COCKPIT®

July - December 2014

THE SOCIETY OF EXPERIMENTAL TEST PILOTS
BOARD OF DIRECTORS

President	*Mark Stucky, Virgin Galactic*
Vice President	*Michael Wallace, Boeing*
Secretary	*Todd Ericson, Virgin Galactic*
Treasurer	*Nicola Pecile, NTPS*
Legal Officer	*William Gray, USAF TPS*
Executive Advisor	*Kevin Prosser, Calspan*
President-Elect	*Timothy Morey, Wyle*
Technical Advisor	*Greg Lewis, NTPS*
Technical Advisor	*Terry Lutz, Airbus*
Canadian Section Representative	*William Colquhoun, Bombardier Aerospace*
Central Section Representative	*Steve Stowe, Bombardier Aerospace*
East Coast Section Representative	*Eric Mitchell, Northrop Grumman*
European Section Representative	*Jeremy Tracy, AgustaWestland*
Great Lakes Section Representative	*Eric Fitz, Dept. of the Air Force*
Northwest Section Representative	*Jennifer Henderson, Boeing*
Southeast Section Representative	*David Wright, Dept. of the Air Force*
Southwest Section Representative	*Norm Driscoll, Designet*
West Coast Section Representative	*David Kern, Lt Col, USAF*
Executive Director	*Paula S. Smith*

CANADIAN SECTION

Chairman	William Colquhoun
Vice Chairman	Richard Ling
Secretary	Brad Koskie
Treasurer	Constantin Stan

EAST COAST SECTION

Chairman	Brian Sandberg
Vice Chairman	Tobias Van Esselstyn
Secretary	Todd Lardy
Treasurer	Andrew McFarland
Educational Outreach	Eric Mitchell

GREAT LAKES SECTION

Chairman	Eric Fitz
Vice Chairman	David Glade
Secretary	Ryan Smith
Treasurer	Ed Conant
Educational Outreach	Gary Konnert

SOUTHEAST SECTION

Chairman	David Wright
Vice Chairman	Brian Taliaferro
Secretary	Jason Dotter
Treasurer	Ryan Sanford

CENTRAL SECTION

Chairman	Steve Stowe
Vice Chairman	Moe Girard
Secretary	Stu Rogerson
Treasurer	Jeff Karnes
Educational Outreach	Aaron Tobias

EUROPEAN SECTION

Chairman	Rudolph Engeler

NORTHWEST SECTION

Chairman	Jennifer Henderson
Vice Chairman	Stu Farmer
Secretary	Jim Young
Treasurer	Chad Lundy
Educational Outreach	Jennifer Henderson

SOUTHWEST SECTION

Chairman	Dan Wells
Vice Chairman	Norm Driscoll
Secretary	Jim Acree
Treasurer	Jeff Trang

WEST COAST SECTION

Chairman	David Kern
Vice Chairman	Andrew Thurling
Secretary	Glenn Graham
Treasurer	Richard Zins
Educational Outreach	Timothy McDonald

SETP COMMITTEES

Flight Test Safety Committee Chairman	Gerald Whites
Membership Committee Chairman	Eric Hansen
2015 Fellows Coordinating Committee Chairman	Steve Rainey
Publications Committee Chairman	Allen Peterson
Critical Incident Response Committee	Billie Flynn
SOP Committee / Constitution	Greg Lewis

SETP 2015 CALENDAR

8th Southeast Symposium
20 February 2015
Eglin Bay Club, Eglin, FL

31st East Coast Symposium
10 April 2015
Bay District Volunteer Fire Department Company 3 Social Hall, Lexington Park, MD

Flight Test Safety Workshop
4-7 May 2015
The Scottsdale Plaza Resort,
Scottsdale, AZ

47th European Symposium
10-13 June 2015
Luzern, Switzerland

45th West Coast Symposium
27-28 March 2015
Catamaran Resort, San Diego, CA

5th Northwest Symposium
24 April 2015
The Museum of Flight, Seattle, WA

Great Lakes Symposium
14 May 2015
Wright-Patterson AFB - Banquet Center
Dayton, OH

Central Section Symposium
19 June 2015
The Hotel at Old Town, Wichita, KS

59th Symposium & Banquet
23-26 September 2015
Grand Californian Hotel & Spa
Anaheim, CA

COCKPIT is published by The Society of Experimental Test Pilots

Address all correspondence to SETP Publications Chairman,
Post Office Box 986, Lancaster, California 93584-0986
661-942-9574

Table of Contents:

President's Memo.....4
Technical Articles.....5
Editor's Memo.....45
2015 Symposium Information.....87
New Members and Upgrades.....92
Who...What...Where.....98
Book News.....101
Section News.....103
Scholarship Foundation News.....110
SETP Foundation News.....111
58th Annual Symposium and Banquet Report.....112
2014 Symposium Highlights.....131
Last Flights.....136

Cover Photo

The F-35 Lightning II carrier variant Joint Strike Fighter (JSF) made history in November 2014 as it performed its first set of arrested landings and catapult launches aboard an aircraft carrier. The F-35's initial at-sea developmental test (DT) aboard the USS Nimitz (CVN 68) also featured a 2-plane flyover off the coast of California led by Lockheed Martin test pilot Elliott "Hemo" Clemence (M) in CF-03 (Flt 193) and LCDR Theodore Dyckman (M) in CF-05 (Flt 100). Lockheed Martin photo by Dane Wiedmann.

PRESIDENT'S MEMO

Mark P. Stucky (F)
Scaled Composites
SETP President

For 2015 the Society's Board of Directors will strive to continue increasing the benefits and value that membership brings to all members by facilitating outstanding symposia and improving the ability to use the SETP website to research the latest lessons learned, flight test techniques and identify discipline experts. We are also taking new measures to ensure the Society remains fiscally viable and poised for the future. Membership is at an all-time high and this is being accomplished not by relaxing the rules but by a two-pronged approach that first ensures the qualifying criteria reflect our modern pilot-in-the-cockpit flight test industry and secondly by using local Section representatives to facilitate the application process. Similarly, the process for Fellow selection has been revamped to make it more equitable and less prone to cronyism.

As a reminder, SETP's mission is to further advance aerospace science and engineering by promoting safety, communication and education in the design and flight test of aerospace vehicles and their related systems, to mentor rising generations and to be the world's leading authority and source of history about the test pilot profession and the practice of test and evaluation of aerospace systems.

The SETP Foundation is chartered with preserving and maintaining the Society's important historical data to include memorabilia, written and oral records, reports, photographs and other artifacts of historical significance relating to test pilots and our profession. But to be blunt we have been doing an abysmal job at this, the main reason being SETP needs a facility better suited for this mission. Additionally, simply storing historical artifacts does not support our above mission statement. Recently, we were informed the Society is on the short list of potential recipients to be gifted a private collection of aviation documents and memorabilia that is literally worth millions of dollars.

And that is the rub – does the Society want a building that includes adequate space not just for meetings but also for research and mentoring? Are we ready to undertake the short term fund raising challenge as well as the long-term responsibility? We will be conducting a membership survey to answer these questions.

Per aspera ad astra,

Mark P. Stucky

Mark 'Forger' Stucky
President, SETP

TECHNICAL ARTICLES

REMOTELY PILOTED VEHICLE FLIGHT TEST TECHNIQUE DEVELOPMENT AND TRAINING AT THE NATIONAL TEST PILOT SCHOOL

Ryan T. Olson 1, Chris M. McElroy 2

1 National Test Pilot School, Mojave, CA, USA
Email: rolson@ntps.edu

2 National Test Pilot School, Mojave, CA, USA
Email: cmcelroy@ntps.edu

ABSTRACT:
The National Test Pilot School (NTPS) began offering a Remotely Piloted Vehicle (RPV) flight test short course in April of 2006. Initially various flight test techniques were taught solely via simulation. To improve the value of training provided it was considered necessary for NTPS to operate a RPV. Accordingly, a Cessna 150 was converted into an Optionally Piloted Aircraft (OPA). The aircraft was certified in August of 2010 as an OPA by the Federal Aviation Administration (FAA) and following comprehensive ground testing the first flight of the OPA occurred in June 2011. Subsequently two phases of flight testing were completed the second of which was completed in early 2013. Current certification requires that the OPA be operated with a certified safety pilot on-board who can deactivate the ground-controlled autopilot system if necessary. The system is capable of being controlled via command direction or in a remotely piloted vehicle mode. This paper incorporates a description of the development, evaluation, and validation of flight test techniques using the OPA as a surrogate for RPVs. Additionally, this paper focuses on the unique considerations required for effective OPA/RPV flight test team collaboration, due to the increased complexity of Crew Resource Management (CRM).

1 INTRODUCTION

The primary objective of NTPS is to educate and train test pilots and flight test engineers to be able to successfully plan and execute flight test programs for their military or civilian test and evaluation organizations immediately upon graduation. The NTPS professional course is divided into two six-month phases of performance and flying qualities (P&FQ) and avionics systems. NTPS also offers specialized flight test training via scheduled and on-demand short courses of two to six weeks duration. Although specific flight test techniques are taught, the underlying philosophy of flight testing is continually reinforced throughout the course. Graduates of NTPS are capable of applying this fundamental philosophy to any flight test program or flight test technique.

The development of RPVs has been intertwined with manned flight throughout the history of aviation. Initial unmanned aircraft were typically employed as technology demonstrators used to test and evaluate theories and ideas before implementation on manned versions [1]. Thanks both to the introduction of the Global Positioning System (GPS) and technology spurred by the ever improving capabilities of microprocessors, the utility and importance of RPVs has increased apace since the mid-1990s. The value gained by preventing the loss of human life (or prisoner of war/hostage situations) during dangerous operations as well as the ability to eliminate life support and egress systems from manned aircraft has gradually exceeded the cost of integrating the required technology to support unmanned vehicles [2, 3]. RPVs have demonstrated their effectiveness in carrying out missions that are impossible for an onboard pilot. In short, RPVs are ideally suited for many missions that are deemed “Dull, Dangerous or Dirty” (D3) [4].

As a consequence of the rapid expansion of the RPV industry, NTPS recognized a need for RPV flight test training and began offering a two-week RPV flight test short course in April of 2006. Initially, the course was comprised of academic lectures and RPV flight test technique demonstrations, the latter taught solely via simulation. Whilst the initial courses were considered to be successful, it became clear that in order to enhance the realism, and hence, value of training it would be necessary for NTPS to acquire a RPV in order to demonstrate RPV Flight Test Techniques (FTTs) in-flight. It was therefore decided to proceed with converting an underutilized Cessna C-150 aircraft in the NTPS fleet into an OPA. The choice of OPA rather than a RPV was made in order to ensure that the vehicle could be operated from Mojave Air and Space Port, within the National Airspace System (NAS) and be free from significant weather and range limitations.

2 NTPS CESSNA C-150 OPA

The C-150 OPA, (Figure 1) has a single Continental O-200-A piston engine that produces 100 horsepower at 2750 RPM at sea-level. The aircraft has fully reversible flight controls driven by a conventional mechanical pulley system and electric flaps. In the OPA configuration the aircraft has an empty weight of 1,135lbs and a gross weight of 1600lbs, giving it a 465lb useful load. The aircraft is capable of reaching speeds up to 106kts in level flight and has a service ceiling of 12,650ft [5].

The C-150 was modified to be operated remotely via ground-based operator inputs made at a dedicated Ground Control Station (GCS). Control inputs at the GCS are transmitted to the OPA via a dedicated datalink and are input to a Cloud Cap Piccolo II autopilot onboard the OPA. The autopilot controls the OPA via vehicle elevator, ailerons, and throttle displacements.

Figure 1 – NTPS Cessna C-150 OPA

The autopilot obtains vehicle navigational, aerodynamic, and environmental data from several onboard sources: Inertial Measurement Unit (IMU), GPS, dedicated Pitot-static system, Above Ground Level (AGL) laser, magnetometer, RPM Hall effect sensor, Outside Air Temperature (OAT) thermocouple, angle of attack and angle of sideslip vanes, and control surface deflection string potentiometers. The autopilot sensor installation is packaged on a removable pallet in the baggage compartment behind the pilot's seat.

The Piccolo autopilot allows the system to be controlled via Command Directed Vehicle (CDV) mode or in a Remotely Piloted Vehicle (RPV) mode. In CDV mode airspeed, altitude, heading, bank angle, vertical rate, and navigation are commanded through the Piccolo Command Center (PCC) via one of three methods: 1) through the primary flight display by clicking and dragging command flags 2) by imputing a numerical value into the command loop window and sending the command to the aircraft 3) via mouse click on the moving map. PCC also enables the aircraft to fly preloaded or modified flight plans. The software supports up to 250 waypoints that can be utilized to create multiple flight plans [6].

In RPV mode the C-150 OPA is designed to be controlled using a joystick and throttle. The autopilot supports several different types of stability augmented manual control modes known as assist modes. The controller has steering and full authority modes. In steering mode the joystick controller is solely used to command bank angle for the autopilot. Full authority adds the elevator control of vertical rate, and the throttle control position is used directly. An autopilot disconnect is incorporated into the RPV control box in front of the joystick controller. With the autopilot off, in full authority override mode, the joystick and throttle on the RPV control box directly command control surface or throttle position. The keyboard and mouse can be utilized while the RPV mode is activated, although the control loops are deactivated.

The OPA is also equipped with a sensor payload system incorporating a Cloud Cap TASE200 gimbal mounted on the vehicle's port wing strut and a fixed forward looking electro-optic camera mounted on the top of the fuselage. The TASE200 gimbal (Figure 2) incorporates a FLIR Systems long wave Infrared (IR) sensor and a Sony color Electro-Optic (EO) sensor. The gimbal has its own IMU, GPS receiver, and also receives sensor information from the Piccolo II autopilot. The imagery from the gimbal and forward looking camera is digitized and downlinked to the GCS via a line-of-sight Orthogonal Frequency-Division Multiplexed (OFDM) Broadband Ethernet datalink operating in the

5.8GHz band. Software is utilized to display gimbal imagery and control the gimbal in manual, geo-referenced, or multiple tracking modes from the GCS.

Figure 2 - TASE200 Gimbal

Figure 3 - C-150 OPA GCS

The GCS is located in dedicated, restricted access control room. The configuration utilizes an array of four widescreen monitors to display the PCC and a projector to display the real-time forward looking video. A typical arrangement is shown in Figure 3. PCC has the capability to display a variety of windows for aircraft control and situational awareness. The GCS makes use of a Very High Frequency (VHF) radio for communications link and a steerable antenna controller to automatically track the OPA. The GCS communicates with the OPA via a Command and Control (C2) line-of-sight frequency hopping datalink operating in the 900MHz band.

In order to broaden the scope and increase the realism of the OPA training provided at NTPS the training scenario was expanded beyond simple OPA direct GCS control. Accordingly, the GCS was integrated into a typical flight test mission framework controlled by a Test Conductor (TC) supported by multiple Flight Test Engineers (FTEs). An interface was developed by NTPS allowing real-time parameters from the C-150 OPA to be displayed in the NTPS control room utilizing IADS software. A networked PCC display was projected in the control room to provide high resolution moving map, primary flight display, system status lights, and command loops for student TC/FTE situational awareness. The real-time feed from the OPA forward looking camera was also displayed.

