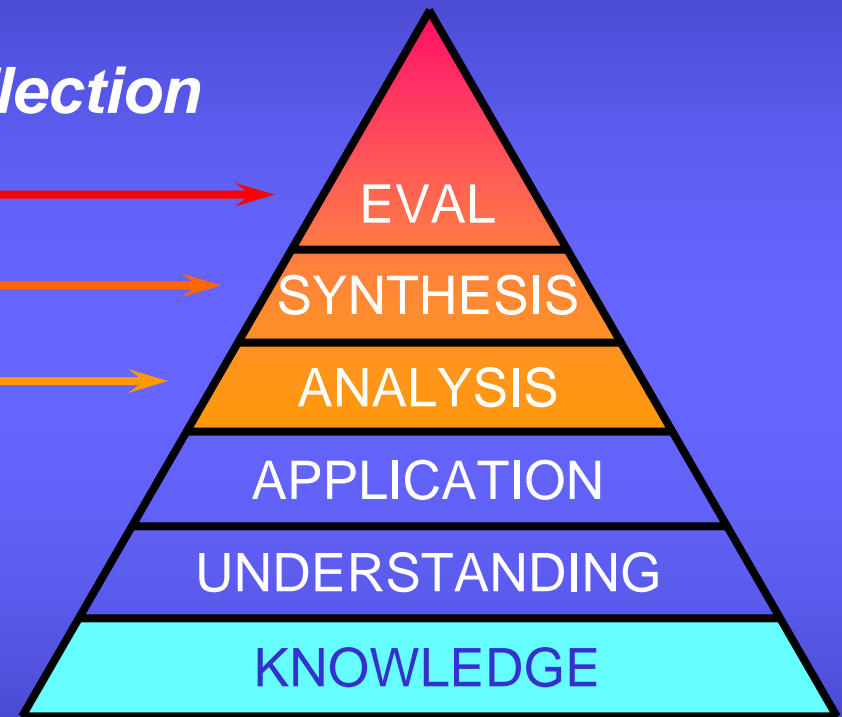
*An Applications-Oriented Pedagogy*



# DEDUCE



- *The Most Difficult Step*
  - *Requires Time for Reflection*
    - *RECOMMEND* →
    - *CONCLUDE* →
    - *ANALYZE* →
  - *Stimulates  $\alpha$ -level Neural Activity*
  - *The “E” in T&E*



*Bloom's Taxonomy*

- *95% of a BS program remains at knowledge level*
- *What we mean when we say “Critical Thinking”*

# Performance Phase



## Purpose

- *Basic flight test methodology*
- *Learn test program conduct*
- *Motion of the aircraft C.G.*  
“How far, how fast, how high...”

## Courses

- *Introduction to Aerodynamics*
- *Compressible Aerodynamics*
- *Data Standardization*
- *Air Data System Calibration*
- *Energy Concepts*
- *Takeoff and Landing*
- *Cruise*
- *Modeling and Simulation*
- *Propulsion*

## Resources

- *65 hr Performance Theory*
- *16 hr Flight Test Techniques*
- *25 flt hr-pilots (20 flt hr-FTE/Ns)*
  - *Data Group acft*
  - *Gliders*
  - *C-12*
  - *HU-16*
- *8 flt hr (pilots only)*
  - *T-38 & F-16*
- *8 flt hr crew solo (data groups)*
  - *C-12, F-16 or T-38*



# Flying Qualities Phase



## Purpose

- Evaluate aircraft flying qualities
- Aero & flight control system models
- Motion of aircraft about its C.G.

## Courses

- Equations of Motion
- Trim & Stability
- Handling Qualities Evaluation
- Flight Control Systems
- Aero-Servo-Elasticity
- Stall and High AoA
- Flight Test Simulators
- First Flight Testing
- Envelope Expansion Testing
- Failure State Testing
- Structures
- Stores Certification

## Resources

- 126 hr Flying Qualities Theory
- 29 hr Flight Test Techniques
- 3 hr Handling Qualities Sims
- 49 flt hr-pilots (33 flt hr FTE/Ns)
  - Glider FQ & spins
  - T-38 FQ, HQ & stalls
  - Var-Stab Learjet / VISTA
  - F-15 Asym Stores
  - F-16 High AoA & LCO



# Systems Phase



## Purpose

- Evaluate aircraft systems
  - Performance, Suitability, Human Factors, Pilot Vehicle Interface
- Exposure to wide variety of systems