2.1 GROUND TESTING

Ground testing of the OPA was undertaken over a period of six months, between December of 2010 and May of 2011. Ground testing included: Pitot-static instrument calibration, motor controller optimization, surface calibration, software and hardware in the loop simulation, sensor variable validation, magnetometer calibration, and RF spectrum analysis. The original analog servo amplifiers were found to be unacceptable and were subsequently replaced with Proportional-Integral-Derivative (PID) motor controllers which were tuned to achieve the desired response. Surface calibrations were completed for each individual axis after the motor controller settings were finalized. The initial autopilot parameters and feedback gains were determined using the Cloud Cap Software-In-the-Loop (SIL) simulator. Subsequently, Hardware-In-the-Loop (HIL) simulation was set up using the actual aircraft hardware, which helped identify several wiring and autopilot interface issues. All autopilot system sensors were tested to ensure accuracy of data output while being subjected to vibration during engine ground runs.

A comprehensive Radio Frequency (RF) spectrum analysis was completed throughout the OPAs intended geographical operating area prior to the first datalink flight test. Spectrum analysis testing utilized the GCS steerable antenna to evaluate individual radials with the transceiver's built-in spectrum analysis feature. Concurrent with the spectrum analysis, areas of potential antenna blanking due to obstruction/blockage were investigated by employing a camera mounted on the antenna rotator. Potential sources of interference were further investigated using a spectrum analyzer to aid in the selection of the desired frequency band for the C2 datalink.

2.2 FLIGHT TESTING

Following the successful completion of the ground testing activity the OPA entered its first phase of flight testing. This flight test effort was undertaken over a period of five months, between June and October of 2011. Twenty days of ground testing and 24 test flights totaling 28.8 flight hours were undertaken. The primary focus of the initial flight testing was to ensure autopilot controls were suitably optimized for both RPV and CDV modes. This initial period of flight testing also incorporated the following tests and evaluations: pitot-static differential between the aircraft and autopilot systems, navigation accuracy, laser altimeter accuracy, command and control datalink envelope, baseline response determination, inflight motor controller optimization, autopilot gain tuning, control authority and limit confirmation, flight plan track navigation logic validation, failure state testing, and RPV flying qualities evaluations.
The aim of the first flight was to ensure that the autopilot sensors, i.e. the IMU, GPS, dedicated pitot-static system, etc. transmitted timely and accurate data to the GCS and that the sensor outputs observed at the GCS concurred with those observed by the safety pilot onboard the OPA. The second through sixth flights focused on testing and refining the C2 and sensor payload datalinks. Without the benefit of the onboard safety pilot these vital confidence building tests would have been impossible.

Having confirmed the accuracy of the autopilot sensor data and operational range for the C2 datalink the seventh flight engaged the autopilot inflight for the first time. Engagement of the autopilot was initially found to be problematic as the autopilot was designed to be in the loop from takeoff to landing. The autopilot was taken out of the loop by selecting a full authority RPV override or rate command mode, prior to and throughout the engagement procedure. Once the clutches were engaged the override mode was disengaged immediately and introduced into the loop.

The remainder and majority of the first phase of flight testing focused on refining the parameters within the autopilot to enable smooth controllable flight. Within each axis, a standard series of tests were conducted to evaluate required adjustments. From these tests data was obtained to ensure an informed modification to control gain was made. The safety pilot onboard remained in control of the disengaged axes throughout the incremental testing. Eventually all axes were engaged and the final gain modifications were completed. The autopilot was tested for control authority and limit confirmation to ensure the autopilot mandates avoidance of set limits. Testing was also conducted to evaluate the system response to loss of GPS and C2 datalinks.

The second phase of flight testing focused on the integration of the TASE200 gimbal sensor payload system. This phase was completed over a period of eight months, between July of 2012 and March of 2013. Fifteen days of ground testing, six taxi tests, and 11 test flights totaling 15.2 flight hours were undertaken. Ground testing for the TASE200 dual sensor EO/IR gimbal was analogous to testing a similar gimbal on a manned aircraft, however the testing was conducted both at the aircraft and from the sensor control station through the sensor datalinks. An extensive victim source Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) matrix was completed to ensure that all OPA electronic systems were unaffected by EM interference. The majority of the flight testing was focused on improving sensor payload datalink performance.

2.3 CERTIFICATION AND LIMITATION REDUCTION

The C-150 OPA initially received a standard Experimental Airworthiness Certificate in 2009 before the creation of the OPA category. In the spring of 2010 the FAA requested that NTPS surrender the experimental aircraft airworthiness certificate for the C-150 and contact the Production and Airworthiness Division, AIR-200, for recertification as an OPA. The OPA regulations had been recently established for any aircraft that could be controlled via datalink from a GCS. NTPS submitted the required program letter and safety checklist which was followed by an inspection from a team of subject matter experts from FAA engineering, operations, production and airworthiness, and air traffic management. Following the inspection NTPS complied with a list of required action items and received an OPA Special Airworthiness Certificate on August 11, 2010. This was only the third such certificate issued by the FAA. The initial certification imposed over 50 operating limitations including a restriction requiring that the OPA be operated at altitudes above 1,500ft AGL.

FAA OPA certification is valid for 12 months requiring re-certification each year. Although burdensome from a paperwork point-of-view the re-certification process afforded the opportunity to present results from OPA flight test together with revised standard operating procedures to the FAA with the aim of removing limitations and restrictions attendant to the prior certification. Accordingly, the 2012 certification reduced the minimum operating altitude to 500ft AGL for both day and night operations. This minimum altitude was essential for the testing of the EO/IR sensor gimbal. With the most recent certification in July 2013, by providing a Flight Test and Safety Plan with the required certification paperwork, the minimum operating altitude has been reduced to 50ft AGL. This reduction in altitude was required in order to facilitate future RPV Pitot-static FTT testing, i.e. tower fly-by. With supporting flight test data and the development of appropriate safety procedures it is hoped that the NTPS OPA will eventually be permitted to execute automatic takeoff and landings.

3 RPV/OPA FTT DEVELOPMENT

To date flight test techniques (FTTs) specifically designed for RPV testing have not been published. Although many of the unique aspects of flight testing RPVs have been acknowledged, for example as discussed in [7, 8], specific practical techniques have yet to be fully developed. The diversity in RPV vehicle size, operating envelope, flight control modes, and missions adds significant further complexity to the development of such RPV FTTs.

In the absence of dedicated RPV FTTs, following certification, ground and flight testing of the C-150 OPA, it was necessary to develop appropriate RPV FTTs which could be demonstrated during the school's RPV course. The starting point for this endeavor was to attempt to apply FTTs for manned aircraft to the OPA with the aim of identifying those manned FTTs which transferred readily from the manned to RPV regime and those that did not. The initial RPV FTT development effort focused solely on P&FQ FTTs employing the NTPS Volume X, Fixed Wing Flight Test Handbook [9] as the primary reference for the accepted manned fixed wing P&FQ FTTs.

Numerous FTTs incorporated in the Volume X could immediately be excluded as they were considered to be inapplicable to RPVs. For example, as RPVs typically have a limited operational speed envelope, testing the nonlinear portion of the envelope, e.g. stall speed determination, stall characteristics, and spins, was considered to be inapplicable and hence FTT for such tests were excluded.

As discussed in [7], RPV vehicle performance can be tested in two main ways: testing of the full integrated system or testing of the capability of the baseline aircraft-power plant combination. RPV vehicle performance FTT development with the OPA was focused on the baseline aircraft-power plant combination. Baseline aircraft-power plant combination is analogous to developmental flight test and evaluation of manned aircraft. The P&FQ subjects evaluated to date include: pitot-statics, cruise performance, climb performance, longitudinal static stability, dynamic stability, and RPV mission task related flying qualities evaluations.

The OPA is ideally suited for RPV FTT development due to the vehicle being capable of being operated in both CDV and RPV methods of control. The CDV mode can be used to emulate a range of vehicles, e.g. from one that is limited to autonomous preloaded flight plans to one with direct command loop control. The RPV mode is currently limited to vertical rate being controlled by longitudinal stick displacement. With basic software upgrades and autopilot tuning the RPV control can be upgraded to pitch attitude control with longitudinal stick displacement.

The succeeding paragraphs summarize results and observations from several of the P&FQ FTT development tests undertaken to date.

3.1 PEC TESTING

Multiple manned FTTs for Pitot-static testing were evaluated using the OPA.

The GPS method Position Error Correction (PEC) FTT was found be most appropriate technique for measuring airspeed position error (ΔVpc). The RPV method of control could directly execute the traditional manned GPS method FTT. Although the CDV method of control typically commands track as opposed to heading this was found to be inconsequential as long as both heading and track were stable for each test point.

The modified tower flyby FTT was found to be the most appropriate technique for directly measuring altitude position error (ΔHpc). This technique can be safely executed on a CDV by commanding height above ground level using a laser/radar altimeter or by commanding DGPS altitude. It is recommended to determine the airspeed position error prior to conducting such testing at low altitude. The required precision and requirement to conduct the test at low altitudes over a known reference would likely preclude an RPV from safely executing the technique.

A FTT specifically designed to test RPV Pitot-statics is under development. This FTT would combine the two suggested methods, i.e. GPS for ΔVpc and modified tower flyby for ΔHpc, and be applicable to any type of unmanned system without any additional onboard instrumentation. Additionally, due to the digital nature of RPVs potential certification criteria directly related to the errors in measured static and total pressure are planned to be proposed for varying RPV categories.

3.2 CRUISE PERFORMANCE TESTING

Through flight testing conducted with the OPA it was determined that the manned Piw-Viw FTT for evaluating reciprocating engine cruise performance was applicable albeit with proper implementation. Using the RPV method of control the pilot directly controlled throttle position, allowing stable trim shots to be obtained at different speeds. Using the CDV method of control it was not possible to set a fixed throttle position free from oscillation. Therefore, testing cruise performance in CDV mode required stable air to prevent throttle oscillation. Forcing the CDV to the backside method of control where airspeed is controlled with the elevator and altitude is controlled with the throttle was found to be successful when performing cruise performance testing.

3.3 CLIMB PERFORMANCE TESTING

The manned climb performance FTTs, including sawtooth climbs and level accelerations, were found to be directly applicable to both CDVs and RPVs. Forcing the CDV to the backside method of control was once again found to be required for sawtooth climbs. Alternatively, forcing the CDV to the frontside method of control was found to be required for level accelerations. This allowed the altitude to be held constant with elevator deflection with maximum throttle. It was also found that executing sawtooth climbs through a larger band of altitudes provided acceptable data as the vehicle was always on the commanded condition. It was possible to execute approximately five sawtooth climbs at different speeds and cover the desired airspeed range for a RPV.

3.4 DYNAMIC STABILITY TESTING

Dynamic stability of the baseline aircraft-power plant combination could not be directly evaluated in either CDV or RPV modes since both modes are stability augmented resulting in a modified dynamic response. Consequently, the dynamic stability of the

OPA was evaluated by directly injecting commands to a specific control surface using a special application within the GCS software. PCC allows for singlet or doublet inputs of a specified amplitude and frequency. The system is capable of executing an extremely precise input that would likely be challenging for a test pilot in a conventional manned aircraft. The dynamic aircraft modes were evaluated by commanding varying frequency sweeps, doublets, and singlets. Following a doublet or singlet input the controls were held fixed at the trim position for a specified period of time. Each of these commands was able to be terminated during the maneuver, with the autopilot resuming control at the initially commanded condition, if a test limit was reached.

3.5 FLYING QUALITIES

A limited flying qualities assessment was carried out, restricted to the RPV method of control focusing on mission oriented tasks. A RPV flying qualities rating scale developed by Cotting [10, 11] was employed to evaluate various mission related tasks. The OPA tasking has focused on the vehicle performing the Intelligence, Surveillance, and Reconnaissance (ISR) mission. Simple tasks such as holding constant airspeed and altitude were evaluated. More complex tasks such as a climbing orbit around a target of interest while maintaining additional parameters were also evaluated. Analysis of the results of these limited flying qualities assessments is ongoing. However, it is anticipated that extensive future research with the C-150 OPA will be focused on RPV flying qualities, as it is the area of flight testing which has the most significant differences from manned aircraft.

3.6 OPA FTT DEVELOPMENT – OUTCOMES & OBSERVATIONS

P&FQ FTT development with the OPA is still ongoing and evolving, but already several significant outcomes and observations have resulted.

Many of the fundamental considerations and flight test techniques employed for the flight test and evaluation of manned aircraft are congruent for RPVs, but the fact that the RPV pilot is withdrawn from the aircraft is significant and requires unique approaches to effectively execute RPV flight testing with minimal risk. An on-vehicle test pilot's cognizance, judgment, and experience provide an inherent flexibility to react to unanticipated events that simply cannot be replaced by an automated system. A substantial part of a pilot's conscious and subconscious feedback from aural, visual, and proprioceptive cues is eliminated when the pilot is repositioned to a GCS. Furthermore, the RPV pilot may be burdened by the time delay induced by the C2 datalink to the aircraft and any system latency of the flight instruments and video viewed at the GCS. Although such factors warrant at least cursory consideration when testing CDVs, their effects must be carefully examined and fully understood when testing RPVs since they play a significant role within the human-vehicle control-loop while operating under RPV control.

A key outcome of the FTT development effort was that different methods of control require significant differences in the required modification to manned FTTs. It was found in some cases that the CDV was well suited to a particular FTT, while in others the RPV was preferred. It was found that the primary issue with executing a particular FTT under a specific method of control was the inability to maintain constant control position. This could be overcome via short-term modification of simple control system settings, such as forcing the aircraft to the frontside or backside methods of control. It was also found that it would be of significant benefit if an application allowing particular modes of control and direct inputs to the flight control system is incorporated for testing.

4 OPA/RPV FLIGHT TEST TEAM COLLABORATION

During the OPA development and academic module integration flights related above several issues concerning test team collaboration/effectiveness during test execution were identified. As these issues were identified appropriate steps were taken to ensure that the issues were suitably addressed in order that maximum test team effectiveness was achieved during subsequent test execution. Several aspects relating to the issues observed are outlined in the succeeding paragraphs.

As with many other RPVs, the C-150 OPA missions were found to require significantly more personnel than an equivalent mission with a manned aircraft. A nominal instructor only sortie with the C-150 OPA involved no less than five personnel: Safety Pilot, a GCS Instructor Pilot, Sensor Instructor, Instructor Test Conductor, and a TM/Auto tracking operator. As with any flight test event with a large amount of participants, strict test discipline, e.g. strict adherence to checklist, test cards, and pre-briefed mission limitations, was found to be imperative in order to achieve the highest level of OPA mission success.

In addition to noting that the C-150 OPA missions were found to require significantly more personnel than an equivalent mission with a manned aircraft it was also observed that individual test team members had an individual level of situational awareness related to their individual test team responsibility e.g. the sensor operator was aware of senor performance but not necessarily of traffic conflictions; the safety pilot was aware of traffic conflictions but not of ground antenna pointing angles, etc. Accordingly, it was assessed that no one team member had a complete and full appreciation of every aspect of the test at any given point in time, a condition that demanded efficient and concise of intra-team communications in order to share pertinent information. Such sharing of information allowed team members to increase their overall situational awareness beyond the limited scope of their own responsibility.

Of particular note regarding situational awareness was the contrasting level of awareness encountered by the GCS Pilot regarding autopilot status and aircraft feedback cues. The GCS Pilot had a very high level of situational awareness with respect to autopilot control but lacked normal conscious and subconscious aural, visual, and proprioceptive feedback cues afforded to a pilot onboard an aircraft. The lack of such onboard feedback cues required the GCS Pilot to seek surrogate feedback information from GCS displays in order to complete the command feedback loop. In some cases such surrogate feedback information was not presented by the GCS, e.g. in-flight turbulence levels, and could only be obtained via enquiry with the Safety Pilot. This interaction between the GCS Pilot and Safety Pilot allowed the GCS to apply autopilot control in keeping with the airborne environment but, more importantly perhaps, highlights the fact that a GCS Pilot may have very high situational awareness in one regard, e.g. autopilot, but may be lacking in other regards, i.e. flight conditions.