## Courses

- Human Factors
- EO & IR systems
- Radar systems
- Electronic Warfare systems
- Integrated Navigation systems
- Weapons Delivery Testing
- Smart Weapons
- Avionics Systems Integration
- Integrated Systems Evaluations
- Data Link systems
- UAVs

## Resources

- 84 hr Systems Theory
- 14 hr Flight Test Techniques
- 18 hr Labs (22 hr FTE/Ns)
- 5x F-16 IFAST Labs (6x FTE/Ns)
- 15 flt hr-pilots (11 flt hr FTE/Ns)
- BAF tour
- NTTR field trip
- 2-dy UAL field trip (B777 & A320)





# Test Management Phase



## **Purpose**

- *Spans entire curriculum*
- *Test management*
  - *Systems acquisition process*
- *Capstone Test Management Project*
  - *Real world / real customer*
- *Experience broadening in wide variety of aircraft (Qual Eval Pgm)*
- *Reporting in multiple formats*

## **Resources**

- *53 hr Academics*
- *1 hr Flight Test Techniques*
- *10-12 flights in non-curricular aircraft*
- *Test Management Project*
  - *AFFTC/Customer-sponsored*
  - *Major oral & written report (“greenback-equivalent”)*

## **Courses**

- ***Test Management Course***
- ***Test Safety (UTSO) Training***
- ***Qual Eval Demo FTT***
- ***Deficiency Reporting***
- ***All-Weather Testing***
- ***Test Conduct***
- ***DOE / Probability & Statistics***
- ***Technical Writing***
- ***Instrumentation***



# Staff/Student Test Management Project (TMP) Research Opportunities



- **What are TMPs?**

- Limited Scope/Duration Flight Test Projects
- Conducted by Students and/or World-Class TPS Staff
- Approx 10-15 fighter hours or 20-25 heavy hours
- Conduct ~ 8 Projects/Year (4 in Spring, 4 in Fall)

- **Customer Provides:**

- Research concept or “widget” to be flight tested
- \$\$\$ for any specialized support or major acft mods

- **TPS Provides:**

- Test Aircraft - Usually flown on AFFTC Assets
- Dedicated Test Team of Pilots/Engineers (4-6 individuals)
- \$\$\$ for Flight Hours, “minor” acft mods, T&E
- Flight Test Data, Data Reduction, Data Analysis
- DTIC-Ready Technical Report

# NO GYRO Student TMP



## AERONAUTICAL ENGINEERING

# Hands-Off Aerial Refueling

Student-designed computer program and control system could help increase deployment range and endurance of UAVs

DAVID FULGHUM/WASHINGTON

Two U.S. Air Force test pilot school students have designed an autonomous aerial refueling scheme for an unmanned tanker and an unmanned combat aircraft, and have completed a test flight program.

Capt. Chris Spinelli designed a program for the two aircraft's carrier phase differential GPS systems. Capt. Steve Ross designed a control system for the Learjet (surrogate unmanned aircraft).

Bank-angle and roll-rate measurements and the relative positions of the C-12 (surrogate tanker, top) were recorded and linked to the receiver aircraft. These inputs manipulated the control surfaces and throttles, automatically allowing the aircraft to hold a series of positions and transitions while flying a standard race-track course, even when the tanker was in a 30-deg. bank. By the final flights, pilots kept their hands off the controls for nearly 2 hr. In straight-and-level flight, the controller held the receiver within 1.3 ft. of the desired refueling position.

The students believe this to be the first demonstration of autonomous aerial re-



fueling maneuvers over a standard race-track course. The capability is expected to increase unmanned aircraft deploy-

ments and decrease dependence on in-theater bases while extending range and on-station time.

# VLSTA

Variable Stability In-Flight  
Simulator Test Aircraft



U.S. AIR FORCE  




# What is VISTA?



- *Variable-Stability In-Flight Simulator Test Aircraft*
- *Highly modified Peace Marble II Block 30 F-16D*
- *Capable of hi-fi sim of aircraft “model” in real flight environment*
- *Rapidly reconfigurable H/W & S/W*
- *Provides a platform for FQ, Systems, TMP, Research:*
  - *technology and S/W demos (e.g. Auto ACAS)*
  - *flight control conceptual research (e.g. MATV)*
  - *high credibility handling qualities evaluations (e.g. HAVE ROVER)*
  - *realistic environment cockpit display flight tests (e.g. JSF, ASAR, HUD)*