In several cases it was found that the Test Conductor and supporting Discipline Engineers had better situational awareness than the GCS Pilot. This condition was due in part to the ability to design Test Conductor and Disciplined Engineer flight test displays specifically for the test mission to be flown. In contrast, the GCS Pilot operated a largely unmodifiable software package for aircraft control that was not easily tailored to specific mission requirements. Accordingly, the Test Conductor was able to monitor mission-specific Abort and Knock-it-Off criteria and hence was furnished with a higher level of situational awareness in this regard. Clearly, in order to realize the benefits of such improved awareness the Test Conductor required a direct VHF communication link to the Safety Pilot.

For an OPA special care should be given to defining and briefing Abort and Knock-it-Off criteria. It is essential to define under what conditions the GCS Pilot will attempt to Abort a test point versus when the Safety Pilot will disengaging the system and take control of the aircraft, i.e. a Knock-it-Off event.

Deciding upon next steps following recovery from an Abort or Knock-it-Off event may take an extended period of time requiring discussion between affected/key team members in order to debrief the situation prior to continuing (if appropriate) with the OPA mission. During this discussion period control of the OPA must still be maintained. Hold/sanctuary points, defined in terms of geographical position and altitude, have proven essential to OPA operations allowing the test team to command the aircraft to autonomously orbit at a defined hold point until such times as the test team have agreed upon the next step in the mission.

5 CURRENT RPV FLIGHT TEST COURSES

NTPS has integrated the C-150 OPA into both the yearlong professional course and RPV short courses. The professional course now has two independent RPV modules utilizing the C-150 OPA. In the final module of the P&FQ portion of the course students are given instruction and then tasked with a project evaluating Pitot-statics, cruise performance, climb performance, dynamic stability, RPV handling qualities, human factors, and workload. The final module of the avionics systems portion of the professional course includes instruction and flight test techniques for evaluating avionic systems on RPVs. The final portion of the course is a capstone project evaluating the remotely operated EO/IR sensor and RNP in various control modes. The students have been extremely satisfied with their experience with the OPA and have even requested further OPA implementation providing hands on experience to the future of aviation.

6 LESSONS LEARNED

Many valuable lessons have been learned throughout the development of the C-150 OPA and evaluation of RPV FTTs. The benefit of having a safety pilot onboard the OPA for the initial testing and FTT development has proven to be instrumental. Having a safety pilot onboard can allow for real-time control parameter modification to safely take place in flight, as the safety pilot can easily recover from an unexpected response. With a truly unmanned system similar testing would need to be approached more cautiously. Less time and cost is required to prefect a high fidelity model when a safety pilot is onboard. The optimized response of a RPV is not the traditional manner which a pilot flies an aircraft for passenger/pilot comfort. The control system design engineer's optimized response is traditionally utilized for RPVs. This coincides with pilot comments from chasing other unmanned platforms. Tuning of a RPV or OPA is dependent on the actual mission of the system. For an optionally piloted system it may be necessary to reduce the response of the aircraft for pilot comfort. At the same time, utilizing the safety pilots qualitative assessment of vehicle response may need to be limited if the vehicle will eventually be operated as a RPV. The entire learning experience for FTE students has been expanded significantly with IADS software integration. FTE students are now able to gain real world experience conducting missions and participating in each RPV flight from the control room.

7 SUMMARY

NTPS converted a Cessna 150 into an OPA, which operates with a certified safety pilot on-board who can deactivate the ground-controlled autopilot system at any moment. The system is certified by the FAA as an OPA and is capable of being controlled via command direction or in a remotely piloted vehicle mode. Many of the FTTs employed for manned aircraft are congruent for RPVs, but the fact that the pilot is withdrawn from the aircraft is significant and requires unique approaches to effectively execute RPV flight testing. Once the C-150 OPA was certified and had completed the initial phase of ground and flight testing, it was necessary to develop and analyze FTTs that would be demonstrated utilizing the system. The initial endeavor focused solely on performance and flying qualities FTTs. The majority of the manned FTTs evaluated were found to be applicable with slight modification and additional considerations. Future research with the system intends to focus on designing FTTs specifically catered to RPVs as well as proposing regulating criteria for RPVs. The C-150 OPA has proven to be an effective RPV flight test training platform for NTPS. The benefit of having a safety pilot onboard the OPA for the initial testing and FTT development has proven to be invaluable. NTPS has found that OPAs are an essential evolutionary step from flight testing manned aircraft to RPVs.

8 ABBREVIATIONS

AGL	Above Ground Level
C2	Command and Control
CDV	Command Directed Vehicle
CG	Center of Gravity
CRM	Crew Resource Management
D3	Dull, Dangerous or Dirty
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EO	Electro-Optic
FAA	Federal Aviation Administration
FTE	Flight Test Engineer
FTT	Flight Test Technique
GCS	Ground Control Station
GPS	Global Positioning System
HIL	Hardware-In-the-Loop
IMU	Inertial Measurement Unit
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
NAS	National Airspace System
NTPS	National Test Pilot School
OAT	Outside Air Temperature
OFDM	Orthogonal Frequency-Division Multiplexed
OPA	Optionally Piloted Aircraft
P&FQ	Performance & Flying Qualities
PCC	Piccolo Command Center
PEC	Position Error Correction
PID	Proportional-Integral-Derivative
RF	Radio Frequency
RNP	Required Navigation Performance
RPV	Remotely Piloted Vehicle
SIL	Software-In-the-Loop
TC	Test Conductor
VHF	Very High Frequency

9 ACKNOWLEDGEMENT

Mr. Olson gratefully acknowledges the contribution and support of his PhD Advisor Professor Thomas Jones, Electrical and Electronic Engineering Department Chair and the Director of the Electronic Systems Laboratory at Stellenbosch University and his PhD Co-Advisor Dr. Lester Ingham, Director of the National Flight Test Institute and Flight Test Engineer Instructor at the National Test Pilot School. Through the generous support of the NTPS Board of Trustees and CEO, all infrastructure including the required software, equipment, laboratories, and operating costs necessary to complete this study have been provided.

10 REFERENCES

[1] Flying Qualities Built-In-Test For Unmanned Aerial Systems. Chiu, A.P., California Polytechnic State University, 2012.

[2] Air Force UAVs the Secret History. Ehrhard, T.P., Mitchell Institute, 2010.

[3] Unique Aspects of Flight Testing Unmanned Aircraft Systems AG-300-V22. North Atlantic Treaty Organization, 2010.

[4] Unmanned Aircraft Systems Roadmap 2011-2036. United States Department of Defense, 2011.

[5] Cessna 150 N18531 Flight Manual, Publication of National Test Pilot School, Cessna Aircraft Company, Wichita, Kansas USA.

[6] Piccolo System User's Guide, Software v2.1.4.f. Cloud Cap Technology, Alex Barchet, Dan Bridenbecker, Van Miley, Bill Vaglienti, 15 October 2012.

[7] Unique Aspects of Flight Testing Unmanned Aircraft Systems AG-300-V22. North Atlantic Treaty Organization, 2010.

[8] The Role of the Society of Experimental Test Pilots in the Development and Flight Testing of UAVs. Smith, R., Society of Flight Test Engineers, 2012.

[9] NTPS Vol. X FW Flight Test Techniques. National Test Pilot School, 2012.

[10] Evolution of Flying Qualities Analysis - Problems for a New Generation of Aircraft. Cotting, C., Virginia Polytechnic Institute and State University, 2010

[11] UAV Performance Rating Scale Based on the Cooper-Harper Piloted Rating Scale. Cotting, C., Virginia Polytechnic Institute and State University, 2011.

11 AUTHOR BIOGRAPHIES

Ryan Olson is a flight test instructor at the National Test Pilot School in Mojave, CA. He is also a PhD candidate at Stellenbosch University in the Western Cape of South Africa. He holds a MS in Flight Test Engineering from National Flight Test Institute/National Test Pilot School and is a Systems Flight Test Engineer Graduate (10A)/ Professional Test Pilot Course Graduate (13B). He also holds a BS in Aerospace Engineering and BS in Aeronautical Science from Embry-Riddle Aeronautical University. He is a commercially rated pilot and instructor in single and multi-engine airplanes and helicopters. He has flown over 1,500 hours in more than 50 types of fixed and rotary wing aircraft. His knowledge of RPVs and control systems was augmented with his thesis work in which he was responsible for design, development, and testing of the C-150 OPA. The author has gained over 100 hours of RPV flight test experience through development of and instruction with the C-150 OPA.

Chris McElroy is a flight test instructor at the National Test Pilot School in Mojave, CA. where he specializes in avionic systems test. He holds a MS (Distinction) in Aeronautical Science/Human Factors from Embry-Riddle Aeronautical University and a BSc (Hons) in Computer Science from Strathclyde University, Glasgow, Scotland. He is a commercially rated pilot and instructor in single-engine airplanes and has flown over 700 hours in many aircraft types. Prior to joining NTPS, Mr McElroy spent 20 years with the British Ministry of Defence where he specialized in operational test and evaluation of air-to-ground weapons and electronic warfare tactics on fast-jet platforms of the Royal Air Force.

Flight Testing the Piper PA-48 Enforcer
By David L. Lawrence, SETP Fellow

The outline for this report is:

1.0 BACKGROUND
2.0 TESTING OVERVIEW
3.0 TEST ITEM DESCRIPTION
4.0 TESTING APPROACH
5.0 RESULTS
6.0 CONCLUSION

1.0 BACKGROUND

In 1968, Cavalier Aircraft owner/founder David Lindsay, using his own resources, began developing a turboprop version of the WWII P-51 Mustang. At that time, Cavalier Aircraft was converting P-51's for civilian use. This new upgraded version of the Mustang was initially fitted with a Rolls-Royce Dart 510 turboprop engine (1670 shp) and was appropriately named the Mustang II. Mr. Lindsay wanted to use the Lycoming T-55 turbine to drive a big propeller but at that time he was not able to lease one from the US Government. The Dart powered Mustang II had stability problems and never met expectations. Both Col Henry Gordon and Bob Hoover, who evaluated the aircraft advised David Lindsey not to proceed with the design. Cavalier Aircraft did not have the manufacturing capability or the funds to continue development of this aircraft and in late1970 the rights were sold to Piper Aircraft Corporation.

In 1971, the PAVE COIN program was established to identify a new counter insurgency/light attack aircraft for the USAF. Piper Aircraft entered the program with an upgraded Mustang II that incorporated the Lycoming T-55-L9A Engine/Gearbox combination with a modified Aeroproducts 11' 6" diameter propeller adapted from an A-1E Skyraider. Piper's new aircraft was initially designated as the "Turbo Mustang III" and later became the known as the "Enforcer".

Piper Aircraft set up a Skunk Works operation at their manufacturing facility in Vero Beach, Florida, and built two prototype aircraft, PE-1 (N201PE) and PE-2 (N202PE) for the PAVE COIN program. PE-2 was lost in an accident during the late stages of testing there. PE-1 was flown to Eglin AFB and participated in the PAVE COIN evaluations.

Although the Enforcer did well during these evaluations, the company did not receive a production contract. David Lindsay, who thought the Enforcer was still viable as a light attack/close-air-support aircraft, bought the rights to the Enforcer back from Piper in 1973. J. Lynn Helms (a friend of David Lindsay) who became President and CEO of Piper in 1974 was also a believer in the Enforcer concept that was for a lower cost Close-Air-Support (CAS) aircraft. In the 1970's there were strong feelings on both sides of the CAS issue – one side advocated a more expensive, more capable aircraft for the mission, i.e. an A-10, and the other side advocated a lower cost, less capable Enforcer type aircraft.

The A-10 was expensive and cost over $8M, while the Enforcer was projected to cost less than $3M in comparative dollars.

Together Helms and Lindsay became a formidable team and lobbied a number of their friends in Congress, i.e., Sam Nunn, Strom Thurmond, John Tower, William Proxmier, and others, to continue Enforcer development. This lobbying effort continued for eight years and finally paid off.

In September 1981, the Piper Aircraft Corporation was awarded an $11.8M contract for conducting a feasibility demonstration of the Enforcer as a low-cost close-air-support aircraft and once again, David Lindsay sold its rights to Piper. Two prototype aircraft were built under this contract. They were designated as EN-1 (N481PE) and EN-2 (N482PE) and incorporated the same Lycoming engine, gearbox, and propeller that was used during the PAVE COIN evaluations. The modified Aeroproducts propeller was considered the weak link in the powerplant system because reducing its diameter, to give adequate ground clearance, made it very inefficient. Piper management however, decided that using this propeller would be acceptable for a feasibility demonstration of the aircraft.

The original Enforcer airframe was redesigned to carry a much more versatile air-to-ground weapon suite, including two GPU-5/A 30mm gun pods that were mounted on inboard pylons.

A chronological summary of the Piper PA-48 Enforcer program:

EVENT	DATE
•Contract Award	September 1, 1981
•Airframe Complete	January 12, 1983
•Engine Installation Complete	February 15, 1983
•First Flight	April 9, 1983
•Airworthiness Testing Complete	February 25, 1984
•Weapon Clearance Testing Complete	May 11, 1984
•Operational Demonstration Complete	August 6, 1984
•Aircraft Ferried to Davis Monthan AFB	August 15, 1984
•Final Report Submitted	October 18, 1984

The testing approach that was used during each of the following Phases will be discussed and results detailed where appropriate. No attempt will be made to present all results of the testing that was done during the course of the three year Enforcer program.

Phase I	- Design of Prototypes (Lakeland, Florida)
Phase II	- Construction of Prototypes (Lakeland, Florida)
Phase III	- Airworthiness Testing (Lakeland, Florida)
Phase IV	- Weapon Clearance Testing (Eglin AFB, Florida)
Phase V	-Operational Demonstration (Edwards AFB, California and Nellis AFB, Nevada)

2.0 TESTING OVERVIEW

Design and Construction (Phases I and II of the program) began in September 1981 and were completed in April 1983. The Enforcer then underwent Phase III Airworthiness testing that required 213 sorties and 202.8 flight hours to complete. This included flutter testing of the clean aircraft and an aircraft equipped with a full compliment of weapons. Phase III testing was completed in February 1984.

A summary is shown below:

Testing	Sorties	Hours Flown
Airspeed Calibration	5	4.9
Flying Qualities	68	69.8
Performance	21	27.7
Systems	41	43.1
Flutter	21	18.2
Airloads	9	6.3
Miscellaneous	48	32.8
Total	213	202.8

The miscellaneous flights included: Functional Check flights, Chase flights, and Ferry flights.

At the conclusion of Phase III, the two prototypes were ferried to Eglin AFB for Phase IV testing. This effort included: weapon clearance, weapon ballistics, Radar Cross-Section, IR signature, and weapon employment testing. Weapon Clearance Phase IV, that required 72 sorties and 81.7 flight hours, was completed in May 1984.

A summary is shown below:

Testing	Sorties	Hours Flown
Weapon Clearance	12	9.5
Weapon Ballistics	22	21.8
Radar Cross Section	6	9.4
IR Signature	6	7.9
Weapon Employment	6	6.6
Miscellaneous	20	26.5
Total	72	81.7

The miscellaneous flights included: Functional Check flights, Chase flights, Range Familiarization flights, and Ferry flights.

After completing Phase IV, the aircraft were ferried to Edwards AFB for Phase V testing which was the Operational Demonstration. This testing, that required 69 sorties and 96.6

flight hours, was completed in August 1984.

A summary is shown below:

Testing	Sorties	Hours Flown
Weapon Accuracy – Day	18	21.3
Weapon Accuracy – Night	6	7.3
Surge/Tactical Weapon Delivery	16	19.4
Survivability	16	35.6
Soft Field	2	.5
Miscellaneous	11	12.5
Total	69	96.6

The miscellaneous flights included: Functional Check flights, Chase flights, Range Familiarization flights, and Ferry flights.

After completion of the Operational Demonstration the aircraft, EN-1 and EN-2, were ferried to Davis Monthan AFB, Arizona, and were placed in permanent storage.

3.0 TEST ARTICLE DESCRIPTION

Airframe

The design of the Piper PA-48 Enforcer was based on the P-51 Mustang and that of the original Enforcer that flew in the PAVE COIN program. This new and improved aircraft was equipped with the same Lycoming T-55 engine (2445 shp), L9A gearbox, and modified A1-E propeller that the earlier Enforcer used. The design of the airframe was driven by, the previous 1970's testing results and the addition of two GPU-5 30mm Gun Pods that were carried on the inboard pylons.

Figure 3-1 shows the completed aircraft with its ten weapon pylons and airspeed boom installed on the left 120 Gallon tip tank. Figure 3-2 shows the 30 mm Gun Pod installation during construction.

Figure 3-1. PA-48 Enforcer with weapon pylons and boom installed

Figure 3-2. 30 mm Gun Pod Installation

The addition of these large gun pods, along with findings from the earlier Enforcer test program, required the empennage section to be larger than that of the original Enforcer design to improve longitudinal stability – the horizontal tail area was increased by 36 percent and the vertical tail area was increased by 9 percent. Also, the fuselage was lengthened 19 inches aft of the cockpit area. Wing and fuselage skin thickness was increased to carry the load of these gun pods.

The Enforcer was equipped with a Stencel "Yankee" seat extraction system used in T-28's supplied to several Foreign Military Sales (FMS) customers. A Parker Hannifin Air Conditioning System was added for pilot comfort. The upgraded aircraft was equipped with Goodyear wheels, tires, and brakes adopted from a Gulfstream I corporate aircraft. A simple Gun Sight from Franti Ltd. was installed.

To support its close-air-support mission, the Enforcer was equipped with ten wing pylons equipped with MA-4A bomb racks and carried a variety of weapons including: CBU-58, MK-82, MK-82SE, MK-20, and CRV-7. The GBU-5/A gun pods were eliminated from the program in Phase III testing.

Flight control system

The PA-48 Enforcer had a reversible flight control system. Manual trim was provided for all axes and electric trim was provided for the rudder and elevator. The lateral control system incorporated aileron boost adopted from the Lockheed T-33 to reduce aileron forces. The boost ratio was approximately 3 to 1. The longitudinal control system was essentially unchanged from that used in the original P-51 Mustang.

Data Acquisition System

The Data Acquisition System (DAS) was developed in-house at Piper and was made up of commercial off-the-shelf components. The data was recorded on tape and appropriate channels were downlinked. Using this system, Engineers could monitor and reduce the data in real-time. This was standard practice in the early 1980's during aerodynamic load (airloads) and flutter testing.

A summary description of the DAS system is shown below:

On-Board Data Recording
- 64 Analog (10 BIT) Channels
- 120 Bilevel Events
- Maximum Scan Rate 200 KBITS/SEC

TM Capability
- 12 Real-Time Strip Chart Channels
- Ground Recording Back-Up

Quick Look Data Options
- All Channels (RAW Data)
- 10 Channels (Updated RAW Data)

Post Flight Data Reduction
- Engineering Units
- Strip Chart Playback

3-Point RCAL Calibration/Correction

Figure 3-3 shows the DAS location directly behind the extraction seat rocket. The DAS itself is made up of equipment contained in the orange boxes shown below.

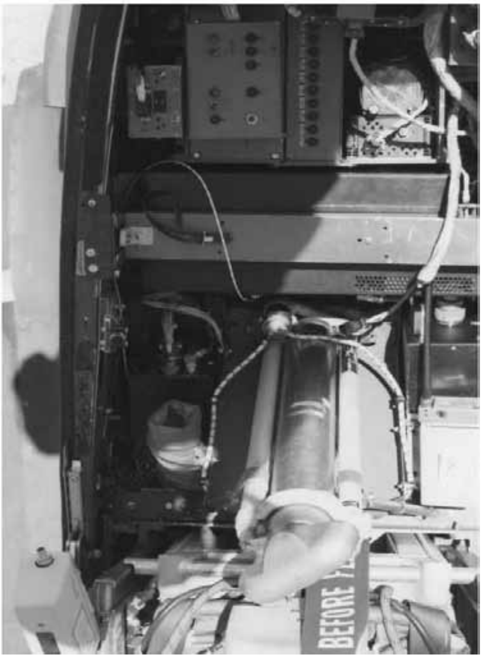


Figure 3-3. Location of the DAS System

4.0 TESTING APPROACH

The final evaluation criteria for airworthiness testing accomplished during Phase III was to insure only that the Enforcer prototypes were "safe" to perform in the Weapon Clearance and the Operational Demonstration – Phases IV and V of the program. MIL-8785C was used as a guideline for qualitative and quantitative evaluations that were performed during this testing.

A comprehensive quantitative evaluation of PA-48 Enforcer flying qualities was planned using the onboard DAS system. However a contract modification mid-way through the airworthiness testing phase, to keep the program within time and budget constraints, limited these evaluations to qualitative surveys only.
Evaluations were conducted for the following configurations:

• Configuration A	- Clean aircraft (no pylons /racks)
• Configuration B	- Pylons/racks only – no weapons/stores
• Configuration Bmod	- Range Measurement System (RMS) pods on stations 1 and 10. Empty LAU-5002 rocket pods (no forward fairings) on stations 3 and 8.
• Configuration C	- GPU-5/A 30mm gun pods on stations 5 and 6. This configuration was eliminated during Phase III of the testing program. Figure 4-1 shows this configuration with RMS pods installed on stations 1 and 10.

Figure 4-1. Configuration C

•Configuration D	- CBU-58 on stations 5 and 6. MK-82SE on stations 4 and 7. LAU-5002 rocket launchers with nose fairings on stations 3 and 8. Figure 4-2 shows this configuration.

Figure 4-2. Configuration D

- Configuration E - Same as Configuration D except MK-20's replaced the CBU-58's on stations 5 and 6.
- Configuration F - SUU-20 dispensers with BDU-33 practice bombson stations 5 and 6.

Figure 4-3 shows weapon configurations:

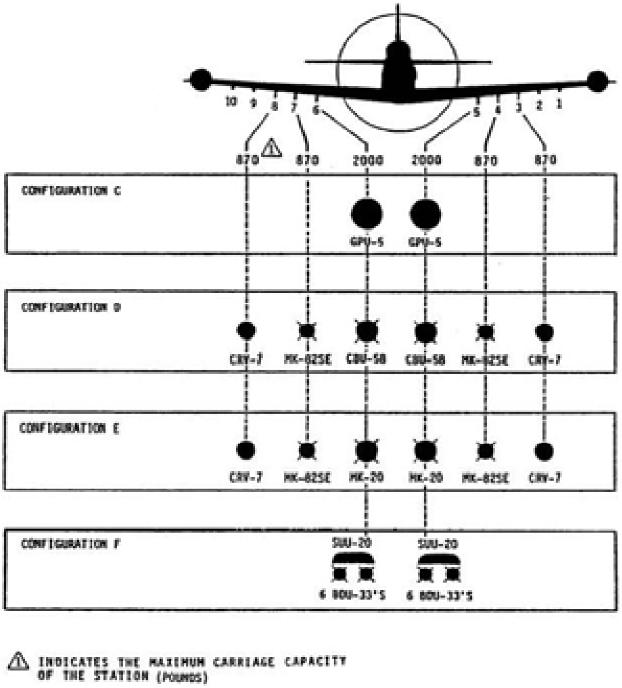


Figure 4-3. Weapon Configurations

Stations 1,2,9,10 were limited to a maximum weight of 350 pounds. RMS pods and cameras were carried on these stations during Phase IV and V testing.

The Enforcer was not equipped to drop live weapons. Inert weapons were used during all Phase IV and V testing. The BDU-33 practice bombs had spotting charges and the CRV-7's had live rocket motors.

Figure 4-4 shows the weight and center of gravity envelope for the Enforcer aircraft. Included in this figure are the forward and aft center of gravity (c.g.) envelopes for the max gross and nominal weight conditions used during the evaluations. The structural design and operational flight envelopes are also shown.

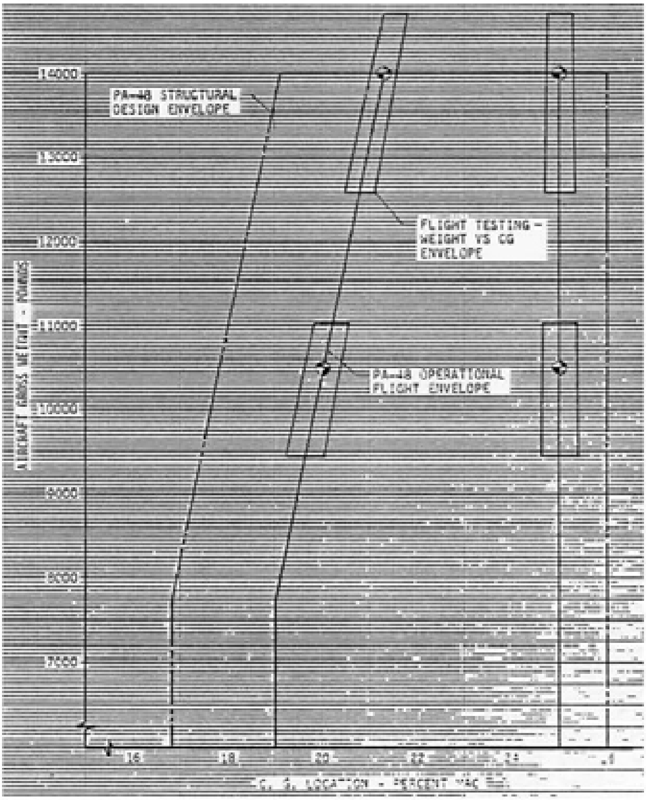


Figure 4-4. Weight and Center of Gravity Envelopes

Additional test configuration information includes:

- Maximum wing flap deflection for Configurations A and B is 47º
- Maximum wing flap deflection for Configurations Bmod, D, E, and F is 30°
- Gear up configuration – landing gear is up and the associated landing gear doors are closed
- Gear down configuration – main and tail landing gear (extended), inboard landing gear doors closed, tailwheel doors open
- Airspeed boom was not installed during flutter testing
- Oil cooler doors were closed during all testing

Phase III Airworthiness Testing

Airspeed Calibration

Each PA-48 Enforcer prototype was equipped with a Rosemont boom mounted on the left tip tank. Calibration of the boom system was accomplished using the Tower-Fly-By course at the Piper facility in Lakeland, Florida. This airspeed calibration technique/methodology was developed based on that being used at Edwards AFB. Testing was performed over an airspeed range of 110 to 250 KIAS with the landing gear and flaps up, 120 to 160 KIAS with the landing gear up and flaps 20°; and 100 to 140 KIAS with the landing gear down and flaps 47°.

Static/Dynamic Stability

Stability data was obtained quantitatively using a hand held stick force gage and an elevator position indicator. Maneuvering stability was also evaluated.

Qualitative dynamic longitudinal stability investigations of the Phugoid and short period were conducted. Pitch doublets were used to excite the short period.

Qualitative lateral/directional static and dynamic stability characteristics were obtained. Investigations were made using steady heading sideslips in both directions. Dynamic stability characteristics were obtained using rudder doublets. Investigations of Dutch roll, spiral stability, and roll were performed.

Stall

Qualitative and quantitative evaluations of PA-48 stall characteristics were performed. These evaluations included:

- 1g stalls (1 knot per second deceleration rate)
    - -Power (off/on)
    - -Gear and flap configuration (gear/flaps up, gear up/flaps 20°, gear down/flaps 30°, gear down, flaps 47°
    - -Entry (straight ahead/left turn/right turn)

- Accelerated Stalls (3 – 5 knots per second deceleration rate)
    - -Power (off/on)

-Gear and flap configuration (gear/flaps up, gear up/flaps 20°, gear down/flaps 30°, gear down/flaps 47°)

-Entry (straight ahead/left turn/right turns)

No post stall, high angle-of-attack testing was conducted.

Takeoff/Landing

Takeoff and Landing tests were performed at the Airport in Sanford, Florida. Distances for takeoff ground roll and landing ground roll were measured directly using observed lift-off and touchdown points. Data was reduced using in-house takeoff and landing performance programs.

Testing to define crosswind limits was not accomplished.

Climb

Climb data was obtained for Configurations B, Bmod, and D using the double-header sawtooth technique. All testing was accomplished at the forward c.g. with the landing gear and flaps 0° and the oil cooler doors closed. Once stabilized at maximum power in the climb, the test airspeed was held for two to four minutes while the data was recorded using the DAS.

Data was reduced using in-house climb performance programs.

Cruise

Cruise performance data was obtained at a range of altitudes from sea level to 25000 feet for Configurations B, Bmod, and D using standard speed/power techniques. The aircraft was stabilized in level flight at a specified power setting using a range of airspeeds appropriate for each configuration tested. Data was recorded using the DAS for two minutes after stabilized flight conditions were achieved. All data was obtained with gear up and flaps 0°, oil cooler doors closed, and the electrically driven air conditioner, "ON".

Range data was obtained for various weights appropriate for each configuration tested, at specified altitudes.

Data was reduced using in-house cruise and range performance programs.

Flutter

Flutter testing was conducted using EN-1. The aircraft was equipped with left and right "shakers" mounted inside, the tip tank structure and aft fuselage of the aircraft. The aircraft was equipped with accelerometers placed at critical locations of the structure. All data was downlinked for real-time evaluation/analysis during each test point.

During each run, these shakers produced frequencies ranging from 5 to 40 cycles per second to excite potential flutter modes. The wing tip mounted "shakers" could be operated in two modes: “Wings in phase” or “Wings 180° out of phase”.

To clear a test point, three runs had to be flown: (1) Wing Shakers ON – “in phase”, (2) Wing Shakers ON – “180°out of phase”, and (3) Fuselage shaker ON. As the test point airspeed increased, the starting altitude had to continually be increased to allow for the entire range of frequencies produced by the shakers to be swept. At the higher airspeeds and altitudes, Mach number had to be considered because of the .703 Mach number limit on the horizontal tail.

Airloads

Airframe integrity was verified by static testing under simulated loading conditions. The airframe of EN-2 was used during this effort. Strain gauges were placed in critical locations of the structure where the highest loading conditions were expected to occur. Figure 4-5 shows the set-up used for this testing.

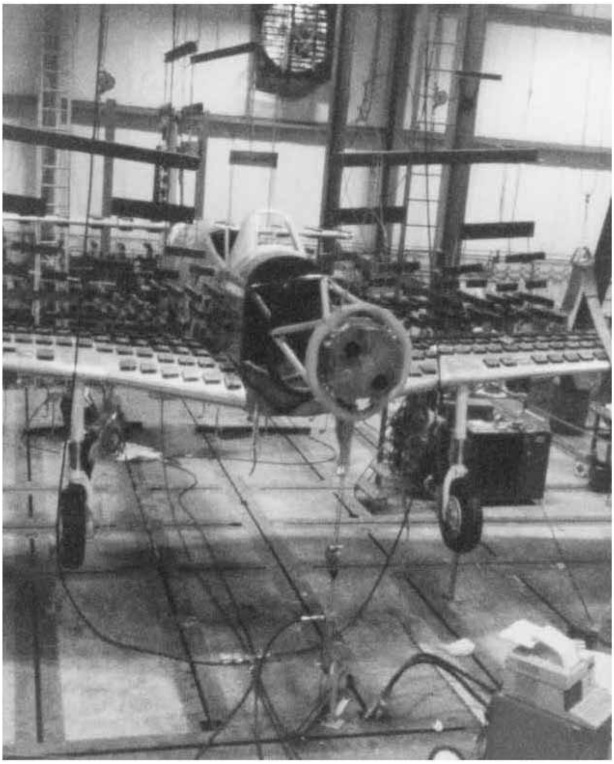


Figure 4-5. Static Testing

Drop testing to verify the strength of the landing gear and associated structure was also accomplished during the ground testing effort.