***A unique national asset...sets USAF TPS apart!***



# Student VISTA

## Research Projects/TMPs

- 98B HAVE TRACK**     *HUD Target as Substitute Aircraft Target for HQ Evals*
- 00A HAVE OLOP**     *PIO in the Presence of Rate Limiting*
- 00B HAVE ATTITUDE** *Off-Axis Attitude Cueing for Helmet Mounted Sights*
- 01A HAVE ROVER**    *PIO Detection and Suppression*
- 01B HAVE GRAPE**    *Collect GPS TSPI data for follow-on TCAS testing*
- 02A HAVE PREVENT** *Comparison of PIO Prevention Algorithms*
- 02B HAVE SYCLOPS** *Flight Reference Displays*
- 03A MAX GAP**        *PIO Prediction Algorithms*
- 03B SELF SERVE**    *Autonomous Rendezvous for AAR*
- 04A SOLO FORM**     *Automatic Formation Flight*
- 04A DOLLAR DRAFT** *Refine Positioning for Formation Cruise Drag Reduction*



# Staff VISTA

## Research Projects

- 2001 *Helmet Mounted Display Demo*  
*Air National Guard Weapons Conference*
- 2003 *Helmet Mounted Assembly*  
*British Aerospace Engineering*
- 2003 *Automatic Air Collision Avoidance System (Auto ACAS)*  
*AFRL/VA (SETP - Tony Levier Safety Award)*
- 2004 *Arc Segment Attitude Reference (ASAR), Head-Up Display (HUD)*  
*AFRL/HEVC*

# Qualitative Evaluation Program

(representative aircraft)



- ***Builds a broad foundation of experience***
- ***Exposure to unique civil/military aircraft***
- ***Reinforce TPS curriculum learning objectives***
  - ***Performance, flying qualities, systems and mission suitability***
- ***Evaluates students' abilities to plan, execute and report a unique and unfamiliar flight test experience***
- ***Builds confidence to handle new flight test situations in a systemic/logical manner (build-up approach)***





# Short Courses



- *Senior Executive Short Course* 3 days
- *EW Flight Test Engineering Short Course* 4 days
- *Aerospace Vehicle Test Course* 4 weeks
- *Test Management Short Courses* 4 days-  
3 weeks
- *Propulsion Academic Course* 4 days
- *Equations of Motion Flight Test Course* 3 days
- *UAV Flight Test Course (newest course)* 3 weeks