After ground testing was completed, the loads and stresses in the critical areas of the airframe were monitored during flight. Beginning maneuvers were initiated at a low starting ”g” condition and progressed in increments up to the limiting “g” condition. Before proceeding to a higher “g” condition real-time strain gauge results were examined and approved by engineers monitoring the test. Positive and negative pull-ups and pushovers, as well as rolling pullout maneuvers, were performed. Both the clean aircraft (Configuration A) and an aircraft equipped with weapons (Configuration D) were tested.

Systems

Powerplant – Data was recorded during normal and rapid power advances /reductions to validate propeller governor operation and survey propeller reaction to airspeed/power changes. Engine temperature surveys were conducted both during ground and in-flight testing. No significant problems were identified.

A problem was encountered early in Phase III testing with the engine oil system. During engine shutdown, inadequate oil scavenging from the power turbine section occurred, resulting in the power turbine seals to “coke” with residual oil impurities. After these seals became “coked”, excessive oil loss after engine shutdown was seen. The problem was caused by the 12° nose-up ground attitude of the aircraft and the inadequate oil scavenging capability of the engine driven pump. Incorporation of an additional scavenge pump corrected this problem.

Electrical – Ground and in-flight evaluations of all electrical components/systems, including electromagnetic interference (EMI) and stray voltage tests were conducted. All electrical system components were functionally tested. No significant problems were identified.

Temperature data was recorded during specified ground/in-flight testing profiles, using thermocouples located in critical locations and an instrumented starter/generator unit. Maximum electrical load using all appropriate electrical equipment and on-board test instrumentation was used. All temperatures were found to be within allowable operating limits.

Fuel – After ground testing was completed, the fuel system was tested in- flight. This testing included; fuel feed pressure measurements as a function of altitude up to 25,000 feet, timing of fuel dumping from the tip tanks using both gravity and pump assisted modes, evaluating fuel system operation during normal and simulated combat maneuvering, and evaluating the fuel transfer operation. An asymmetric fuel-feeding problem from the main wing tanks occurred that resulted in unacceptable fuel imbalance levels. The addition of a small weight to the left main tank float arm corrected the problem.

Fuel siphoning from tip tank and fuselage belly vents occurred during maneuvering flight. This problem, although annoying, did not compromise safety and therefore was not corrected.

Hydraulic – Ground tests were conducted to measure hydraulic system temperatures and pressures that occurred during; landing gear, wheel brake, wing flap, and the aileron boost system operations. Initial taxi testing identified a wheel brake problem. After the first braking application, the brake pucks would not retract and resulted in brake lock-up. Incorporating brake puck return springs solved this problem. Also, braking effectiveness was reduced after several landings. This was a result of the brake pucks not being set properly during the initial brake installation. The G-1 brakes used in the prototypes, required 3000 psi to set the brake pucks. The hydraulic system of the Enforcer operated at a maximum pressure of 1000 psi. This lower pressure did not allow the pucks to set properly. After using a hydraulic mule to apply 3000 psi to set the pucks, the system operated normally.

Control – Both qualitative and quantitative investigations were conducted during ground and in-flight testing of the PA-48's control system. Results for; elevator friction and breakout forces, control system freeplay, elevator and rudder force versus rudder deflection, were obtained. Investigations of elevator trim effectiveness and control/trim changes with power application and/or flap extensions/retractions were also accomplished. Initial aileron centering problems were identified and were subsequently eliminated by drooping both ailerons 2° below their trailing edge neutral position.

Avionics – Nine flights were conducted to evaluate; the TACAN, VOR, ILS, Radar Altimeter, ADI, Standby ADI, HSI, RMI, DG, Transponder, VHF/FM, UHF, and ADF.

TACAN and VOR were operationally checked up to17500 feet and 100 NM from the Lakeland VORTAC in level and descending turning flight profiles. The systems operated satisfactorily with no dropouts with a strong station identifier.

The ILS glideslope, marker beacons, and localizer were evaluated during four normal approaches to the Lakeland Airport, and one back course ILS approach to the Tampa International Airport. ILS operation was found to be satisfactory.

The radar altimeter was evaluated during ILS approaches. Radar altimeter accuracy was checked during airspeed boom calibration flights. System accuracy and operation was found to be satisfactory.

The primary and standby ADI's were evaluated during unusual attitude maneuvering and level left/right turns at various bank angles, load factors, and heading changes. Both indicators functioned normally with no unacceptable precession occurring after maneuvering.

The directional gyros for the HSI and RMI were functionally checked in "SLAVE" and "MAG" modes. INC/DEC operations were timed. These systems were found to be satisfactory.

Transponder evaluations were made using Tampa Approach and Miami Center. Testing was conducted over remote radar facility sites. Climbs and descents, left/right 30° banked turns for various heading changes, and for various gear/flap configurations were accomplished. No dropouts were reported by either radar facility during this testing. Transponder operation was found to be satisfactory. The encoding altimeter was not installed during these flights.

The TACAN and NAV transfer systems were self-tested on the ground and in-flight using the Lakeland VORTAC. These systems operated satisfactorily.

Several flights were required to finalize VHF/AM antenna location. Operation of this antenna in its final location was acceptable.

VHF/FM communication was not satisfactory except during close proximity air-to-air communications. This system required further development, but no action was taken to improve its operation.

UHF and ADF testing was accomplished using an AN/MRC-107 communications jeep and with the control tower at MacDill AFB, Florida. System operation was found to be acceptable.

Life Support – Testing of the oxygen system and Environmental Control System (ECS) was conducted both on the ground and in-flight. The oxygen system was found to be satisfactory. The ECS was found to be marginal and required further development. No action was taken to further develop this system.

Stencel "Yankee" Extraction Seat – Ground testing was accomplished to insure adequate clearance for the pilot during extraction egress. Testing of the complete system was accomplished at Stencel's sled test track in Utah using a full-scale mock-up of the Enforcer cockpit and a 98th percentile dummy pilot.

Figure 4-6 shows the setup that was used for this testing. Based on this testing, a safe extraction limit of 100 KIAS and 100 feet AGL was imposed during the program. Computer analysis indicated that above 407 KIAS the pilot would not be clear of the aircraft during extraction.

Figure 4-6. Extraction Seat Sled Testing

Phase IV Weapon Clearance Testing

Testing was accomplished to clear selected weapon configurations for safe separation, identify the Radar Cross Section (RCS) and Infrared (IR) Signatures of the PA-48 aircraft, verify the ballistic tables that were provided by the USAF, and develop the weapon delivery techniques that were to be used during the Operational Demonstration at Edwards AFB. All missions were flown using Eglin AFB ranges and were chased/photographed by USAF personnel. Since this was a new aircraft, safe weapon handling/loading methodology was also developed during this phase of the program.

Phase V Operational Demonstration

This testing was conducted at Edwards AFB and used the Precision Impact Range Area (PIRA) and the tactical range at Superior Valley. The Survivability testing was conducted from Edwards AFB, using the Nellis AFB Survivability Ranges.

5.0 RESULTS

A complete summary of all results obtained during this three-year program will not be shown. Only highlights of the testing results will be presented. The real purpose of this program was to determine the feasibility of the Enforcer concept as a low-cost CAS candidate. The Enforcer prototypes that underwent testing were not mature in capabilities or performance making many of the results unrealistic.

Phase III Airworthiness Testing

Flight Control System

The PA-48 Prototype had a reversible flight control system with boosted ailerons. It was equipped with mechanical trim for all axes and electric trim for the elevator and rudder. Ground testing indicated that the friction and breakout forces were 1.5 pounds for the longitudinal control system and 1.0 pound for the lateral control system. The trim characteristics for all three axes were found to be satisfactory. Control harmony was found to be poor. Heavy pitch forces resulting from an immature elevator design, created poor harmony with the aileron/rudder control forces.

Static/Dynamic Stability

Longitudinal static stability was evaluated for Configurations A and D. The results of these evaluations indicated that the aircraft had an adequate stability margin for any configuration that was anticipated for use during the course of the program.

Maneuvering stability was evaluated quantitatively. Stick force per “g” (Fs/g) at 22.9%MAC (forward c.g.) and 24.6%MAC (aft c.g.) were found to be 16.3 pounds/g and 15.5 pounds/g respectively. These values were obtained at 10000 feet for an aircraft weighing 14000 pounds flying at 242 KIAS. These Fs/g values were essentially the same for both configurations tested.

Qualitative dynamic longitudinal stability investigations were conducted. Pitch doublets were used to excite the short period that was found to be "Dead Beat" for all configurations. The long period (Phugoid) was seen to be convergent for cruise and climb conditions regardless of the configuration.

Dutch roll had a Φ/ß ratio of 1 to 3. Spiral stability was found to be neutral. The roll mode characteristics were found to be satisfactory – no residual lateral oscillations occurred using rapid full aileron control inputs.

Roll performance was evaluated with full tip tanks at 10000 feet for an aircraft weighing 14000 pounds. Configurations A and D were evaluated. The results for Configuration A were obtained with the landing gear up and flaps 0° at 240 KIAS. The results for Configuration D were obtained at 140 KIAS with the landing gear down and flaps 30°. These results are shown Table 5-1 below.

	Direction of Roll	
Flight Phase	Left	Right
Cruise	90.2 °/sec	90.5 °/sec
Landing	35.8°/sec	39.3 °/sec

Table 5-1. PA-48 Roll Rate Performance

Stall

Stall characteristics were obtained for Configurations A, C, and D at forward and aft gross weight and c.g. conditions. The results indicated very benign stall characteristics for any configuration, entry type, weight, or c.g. position. Lateral/directional control existed after the stall break. Stall warning was produced by airframe buffet occurring 5 – 10 knots prior to the stall break depending on flap position. Stall recovery was immediate with relaxation of backpressure accompanied by the addition of power.

The stall speed for Configuration A with landing gear and flaps up at a gross weight of 10000 pounds was 90 KIAS. The stall speed for this same configuration and weight with gear and flaps down (47°) was 82 KIAS. These speeds were seen to be increased approximately 10 knots for Configuration D with a full load of weapons at a gross weight of 14000 pounds.

No post stall investigations were performed.

Takeoff/Landing

Takeoff characteristics of the PA-48 Enforcer with the T-55 (free turbine engine) were found to be similar to those of the P-51D except in the area of torque. The free turbine engine has the two masses of the propeller and compressor section rotating in opposite directions. The resulting torque is essentially cancelled out. With the rudder trim set at 4° to the right, very little rudder was required to keep the aircraft straight during the takeoff roll. The aircraft lifted off between 105 and 120 KIAS, as a function of gross weight. Forces required at liftoff were approximately 10 to 15 pounds and gave the pilot the impression that the aircraft was difficult to “unstick” from the runway. After liftoff, trim changes during gear and flap retraction were insignificant.

The sea level ground run distance for Configuration B at 10000 pounds with the flaps up at a liftoff speed of 105 knots was 1740 feet. The sea level ground run distance for Configuration D equipped with a full load of weapons at 14000 pounds at a liftoff speed of 121 KIAS was 2620 feet. These distances were for a standard day, no wind, and hard surface runway condition.

The landing characteristics of the PA-48 Enforcer were found to be similar to those of the P-51D. The base turn was flown at 130 to 140 KIAS depending on gross weight with the landing gear down and flaps set at 30°. Final approach airspeed for a 10000 pound aircraft was 110 KIAS. This final approach airspeed was adjusted for gross weight with 5 knots being added for each 1000 pounds of additional fuel and/or weapons. Full flaps were lowered on short final if weapons were not being carried. The aircraft was trimmed in a reduced power condition for a two-wheel, slightly tail low touchdown that occurred between 95 and 110 KIAS.

After touching down, the tail wheel was lowered to the runway at approximately 70 to 80 KIAS. Directional control was maintained with rudder during the tail up portion of the landing roll. After the tailwheel was on the ground, directional control was aided by tail wheel steering when the control stick was in the full aft position.

The sea level landing ground run distance for Configuration B at 10000 pounds with gear down and flaps down (47°) using an approach speed of 120 KIAS and a touch down speed of 105 KIAS was 2625 feet. The sea level landing ground run distance for Configuration D equipped with a full load of weapons at 14000 pounds with gear down and flaps down (30°) using an approach speed of 130 KIAS and a touch down speed of 120 KIAS, was 4735 feet. These distances were for a standard day, no wind, and hard surface runway condition.

Crosswind takeoff and landing testing was not accomplished. However, the aircraft was landed in 15 Knot direct crosswinds on several occasions. A 15 Knot crosswind limit was used during the program. Normal, wing-low crossed control landing techniques were employed in a crosswind landing. Taxiing was limited in gusty wind conditions to below 25 Knots. This limit was established to preclude a tail-up condition occurring while taxiing in high, gusty wind conditions.

Climb

The sea level standard day climb performance is 5000 fpm for Configuration B at 10000 pounds. The sea level standard day climb performance was 3000 fpm for Configuration D equipped with a full load of weapons at 14000 pounds. The best climb airspeed at sea level was 155 KIAS for Configuration B and 150 KIAS for Configuration D.

Cruise

The maximum airspeed of 322 KIAS occurred at 8000 feet for Configuration B at a weight of 10000 pounds. The maximum airspeed of 282 KIAS occurred at 10000 feet for Configuration D equipped with a full load of weapons at a weight of 14000 pounds.

Flutter

Configuration A was cleared to 350 KEAS/0.703 Mach and all other configurations were cleared to 330 KEAS/0.703 Mach.

The decision not to install a Mach Meter during flutter testing was a poor one. The flight test engineer had to calculate the Mach number based on temperatures that were relayed by the pilot during the climb to the test altitude. On one of the last test points that was accomplished during flutter testing of the clean aircraft, the critical Mach number of .703 was exceeded and resulted in a "Mach Tuck" condition – the incident could have been avoided if a Mach Meter had been in the aircraft at the time.

Airloads

Airloads testing, established the "g" limits of +4.2/-2.1 that were used during the program.

Phase IV Weapons Testing

Weapon Clearance

The Eglin AFB W-151 and W-152 Warning Areas over the Gulf along with ranges B-62, B-70, and B-72 were used for this testing. A T-38 photo chase aircraft was used on all weapon clearance flights.

All weapons were cleared to a dive angle of 30° at 300 KTAS except the MK-82SE that was cleared to a dive angle of 15° at 300 KTAS. The MK-20 was cleared for drop without an adjacent store on stations 4 and 7.

An empty LAU-5002 rocket pod was cleared for jettison in an airspeed range of 150 to 200 KCAS for level, 1g conditions.

The CBU-58 was eliminated from further testing due to the tail fins hitting the lower surface of the wing flap.

Weapon Ballistics

The USAF AD/DLYW office furnished ballistic tables for all weapons used during the Phase IV testing effort. Sorties were flown on the instrumented ballistics testing ranges (B-70, C-72) to determine the validity of the bombing tables for both 15° and 30° weapon delivery events.

Results of this testing indicated that the ballistics tables, as supplied, were adequate for use during the Operational Demonstration.

IR Signature

An F-4 aircraft equipped with a Beam Aspect Seeker Evaluation System (BASES) pod that used short and long wavelength thermo-vision cameras to gather the required data. A laser-ranging feature of the BASES pod was used to maintain the desired aircraft separation of 300 to 400 feet. Ground based radars tracked both aircraft in the W-151 and W-152 test areas. The PA-48 Enforcer was equipped with pylons and RMS pods for this testing.

Data was collected at 10000 feet with the Enforcer operating at maximum available power. Only the left hemisphere of the aircraft was surveyed which represented a worst case IR condition.

Finalized IR Signature data was never published.

Radar Cross Section

Radar Cross Section (RCS) data was collected while the test aircraft was flown within the W-151 and W-152 test areas using the Eglin AD Automatic Reflectivity Measurement system (ARMS).

Ground controllers positioned the aircraft during a series of maneuvers to obtain the data. Four time-correlated ground radars were used in combinations of vertical and horizontal polarizations to obtain the RCS data and to track the test aircraft. Pitch, roll, and heading parameters were downlinked from the aircraft and were merged with Time and Space Positioning Information (TSPI) to determine resulting aspect angles.

Data for Configurations B and E was collected to define the Enforcer's RCS Characteristics. Configuration E was used in place of Configuration D because it represented the worst-case loading configuration RCS testing.

Finalized RCS data was never published.

Weapon Employment

A total of eight sorties were flown (using the Eglin C-62 range) to develop the weapon delivery technique for the PA-48 Enforcer aircraft. A new technique was required for delivering weapons because the over-the-nose visibility restricted pipper settings to a maximum depression of 110mils. This technique incorporated an Initial Pipper Placement (IPP) and a Final Pipper Placement (FPP) at weapon delivery. IPP's and FPP's were calculated for a 100mil pipper depression angle for each weapon expended during testing. This technique was used for all weapons, except the CRV-7 rockets, and was required because the target could not be seen when the weapon was released at the FPP. For rocket firing, conventional pipper depression settings and delivery techniques were employed.

Each pilot flew four sorties to become familiar with the new delivery technique that used a standard 100mil pipper setting. Weapon accuracy scores on both the bombing circle and tactical range reflected the lack of familiarity with this new technique.

Phase V Operational Demonstration

For the Operational Demonstration (OD), Piper Aircraft supplied a complete compliment of test team personnel. This included the pilots since USAF pilots were not allowed to participate in the flying portion of the demonstration.

Weapon accuracies were obtained for day, night, and tactical delivery profiles. This testing was conducted on the Precision Impact Range Area (PIRA) at Edwards AFB and the tactical range at Superior Valley, California. Range instrumentation, in conjunction with cockpit video that recorded weapon release parameters for each bombing and rocket-firing event, was used for weapon accuracy determinations.

Sorties were flown on the PIRA to define parameters for new 15° and 30° Pop-Up patterns that were required during tactical weapon delivery testing at the Superior Valley tactical range and the Nellis AFB survivability range.

Day Weapon Accuracy

Day weapon accuracy testing, using BDU-33 practice bombs with spotting charges, was accomplished on the Superior Valley range located 85 nautical miles Northeast of Edwards AFB. A low-level mission profile was flown to the target area.

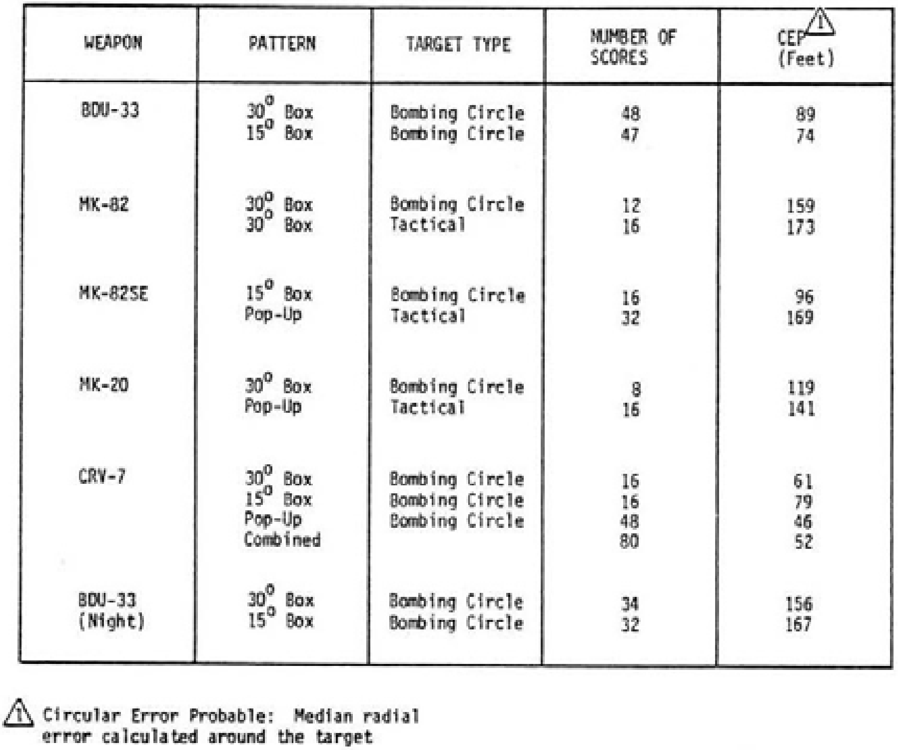
Target information/restrictions were relayed from a FAC operating in an A-37 aircraft. The FAC specified an IP, target location, target description, heading and distance from the IP to the target, and any target restrictions imposed by terrain or location of friendly forces. This scenario added an element of realism to the tactical weapon delivery accuracy testing. Scores were obtained using both a bombing circle and tactical targets.

The weapon scores achieved against tactical targets were less consistent than those achieved on the bombing circle. This was due to the added difficulty of making range estimations for the IPP and FPP from tactical targets and the lack of pilot proficiency using the new Pop-Up pattern profile developed at Edwards AFB.

Night Weapon Accuracy

Night weapon accuracy testing was conducted on the Superior Valley range using BDU-33 practice bombs with spotting charges. Both left and right-hand box patterns were flown to a bombing circle with lighted run-in lines. In addition, flares dropped from an A-7 aircraft were used to illuminate the target area on approximately one-half of the patterns. Range restrictions required a modified 15° Pop-Up pattern to be used when not dropping under flares. For these patterns, weapons were released at 1500 feet AGL instead of the familiar 800 feet AGL release point. This modified pattern was not practiced prior to the conduct of the night accuracy testing.

A summary for the day/night weapon accuracy testing is shown in Table 5-2. The CEP for rockets is misleading because the rockets were fired at vertical panels placed in the center of the bombing circle. The CEP using the centroid of the vertical target would be less than the recorded value of 52 feet.



WEAPON	PATTERN	TARGET TYPE	NUMBER OF SCORES	CEP △ (Feet)
BDU-33	30° Box	Bombing Circle	48	89
	15° Box	Bombing Circle	47	74
MK-82	30° Box	Bombing Circle	12	159
	30° Box	Tactical	16	173
MK-82SE	15° Box	Bombing Circle	16	96
	Pop-Up	Tactical	32	169
MK-20	30° Box	Bombing Circle	8	119
	Pop-Up	Tactical	16	141
CRV-7	30° Box	Bombing Circle	16	61
	15° Box	Bombing Circle	16	79
	Pop-Up	Bombing Circle	48	46
	Combined		80	52
BDU-33 (Night)	30° Box	Bombing Circle	34	156
	15° Box	Bombing Circle	32	167

△ Circular Error Probable: Median radial error calculated around the target

Table 5-2. Weapon Accuracy Results

Surge

A total of sixteen sorties were flown against tactical targets on the Superior Valley range. Four sorties per day were flown as two-ship tactical elements for four consecutive days. During this testing, accomplished in conjunction with the weapon accuracy testing, times for combat turn-around and quick reaction alert (QRA) were obtained. Figure 5-1 shows a MK-20 being loaded during Surge testing.

The results of Enforcer surge testing indicated an average combat turn-around time of 26.5 minutes and an average QRA time of 2.0 minutes.

Figure 5-1. Loading a MK-20

Survivability

Survivability testing of the PA-48 Enforcer was conducted using the Nellis AFB ranges. Missions were flown from Edwards AFB with each aircraft carrying two inert MK-82SE weapons. These weapons were not expended during simulated attacks due to range restrictions. USAF two-ship attack and maneuver tactics were employed during all survivability missions. The Enforcers were not equipped with IFF, Radar Warning, or Flare/Chaff Dispensing systems.

Nellis AFB survivability ranges, EC East and EC West, were used for this testing. These ranges contained a mixture of threats and simulated targets that represented a typical CAS engagement scenario. Friendly forces were located to the East of the Forward Edge of the Battle Area (FEBA) that was specified as the ridge of the Kawich mountain range.

Attacks on pre-briefed targets located to the West of the FEBA were initiated from the East side of the Kawich range. Approximately 5 attacks were made on FAC specified targets during each mission. Repeat attacks were made on the same target approximately 25 percent of the time. Ingress and egress profiles to/from the target area were flown at approximately 100 feet AGL and were structured to maximize terrain-masking times. Smoke Rockets (Smokey Sam's) were used to simulate Surface-to-Air Missile (SAM) launches and Anti-Aircraft Artillery (AAA) firings. Attacks were made using the Pop-Up patterns developed during the tactical weapon delivery testing. Gun camera film and cockpit video was used to identify weapon delivery parameters for each attack.

A complete post-test evaluation of the PA-48's performance against specific threats is not available. Preliminary findings indicated:

(1) Acquisition and height-finding radars could see the Enforcer during the Pop-Up portion of an attack but when the aircraft was low-level in the target area or when using terrain masking, these radars could pick up the aircraft only 10 to 20 percent of the time.

(2) The Long range SAM radar, could track the Enforcer during the Pop-Up portions of an attack, but could not achieve lock-on due to insufficient time for missile fly-out.
(3) The AAA simulators in the immediate target area were of primary interest during the survivability testing effort. Lock-on in ground clutter could be achieved at 4 – 5 km for a non-maneuvering aircraft with lock-on being delayed to 3 km for a maneuvering aircraft. Against a sky background, the Enforcer could not prevent or break lock within 14 km of the AAA threat.
(4) The short-range SAM was ineffective against the Enforcer due to the low IR signature. Post-test analysis showed that clouds and desert terrain had more IR energy than the Enforcer when operating in the threat area.
(5) Aggressor pilots could visually detect the Enforcer at a range of 3.2 km when it was flying over dark terrain or in cloud/terrain shadows. Aggressor pilots could visually acquire the Enforcer up to 6.4 km when it was operating in direct sunlight or against a sky background.
(6) Threat tracking was simplified by the relatively slow speed of the Enforcer (250 – 280 KIAS) and its limited "g" capability (4.2g's).

Soft Field

Testing the Enforcer while operating from soft/unprepared runway surfaces was conducted using Graham field located off the departure end of Runway 22 at Edwards AFB. Two adjacent landing strips, each strip 5000 feet long and 75 feet wide, were compacted and tested to known California Bearing Ratios (CBR). The hard strip had a CBR of 70 and the soft strip had a CBR in the range of 15 to 25. The weight of the Enforcer during this testing was 10260 pounds.

Takeoff and landing using the hard surface posed no problems. Taxi operations, on the soft runway surface, were discontinued because of blowing dust and severe rutting caused by the propeller and narrow profile tires. Takeoff or landing operations from the soft surface were not attempted.

Soft Field-testing was unrealistic:

(1) The Enforcer aircraft was equipped with narrow profile tires that were unsuitable for soft field operations.
(2) The soft field surface was very loosely packed dust to a depth of approximately 6 inches. This type of surface was not representative of a grass field as was originally envisioned for this testing.

In August 1984, after completing the Operational Demonstration both Enforcer prototypes were flown to Davis Monthan AFB where they were put into permanent storage. Today both prototypes have been refurbished and are being displayed in USAF museums. EN-1 is on display at Wright Patterson AFB in Ohio and En-2 is on display Edwards AFB in California.

David Lindsay purchased the rights to the Enforcer, once again, from Piper Aircraft in 1985 and moved all data and hardware (including N201PE that was used as a mock-up during the construction phase of the contract) to his facility in King City, California where it remains today.

6.0 CONCLUSION

The Enforcer program was controversial from the very beginning when J. Lynn Helms and David Lindsay lobbied congress for support. The contract, awarded to the Piper Aircraft Corporation in 1981, was to determine the feasibility of using a lower cost, less capable aircraft to support the CAS mission. However, at that time the USAF was not interested in adding a conventional landing gear, propeller driven Enforcer to their inventory and displayed an uncharacteristic lack of enthusiasm for the program.

The budget and schedule limitations imposed by the contract resulted in an Enforcer that was not representative of what a mature Enforcer concept could have achieved in terms of both capabilities and performance. This compromised aircraft was a direct result of not being able to address problems that were found in the early phases of development testing.

Factors that influenced the outcome of the feasibility demonstration included:

1. Not having enough time or budget to develop a suitable engine/gearbox/propeller for the Enforcer. Use of the Lycoming T-55 engine and L9A gearbox was acceptable for a demonstration but the Enforcer needed more shaft horsepower to realize its full potential. The real weakness was in the use of the very inefficient Aeroproducts propeller that did not allow true performance capabilities of the Enforcer to be demonstrated.
2. Not correcting problems found during development testing. The Enforcer had very high stick force/g levels created by a poor elevator design that was never corrected. This resulted in poor control harmony and difficulty in performing evasive maneuvers in the threat environment. Also, the total lack of an ECS system was never addressed. This system was grossly undersized and was totally inadequate for operations in the hot desert environment.

3. An early design requirement to incorporate 30mm GPU-5/A gun pods was an attempt to keep the Enforcer competitive with the A-10. These large gun pods were heavy and imparted large loads into the wing structure when the guns were fired. Although these gun pods were eliminated early in the program, the wing/pylon structure was unchanged. Redesign for carriage of 1000 pounds (rather than 2000 pounds) on each inboard wing station would have reduced the gross weight and improved overall performance and capabilities of the aircraft.

4. The long nose section of the Enforcer created problems when delivering unpowered air-to-ground weapons that were used during the OD. Typical CAS aircraft have an over the nose field-of-view of at least 14°, with the target in the field-of-view at the time of weapon release. The Enforcer had approximately 5° over the nose field-of-view, positioning the target under the nose of the aircraft at weapon release, where it could not be seen. This made accurate and repeatable weapon scores during Phases IV and V a challenge for the pilots.

5. Enforcer pilots did not have enough time to become familiar/proficient with the unusual IPP/FPP weapon delivery technique prior to conducting weapon accuracy testing.

6. Finally, when the Enforcer was operating in a high threat environment, the 4.2 g Limit and high Fs/g force did not allow for effective jinking maneuvers and was at disadvantage without IFF, Radar Warning, or Flare/Chaff systems.

An Operational Demonstration of the Enforcer was conducted in 1984, but the real answer as to the feasibility of the low-cost Enforcer concept to perform the CAS mission was never determined. Unfortunately, the true capabilities of David Lindsay's visionary Enforcer aircraft will never be known.

Editor's Memo: A Little Help Please!