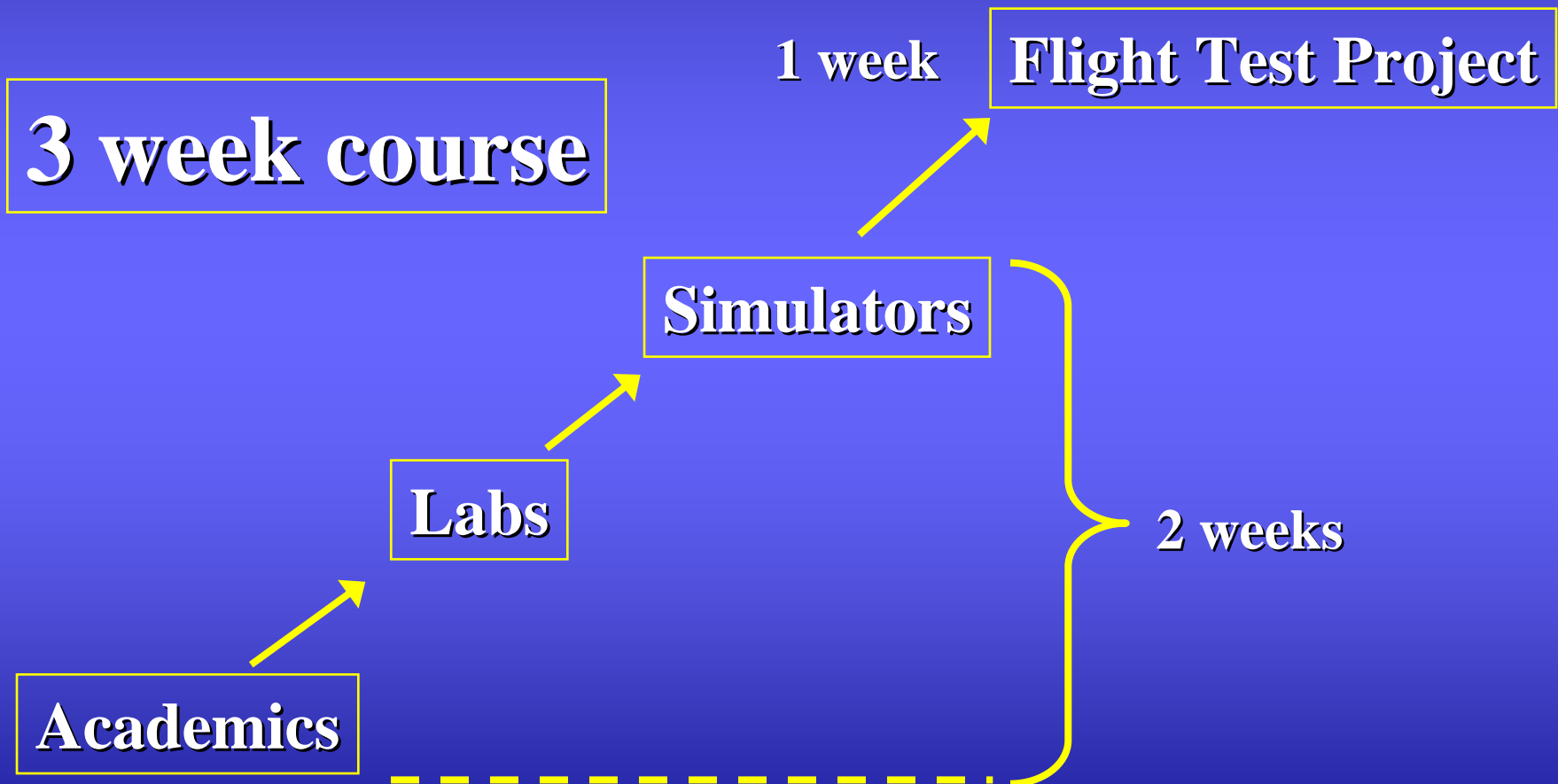
Huge TPS Growth Area

# The First UAV Flight Test Class



Fully Autonomous Mode  
Manual Back Up Mode  
Upload New Mission “On the Fly”