Greetings SETP Members and associates. I'm AL Peterson the SETP Publications Chairman and I have a favor to ask of all of you. I need your help in finding, soliciting, and sending in good technical articles, RefleXtions style articles, photos, and general member news for publication in Cockpit. Our society members are doing great and fantastic work out there in the world, but you would never know it based on the lack of technical articles and other information that get submitted to Cockpit for consideration for publication. Quite honestly, we struggle every issue to find good technical and RefleXtions articles to publish, and I know we don't receive a fraction of the news about the great things our members are doing. If you know someone who has written a technical or historical flight test article please encourage them to submit it. If you know someone who has done some interesting flight test work (past or present) but hasn't written an article, encourage them to hit the keyboard and then send it in. Likewise for sending in news about the great things our members are doing, if you know something interesting that has happened in the flight test world please send it in. Good quality and interesting photos should also be sent in for inclusion in the news section and also for consideration for the cover of Cockpit. Cockpit is sent to and belongs to everyone in the Society and in order to keep it useful and relevant technically, journalistically, and socially we need everyone to actively seek out and send in articles, news, and photos. Thanks in advance for your support. Cheers, AL

RetroX

Editor's Note: In response to my perpetual note in COCKPIT appealing to the members for technical articles to publish, Lynn Hanks (F) suggested that perhaps the younger membership of the Society could benefit from some of the past articles that were published in the good old days, especially since "Retro" is all the rage these days. I quickly agreed with his logic and here is our first installment of the new RetroX article section. This first article is Lynn's suggestion, if anyone else out there would like to suggest a particularly good article from the archives please let me know. Cheers, AL

PRELIMINARY AIRWORTHINESS EVALUATION (PAE) OF THE WILLIAMS AERIAL SYSTEMS PLATFORM II (WASP II), INDIVIDUAL LIFT DEVICE (ILD)

LTC Donald L. Underwood, USA
Experimental Test Pilot
Edwards Air Force Base, California

Abstract

The United States Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation of the Williams Aerial Systems Platform II (WASP II) from 4 October 1981 through 29 March 1982 at the Williams International facility at Walled Lake, Michigan. The objectives of the evaluation were to assess the performance and handling qualities of the WASP II and provide an assessment of safety and scope of training for other Army operations to perform free flight during a concept evaluation program. Phase I of the program consisted of pilot qualification and general evaluation under gimbaled and tethered flight conditions. Phase II consisted of pilot familiarization and free flight verification of performance and handling qualities data obtained during gimbal/tethered tests. Fifty-nine tests (3 gimbal, 38 tethered, and 8 free flight) were performed for a total of 6.1 productive hours. The results obtained during the test improved the data base for assessing ILD requirements. Moreover, it was determined that present day direct thrust lifting aircraft can be evaluated utilizing conventional rotary-wing engineering flight test techniques with meaningful results.

Introduction

The concept of wingborne individual mobility has been an everlasting ambition of man since prehistory. From the early legendary waxed wings of Daedalus and Icarus, through lighter-than-air balloons and Ornithopters, to the Wright-Flyer and present day technology aircraft and helicopters man has sought to slip "the surly bonds of earth." Although most approaches to this venture have applied conventional aerodynamic designs with current state-of-the art technology to achieve performance and stability and control, some have sought to extend these principles to direct thrust individual lift devices (ILD), whereby, man is the integrating factor for stability and control.

Presented at the 39th Annual Form of the American Helicopter Society, St. Louis, Missouri, May 1983.

Early applications of this concept during the 1960's were embodied in the Bell Aerospace Systems Rocket Belt and later the Williams Research Jet Belt. Both concepts utilized the direct thrust lifting principle and incorporated gimbaled, thrust vectored, hand operated controllers for stability and control in all three axes. The Bell Rocket Belt was powered by a hydrogenperoxide rocket motor while the Williams Jet Belt utilized a turbojet engine. Both concepts were demonstrated to be flyable, however, their application was performance limited due to a maximum endurance of 20 seconds for the rocket belt and 6 minutes for the jet belt at sea level standard day conditions.

Interest in the individual mobility concept, however, continued through the seventies and in May 1977 the United States Army in a Science and Technology Objective Goal (STOG) called for a "one man conveyance, without rotor blades, which can be operated by essentially untrained or quickly trained run-of-the-mill unit personnel..."

As a candidate for the ILD concept, Williams International, Inc. proposed the Williams Aerial Systems Platform II (WASP II) to the US Army Tank Automotive Command (TACOM). Its operational concept is to improve individual mobility in the infantry battalion and combat support units in rough terrain while being operated and maintained by non-aviation personnel.

Description

The WASP II (Photo 1) is a one-man direct thrust lifting, vertical take-off and landing (VTOL) vehicle which is controlled kinesthetically in pitch and roll and mechanically in yaw.

Airframe

The airframe of the vehicle is designed around a wood platform on which the operator stands and to which the engine mount and skid-type landing gear are attached (Fig. 1). Equally sized fuel cells form the left and right side of the vehicle and are attached to the engine structure by means of a tube installed across the vehicle. During gimbal and tether operation, this transverse tube also serves as an attachment structure to the gimbal rig and to the tether harness. The intake duct leading to the engine inlet serves as the structural support for the twist-grip type vertically installed throttle and yaw control handles. Directional stabilizing fins are mounted vertically to the rear edge of each fuel tank. The retractable exhaust deflector prevents the jet from directly impinging on the ground and spreads the exhaust gases radially outward. A balistically deployed modified "Yankee" emergency recovery system is mounted in the forward area above the front fairing and is electrically actuated by a guarded push button switch on top of either the yaw or throttle control handles. The turbine section of the engine is wrapped with multiple plies of Kevlar 29 (Photos 2 and 3) cloth which is designed to contain the turbine blades and disk fragments in the event of a turbine rotor burst. The vehicle is open at the rear to allow ingress and egress of the operator. The vehicle's component weight breakdown is shown in Table 1.

Engine

Thrust is provided by a modified version of the Williams cruise missile engine (F-107) redesignated as the WR19-7 turbofan engine and derated from a maximum uninstalled design thrust of 635 pounds to 570 pounds on a sea level standard day (Fig. 2). The engine is a two-spool engine with the low pressure axial compressor driven by a two-stage low pressure turbine and a high pressure centrifugal compressor driven by a single-stage turbine. The axial compressor has four stages with interstage bypass after the first two (fan) stages. Exhaust is a mixed flow of bypass air and hot gases generated from an annular type combustor with centrifugal fuel (slinger) distribution. The low pressure shaft positioned through a second high pressure shaft supports the two spool rotary group configuration. The two engine shafts are counterrotating to minimize vibration and gyroscopic reactions during engine operation. Accessories are driven from the high pressure spool by means of a radial drive (tower) shaft. The accessory gearbox is mounted beneath the engine and incorporates drive provisions for the fuel pump/fuel control, the lubrication and scavange pump assembly, and the engine accessory generator (alternator/exciter). The various bearings and gears are oil-jet lubricated. Continuous surface gap ignition of primary zone fuel is utilized. The engine has an externally mounted oil tank with the lube and scavange pump an integral component of the tank. The engine is started by using compressed air impingement on the high pressure turbine blade. The engine is mounted with a 15 degree angle from the vertical axis (Photo 4), and a curved exhaust nozzle (15.5 degrees) is utilized to direct the thrust vector through the man-vehicle center of gravity.

At the present stage of development, the engine has not been man-rated in accordance with MIL-STD 5007D and, therefore, has a time between overhaul (build) of 10 hours total operating time since the completion of the last acceptable test procedure (ATP). After each ATP the engine is numerically referred to as a build sequence.

Flight Controls

The vehicle is controlled kinesthetically by the operator longitudinally and laterally (pitch/roll axis) and directionally by manually operating the directional control vanes located in the jet efflux (Fig. 3). The directional control linkage is mechanically operated by a flexible push-pull cable from the directional control mounted on top of the inlet fairing. The directional control vanes are differentially deflected by a walking beam which rotates about the midpoint on a ball bearing pivot affixed to the forward transverse tube of the tubular rectangular base frame of the vehicle.

Thrust control of the engine is accomplished by a throttle hand grip located on top of the inlet faring which governs the fuel control unit through a control cable (Fig. 4).

The test vehicle (No. 1) with serial number (S/N) 102 engine installed (S/N 1-102) was representative of the Concept Feasibility Demonstration (CFD) program vehicle (S/N 1-101/ Builds 1 through 7) with the exception of the following engine modifications and configuration changes:

a. Engine modifications:

(1) Increased diameter fuel slinger

(2) Aft burner section (first stage nozzle) expanded by one percent.

(3) Second stage nozzle Compressor Discharge Pressure (CDP) supply tube vibration dampner installed.

(4) "Deswirl Vanes" (Photo 5) removed.

(5) Twenty stator vanes installed in the plane of the center body support struts of the rear engine housing (Photo 6).

(6) 1/4 inch diameter steel cylinder spanwise mounted to the trailing edge of each directional control vane with half of the cylinder protruding above each of the two surfaces of each vane.

(7) End plates at the root and tip of each directional control vane cut back to the leading edge of the vane and then scarfed 45 degrees to the chord line of the vane (Photo 6).

b. Configuration changes:

(1) Kevlar 29 rotor disc containment ring extended axially forward 1-1/2 inch to the leading edge of the igniter and aft 1-1/2 inch to the thermocouple boss (Photo 2).

(2) Kevlar 29 protective shield attached to the rear surface of the inlet fairing (Photo 7).

(3) Emergency recovery system and ballasted for inertial moments prior to flight tests.

(4) Exhaust gas deflector and acutator removed.

Test Scope and Methodology

Scope

A limited Performance and Handling Qualities Evaluation of the WASP II (ILD) vehicle was conducted in a two phase program at the Williams International facility at Walled Lake, Michigan, during the period 4 October 1981 through 29 March 1982. Phase I of the program consisted of pilot qualification and general evaluation under gimbaled and tethered flight conditions. Phase II consisted of pilot familiarization and free flight verification of the performance and handling qualities data obtained during gimbaled/tethered tests. Fifty-nine tests (3 gimbaled, 48 tethered, and 8 free flight) were performed for a total of 12.7 engine operating hours, of which 6.1 were productive testing. A majority of the tests were conducted under nonturbulent atmospheric conditions to preclude natural disturbances from influencing the vehicle characteristics. Performance and handling qualities data were recorded for a neutral center-of-gravity (CG) (defined as the thrust vector passing through the manmachine CG) and various gross weights. A limited number of flights were accomplished in turbulent air conditions in order to evaluate the stability and control of the vehicle under representative operating conditions. Flight restrictions and operating limitations contained in the airworthiness releases issued by AVRADCOM (Refs 2 and 3) were observed during the evaluation. The test conditions are presented in Table 2.

Test Methodology

Engineering flight test techniques from References 4 and 5 were used, where possible, during this evaluation and are briefly described in the Results and Discussion section. Where applicable, tests were conducted in tethered flight prior to free flight. During tethered flight evaluations slack was maintained in the tethered cable suspension to minimize any influence by the tether system. Qualitative ratings of handling qualities were based on the modified Cooper-Harper Handling Qualities Rating Scale (HQRS). During all tests selected engine parameters were telemetered to a ground station and recorded on a strip recorder. Flight characteristics were obtained from qualitative pilot evaluation and analysis of test results recorded with a video cassette recorder.

Results and Discussion

General

Because of its unique characteristics and operating capabilities, the WASP II presented a number of technical problems not normally encountered in conventional V/STOL aircraft flight testing. Safety considerations inherent with the direct thrust lifting concept and lack of demonstrated emergency forced landing or egress capability limited the operational envelope (Fig. 5) contained in the flight test airworthiness release (Refs 2 and 3) to a minimal injury category. Additionally, the fundamental configuration design of the WASP II severely limited the evaluation due to the lack of performance and flight characteristics instrumentation capability. Primary emphasis, therefore, was placed on obtaining qualitative data describing the vehicle flying characteristics, with calibrated engine condition parameters used to evaluate performance data, and a calibrated Duppler radar speed gun was used to measure ground speeds.

The performance and handling qualities results obtained during this evaluation were used to determine criteria for a limited airworthiness release for non-rated Army operators to become qualified to perform free flight during a Concept Evaluation Program and establish riorities for correcting problem areas noted prior to any further development or production. Accordingly, only those areas affecting further developmental testing will be addressed in this paper. A complete discussion of the results and conclusion of the WASP II PAE is contained in Reference 6.

Performance

Performance flight testing of the WASP II was conducted using vehicle S/N 1-102. The engine was rebuilt three times during this evalution. The test vehicle engine was calibrated during each post-build Acceptance Test Procedure (ATP), but was not instrumented to make in-flight measurements of installed engine inlet and exhaust losses, fuel flow (W_F), or low pressure turbine fan speeds (N_1).

Generalized engine performance data (Figs. 6 and 7) obtained during engine acceptance runs and corrected analytically for installed inlet losses were utilized to determine thrust required. Hover performance (both in-ground effect (IGE) and out-of ground effect (OGE) and level flight performance tests were conducted using ATP high pressure turbine speed (N_2) to determine thrust required. Exit losses were evaluated in a test cell utilizing a calibrated load cell as a basis for determination of thrust losses due to yaw vane deflection.

Vertical takeoff performance tests were conducted on vehicle S/N 1-102 to determine the minimum thrust-to-weight ratio (T:W) required for a vertical takeoff. Gross weight was varied to obtain the minimum T:W at which a vertical takeoff was possible. All tests resulted in a minimum takeoff T/W of 1.1. This is 4 percent higher than demonstrated by the contractor (T/W = 1.06) during the CFD (Ref 7). Reference 8 specifies a minimum design criteria of 1.05. Based on test data, the takeoff performance of vehicle S/N 1-102 was markedly deterioriated as compared to vehicle S/N 1-101.

Hover performance testing was accomplished using the hover shaft technique (Ref 4). Six inch increments up to 3 feet and one foot increments from 3 to 15 feet were used with the vehicle on the tether rig. The hover thrust required (Fig. 8) as a function of height above ground level (AGL) shows a negative ground effect within one foot AGL for both the unmodified and modified directional control system configurations tested. The modified directional control system configuration further required a smaller thrust margin (3%) than the 9% required for the unmodified directional control system (Table 3) due to the influence of effective jet nozzle area variation. Above the negative ground effect influence of one foot skid height to the maximum tested (15 foot skid height) the thrust required for all heights was essentially constant and dependent only on gross weight and ambient conditions.

The induced lift losses in-ground effect were attributed to a combination of jet efflux induced forces and exhaust gas reingestion. IGE lift losses were thought to be caused by negative pressures generated by entrainment of the jet exhaust between the ground and the bottom of the vehicle (Fig. 9).

Exhaust gas reingestion performance degradation (Figs. 10 and 11) would follow the same trend as an ambient temperature rise (Fig. 7).

The resulting performance loss due to exhaust gas recirculation would be at least one percent thrust loss per three degrees farhenheit rise in temperature at the engine inlets. A detailed flow field analysis of air in the vicinity of the vehicle while operating near the ground was not within the scope of this test. To fully understand the sensitivity of wall jet entrainment, mixing, and exhaust gas reingestion would have required laser duppler velocimeters and an engine inlet temperature survey during test operations. It is apparent, however, that the flow pattern and exhaust gas recirculation net effect was a significant degradation to performance near the ground.

Performance variation between the modified versus unmodified directional control systems is associated with the differential engine flow pressure ratios generated in both the bypass and core flows while differentially deflecting the yaw control vanes in the jet efflux.

Level flight performance tests were conducted to determine power required as a function of airspeed. Tests were conducted at takeoff gross weights from 530 pounds to 568 pounds and at density altitudes from sea level to -2000 feet. The results of individual tests indicated that airspeeds from hover to 13 knots had no measureable effect on power required as determined by relatively constant N_2 speed at a specific gross weight. For all weights tested, N_2 speeds varied from 59,500 RPM to maximum allowable (61,800 RPM) depending upon ambient conditions for a T/W equal to or greater than 1.0.