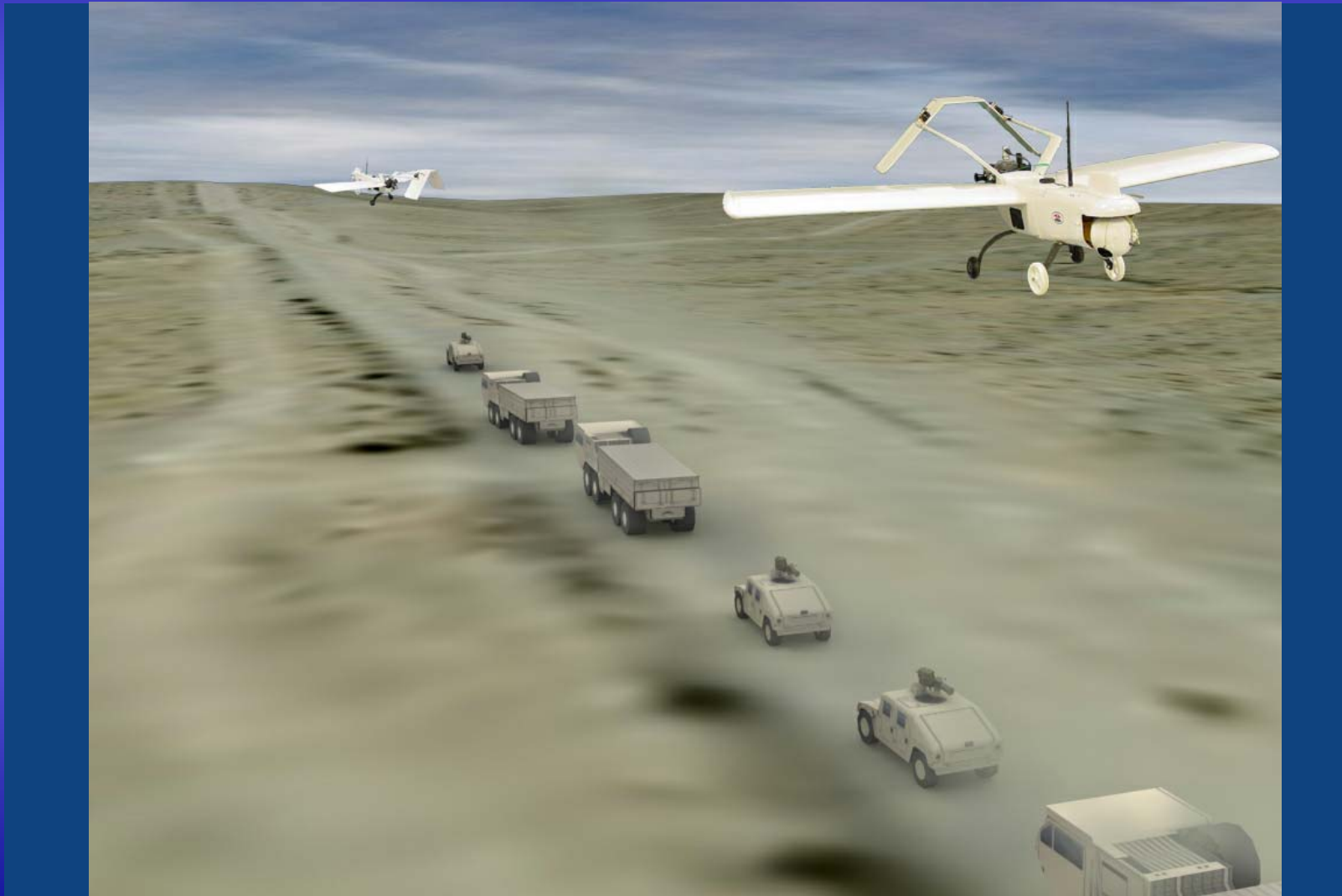
# Build Up Approach



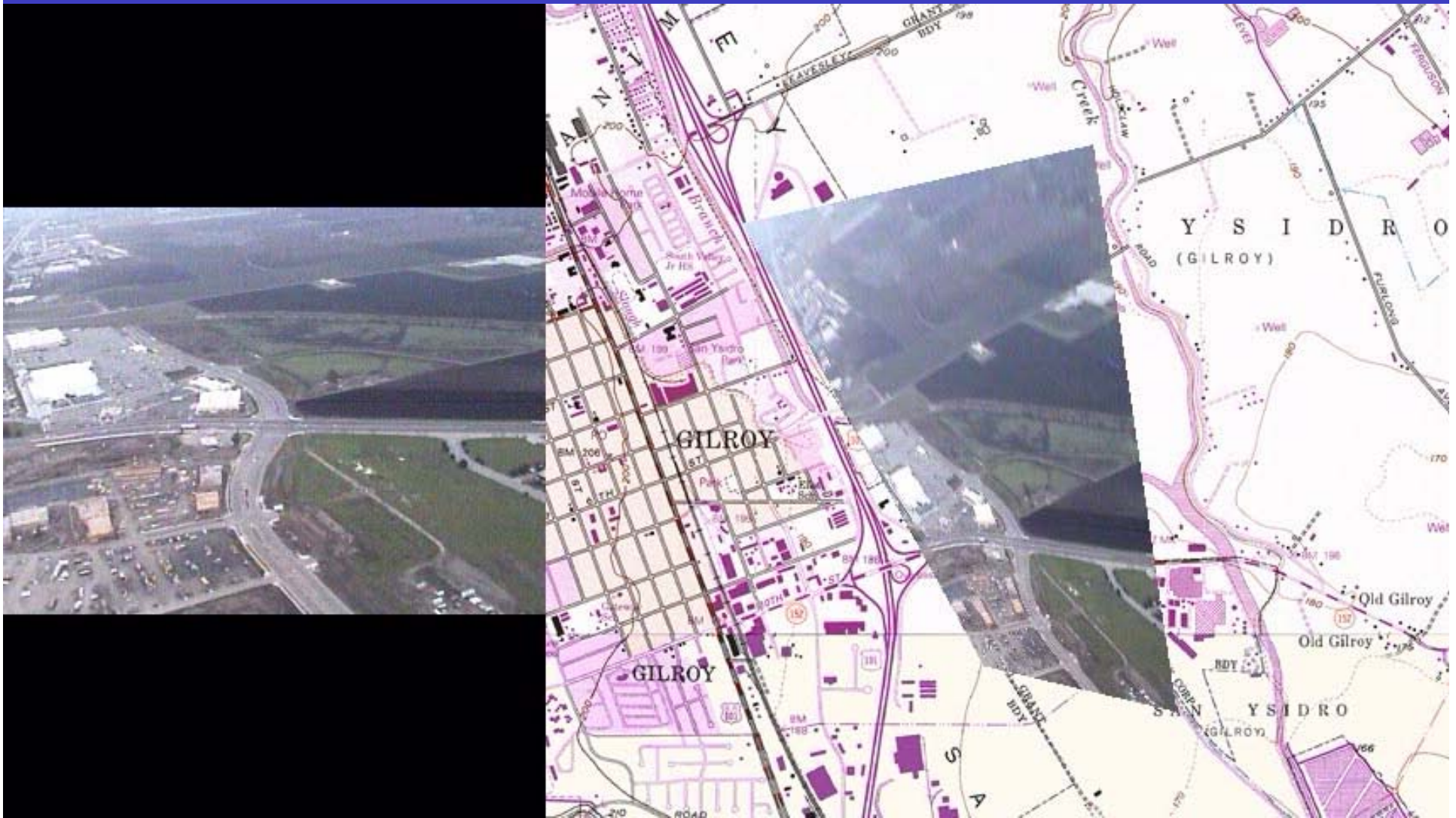
		Week 1				
		Day 1	2	3	4	5
AM	Keynote / Intro History of UAVs	UAV Missions - Systems - Flight Envelopes EO/IR Sensors	SAR	Data Link C <sup>2</sup> (EMI/EMC)	Data Link (Sensor Up/Down Links)	
PM	Current UAVs / Capabilities Course Overview	EO/IR Sensors FTT	SAR FTT	EO/IR / Radar Lab	<i>South Base</i> Global Hawk (GH) Brief	
			X-45 System Brief	Radar/ EO/IR Lab	GH Shelter / Tour	
		Week 2				
		Day 6	7	8	9	10
AM	RF Elint/Signature/EW Directed Energy	Nav Systems - INS - GPS/DGPS - Sensor Integration - Target Geolocation	Mission Planning Airspace/NAS/FAA Range Issues	Aero / Propulsion	GH Pre-Flight	
	EW - Tow Decoy - Self Protect			Launch & Recovery	GH Flight	
PM	Weapons - Hell Fire - Stinger	X-45 Tour	TCAS / GATM	GH Flight Prep (Canned Cards)	GH Brief GH Data / Analysis	
			GH Project Brief	Darpa Brief	UAV Flt Tst Pre-Brief	
		Week 3				
		Day 11	12	13	14	15
AM	HF Computer Interface	(0600) Flight Brief Flight DeBrief	R/C WX Backup	Project Time	Graduation Brief	
	Range & Safety Planning				Grad Luncheon	
PM	UAV Flt Tst Prep	Data Analysis	Predator Tour	Project Time		

# Typical Training Mission

(Video)



# Target Geolocation Accuracy Sensor FOV to Map Overlay (P3I)



# Reduce—Deduce—Report



**Students reduce, analyze, and evaluate data from actual flight test exercises.**

**This is where students achieve the higher levels of learning by reinforcing academic principles and theory learned in the classroom**

# On the Horizon...



- **ACCREDITATION**

- *MS in Flight Test Engineering (ABET)*

- *Requires change to USC Title 10*
    - *USN TPS, EPNER, EMPIRE “on-board”*
    - *AFIT/USAFFA Fully Support this Effort*
    - *Request currently with HQ USAF*
    - *Likely to be the Most Significant Driver of Long-term Institutional Change*



# Graduate Core Competencies



- *Diverse Aerospace Vehicle Exposure*
- *Flight Test Engineering* *THEORY*
- *Flight Test Techniques*
- *Flight Test Planning* *PLAN*
- *Safety Planning & Risk Management*
- *Flight Test Execution* *FLY*
- *Data Management* *REDUCE*
- *Flight Test Evaluation* *DEDUCE*
- *Flight Test Reporting* *REPORT*
- *Integrated Test Teaming* *TEAMWORK*

**= Full-Spectrum Flight Test Professional**

# Summary



- *USAF TPS takes the world's best operational Pilots, WSO/Navs and Engineers and produces the world's best highly adaptive, critical thinking, leaders in flight test and evaluation*
- *Result: Best Weapon Systems for the Warfighters*
- *SAFETY in T&E is our #1 PRIORITY*
- *Very Challenging 48-week program*
- *Best year of their lives!*