The endurance characteristics of the WASP II were derived from ATP fuel flow data (Fig. 7) for representative gross weights and ambient conditions where minimum T/W equals 1.1 (takeoff conditions) and is presented in Table 4. Fuel allowances were made for a 2-minute warm-up at ground idle (N_2 = 39,000 RPM) and a 3-minute or 20 pounds of fuel reserve at the completion of the mission. The specific fuel consumption at maximum N_2 speed (61,800 RPM) was calculated to be 0.64 pound per hour per pound of thrust.

Although the WASP II concept proposes a significant performance improvement over its predecessors (rocket and jet belts) its indicated performance capability is not that significantly better. The variation of net thrust as a function of temperature and N_2 speed severly restricts gross weight loadings and operating conditions for ambient sea level conditions warmer than +68°F as indicated in Table 4.

Handling Qualities

Handling qualities characteristics of direct thrust lifting aircraft without rotor or associative airfoil configurations require precise control-path "minima" due to the safety considerations necessitated by their capability to operate within extremely close proximity to obstacles. In general, the "ideal" handling quality requirements would indicate high ratedamping (ratio of angular velocity to inertia of the aircraft, given in 1 sec), control power (angular velocity per unit of control deflection, in deg/sec), and control sensitivity (angular acceleration per unit of control deflection, in deg/sec^2) in order to reduce the time required to correct deviations from a desired position without oscillatory instability.

In the application of the WASP II principle conventional aerodynamic control surfaces do not provide stability or control. Rather the operator is the integrating factor for stability and control (Fig. 12) and, therefore, must compensate for the static and dynamic instabilities arising from gyroscopic moments and propulsion induced flow fields.

In order to determine the stability and control characteristics and pilot workload requirements of the WASP II a limited handling qualities evaluation was conducted. The handling qualities evaluation, where possible, utilized standard flight test manuevers and was conducted with the vehicle symmetrically loaded at an average engine start gross weight of 530 pounds (T/W = 1.15 to 1.26) with the combined man-machine CG near the thrust vector centerline (±0.15 inch). Primary emphasis was placed on obtaining qualitative data describing the vehicle flying characteristics using an HQRS rating system, with numbers from 1 to 10, where a rating of 1 represents "ideal" characteristics and a rating of 10 "catastrophic" behavior. Control system mechanical characteristics were quantitatively evaluated on the ground with the engine stopped and qualitatively in flight at nominal engine speeds from ground idle to maximum available. A calibrated doppler radar speed gun was used to measure groundspeeds during forward, sideward, and rearward flight.

In general, the WASP II with the modified directional control system could be safely flown throughout the limited flight envelope with minimal but adequate control margins. However, extensive pilot compensation was required to maintain control during all phases of flight. Four unsatisfactory characteristics which contributed to the extensive pilot workload were directional instability, excessive throttle sensitivity, lack of control displacement harmony, and inadvertent pitch and roll inputs due to mechanical/ kinesthetic cross-coupling. The directional stability limits the capability of the vehicle and should be corrected prior to further developmental testing. The other unsatisfactory characteristics reduce pilot effectiveness and vehicle capability by increasing pilot fatigue and should be corrected prior to production.

The throttle and directional control system mechanical characteristics were measured on the ground with the engine stopped, and on the gimbal rig with the engine operating, and qualitatively compared in flight. Throttle and directional control positions were measured in degrees of rotation. The throttle zero degree position was defined as the ground idle position and the directional zero degree position was with the handgrip positioned equidistant between full left and full right control deflection. Control moments were measured by applying torque at the midpoint of the handgrips and measuring the moments (inch-pounds) at incremental rotational positions. Table 5 is a summary of mechanical characteristics with both directional control system characteristics described.

The relationship between throttle position and power turbine speed (N_2) is shown in Fig. 13. Total throttle displacement was 52 degrees (0.91 inches of arc measured at the grip) from ground idle to maximum allowable (N_2 = 61,800 RPM). For nominal flight operations from minimum N_2 speed attainable prior to take-off (approximately 58,000) to the maximum allowable (61,800 RPM), the maximum throttle displacement was 9 degrees or 0.157 inches of arc measured at the grip.

Total directional control displacement was 20 degrees (0.25 inches measured at the grip) either side of neutral, which corresponds to 10 degrees or 100 percent of differential yaw vane deflection either right or left for both systems tested.

The difference in precision and size of control displacements between the throttle and directional control handgrips was objectionable. The directional control required a large wrist rotation at least 5 times greater than the precise rotation required by the throttle. In flight, the directional control movement always felt excessive and not in harmony with the smaller throttle control motions. This difference was most noticeable during maneuvers requiring large directional control inputs as compared to small throttle inputs such as vertical takeoffs or landings, accelerations or decelerations, and initiation of climbs or descents.

Mechanical and kinesthetic control cross-coupling was qualitatively evaluated with the vehicle restrained vertically in the gimbal rig and concurrently throughout the flight test program. Following pitch application to approximately 20° nose down the vehicle rolled left, and for approximately 15° nose up input the vehicle rolled right. Likewise for roll inputs the vehicle pitched up during right rolls and down during left rolls. Under all conditions the initial roll rate following a longitudinal input was greater than the initial pitch rate. Directional control inputs induced roll attitude changes in the direction of the input at a rate less than the initial yaw rate. This was attributed to the roll movement generated by the rotation of the upper body during the directional control input. Little or no yaw excursions were detected during roll inputs. The high degree of pitch-roll/yaw-roll coupling substantially increased the pilot's workload by requiring simultaneous cross control in all three axes (HQRS 6) and detracted from the maneuverability of the WASP II.

Controllability in a hover was determined by measuring the average angular velocity resulting from step type control displacements from trim. Single-axis control step inputs were applied from a stabilized hover and the vehicle response recorded on a video cassette recorder for a specified time or until recovery was necessary.

Longitudinal and lateral control response (angular velocity per unit of control displacement) in a hover could not be determined. The high control sensitivities and large pitch and roll attitude changes attained necessitated a recovery before the maximum velocities were reached. Recoveries were required within 1 to 2 seconds following control displacements with negligible control lag in either axis. Qualitative test results indicated that the longitudinal and lateral kinesthetic control sensitivity (angular acceleration per unit of control displacement) in either axis was nonlinear. Additionally, forward longitudinal control effectiveness (attitude attained per control displacement) was greater than aft longitudinal control effectiveness, and left lateral control effectiveness was greater than right lateral control effectiveness. The asymmetry in control effectiveness was not objectionable. The development of angular velocity and angular acceleration was in the direction commanded. The combination of high longitudinal and lateral kinesthetic control sensitivity, and pitch-roll cross-coupling significantly increased pilot workload (HQRS 6) required to damp pilot induced pitch and roll oscillation during operations in turbulent conditions and tended to induce fatigue within the first five minutes of flight.

Directional controllability characteristics are presented in Figs. 14 and 15.

In a hover, the directional control response was defined as the yaw rate achieved after 90 and 360 degrees of rotation. The yaw rate had not peaked before recovery was initiated. Recovery was necessitated after 360 degrees of rotation due to proverse roll accompanying increasing yaw rate which in some conditions was greater than the final yaw rate. With the orginal directional control system installed, vehicle response to the left was sluggish and undesirable due to the excessive lag time from control input to initiation of vehicle response. This characteristic substantially increased pilot workload required to maintain accurate directional heading within ±10 degrees during turbulent conditions (HQRS 7). Control lag time was reduced and response was increased with the installation of the modified directional control system. Although control sensitivity remained nonlinear the desired response was predictable due to increased sensitivity. In flight, in order to maintain directional control, full control application with a slow return to neutral was required every second to maintain desired heading within ±5 degrees (HQRS 6).

Gust response of the WASP II was qualitatively evaluated during hover operations in turbulent conditions (winds not exceeding 15 knots or a 5-knot gust spread) at skid heights from 5 to 8 feet. Longitudinal disturbances were manifested in a divergent pitch-up tendency which was aggravated by resultant pitch-roll coupling. Lateral disturbances caused the vehicle to turn with a bank attitude developing opposite the direction of the gust accompanied by a directional divergence toward the downwind direction. The response to gusts in all axes was aperiodic divergent in that a control input in the direction of the disturbance was required to stop the resulting rate. The resultant level of directional instability was sufficiently high as to significantly increase the pilot workload while decreasing from the controllability margins during maneuvering.

The turning flight characteristics were qualitatively evaluated using constant power, steady-state turns, left and right. Due to the envelope constraints (Fig. 6) bank angles were limited to approximately 10 degrees and airspeed to 10 knots. All maneuvers were easily performed and required aft kinesthetic control input with increasing bank angle to the left. In turns to the right, aft kinesthetic control inputs were not apparent due to pitch-roll coupling. The characteristic was not objectionable to the pilot. Body lean was required in the direction of the turn. The lateral and longitudinal characteristics in turning flight were satisfactory. Extensive pilot compensation, however, was required to maintain near zero sideslip (±5 degrees) due to directional instability in the turns and yaw-roll coupling (HQRS 6).

Vertical takeoffs to a hover and landing from a hover were evaluated during each flight. These maneuvers were extremely difficult to perform initially and required maximum pilot compensation to maintain a vertical flight path over a selected point on the ground (HQRS 9). During the takeoff transition a nose-down pitching moment was produced with increasing throttle. This pitch moment was very objectionable since the pilot tended to overcompensate and was unable to kinesthetically balance the longitudinal control forces required to maintain the desired takeoff flight path for approximately 3 seconds after takeoff (HQRS 9). Additionally, with the original directional control system installed, the vehicle tended to rotate approximately 45 degrees to the right during the takeoff transition due to insufficient directional control effectiveness (HQRS 10). This situation was corrected with the installation of the modified directional control system which permitted maintaining heading within ±5 degrees (HQRS 6). Following approximately 1.1 flight hours, pilot familiarization with the kinesthetic control motion requirements reduced the pilot workload levels (HQRS 6) and takeoffs could be satisfactorily performed.

Within 3 feet of the ground a stable hover was extremely difficult (HQRS 6) to obtain due to random pitch and roll perturbations. Within this region, pilot workload significantly increased due to a deterioration of longitudinal and lateral stability and variations of ±1 to 2 feet in height were common. At any height in gusting winds (15 knots maximum, with a 5 knot gust spread) pilot workload increased significantly in order to maintain altitude within ±1 foot due to induced pitchroll coupling (HQRS 7). The vehicle exhibited a strong directional instability which required continuous directional control inputs into the wind. This further aggravated pitch-roll coupling by inducing pitch-roll oscillations as a consequence of yaw-roll coupling. Height control was further complicated by excessive throttle sensitivity. The precise throttle manipulations coupled with the weak control moment gradient and "dead-man" feature of the throttle required extensive pilot attention to maintain altitude within ±1 foot (HQRS 6) and contributed to a high workload and early pilot fatigue during transition training.

The vertical landing procedure from a hover, was much more complicated than that for takeoff. The narrow skid base required near perfect vertical flight path control to avoid tipping or rolling the vehicle over. The negative ground effect) and stability and control deterioration experienced within 3 feet of the ground significantly increased pilot workload to maintain a skid level landing attitude and minimize sink rate (HQRS 6). Power management required precise throttle control to maintain the desired sink rate with an abrupt change in power required in the region of negative ground effect to prevent hard touchdowns (HQRS 6). The pilot's aft longitudinal control motion in response to the nose-down pitching moment with increasing power in the region of negative ground effect resulted in a majority of the landings being accomplished with a fore and aft rocking motion. Upon touchdown, the throttle was immediately reduced to ground idle to preclude further perturbations. The narrow skid base of the WASP II is a shortcoming which restricts deployability to improved level surfaces.

Static stability and flight characteristics of the WASP II were evaluated while performing low-speed forward, rearward, and sideward flight at the conditions shown in Table 1. The purpose of the tests was to determine control margins and flying qualities characteristics while hovering in various wind conditions. The vehicle was stabilized at a hover and at 2-knot increments up to the maximum permissible of 13-knots. A calibrated doppler radar speed gun was used to measure groundspeed. With the vehicle maintained at a skid height of approximately 15 feet, control positions were qualitatively noted at each stabilized speed.

Forward and rearward translations were accomplished by tilting the lift vector of the vehicle with longitudinal kinesthetic control inputs while maintaining a constant altitude and heading. This method changed the attitude of the vehicle proportional to the kinesthetic control pitch input. Kinesthetic control in the direction of motion was required for increasing airspeed in either direction. No difficulty was experienced in controlling the vehicle in pitch or maintaining a relatively constant speed. Longitudinal kinesthetic control margins within the confines of the vehicle structure were adequate to the maximum speed tested.

Lateral translations were accomplished by banking kinesthetically in the direction of translation. To the maximum of 13-knots tested, the bank angle and body postion were not excessive or uncomfortable and well within the limits predicted by the contractor During this evaluation directional instability was observed between approximately 2 to 13 knots. It was characterized by a rapid, strong yaw tendency in the opposite direction to the relative wind. Above approximately 5-knots with the original control system installed there was insufficient directional control power to maintain a constant heading reference and the vehicle tended to diverge directionally away from the wind. This was very disconcerting to the pilot and required an immediate deceleration to zero velocity with full opposite directional control input in order to effect recovery within 360 degrees of azimuth rotation (HQRS 10). With the modified directional control system installed there was a minimum of 50 percent control margins available throughout the envelope tested. With crosswind velocities greater than 5-knots, however, the combined workload requirements of directional control and yaw-roll coupling were excessive (HQRS 7). The directional instability presents a hazardous situation when hovering the vehicle in confined areas during gusty wind conditions.

WASP II control characteristics were qualitatively evaluated while performing typical mission maneuvers. The maneuvers performed were nap-of-the-earth (NOE) flight, accelerations, decelerations, bob-ups, and figure eights. The performance of these maneuvers has been previously discussed in the Handling Qualities section of the report. All these maneuvers were safely performed; however, attitude and altitude control were degraded by excessive throttle sensitivity control disharmony control cross-coupling directional instability and gust response characteristics all of which significantly increased pilot workload to maintain control.

Human Factors

Man-machine interface was qualitatively assessed throughout all training and test flights. Cockpit layout, control function design and position, available cues, and crew comfort were evaluated individually and suquentially as prescribed in both normal and emergency procedure checklists. Evaluation of controls included an assessment of location, accessibility, and functional operation.

The functional use of the throttle and directional control system was qualitatively evaluated throughout the test program. The size and shape of the handgrips provided a comfortable and natural hand position. The location of the throttle camlock mechanism and radio switches allowed easy operation. While advancing the throttle the pilot had to reposition his grip at least three times from ground idle to nominal operating speed. This was required to avoid hyperextending the pilot's wrist and to achieve adequate control feel to make precise throttle inputs for power changes. This requirement to make grip position changes to control the throttle distracted from task workload effectiveness and tended to induce early ergonomic stress.

Additionally, the anthropometric design of the WASP II does not afford any body support for the pilot to minimize early muscular fatigue or provide for precise kinesthetic pitch and roll control inputs. During early training, pilot induced pitch and roll oscillations were common and were aggravated by the coupling discussed earlier. To alleviate this condition the contractor recommended an upper torso support system (arm rests) similar to those used by the contractor pilot. After several flights utilizing the contractor pilot's arm rests, a marked improvement in control and decrease in pilot workload was noted. Accordingly, a custom fitted arm rest support was fabricated with polystyrene and ducting tape to provide improved upper torso support with a further improvement noted. The poor anthropometric design of the WASP II further aggravates ergonomic stress and detracts from vehicle control.

Pilot physiological comfort was qualitatively evaluated concurrently with all other tests at free air temperatures ranging from zero degrees fahrenheit to +72°F. At ambient free air temperatures colder than +10°F the extreme cold effects severely restricted the pilot's ability to properly manipulate the vehicle controls after approximately 10 minutes of exposure (HQRS 8) due to a wind chill index of -53°F induced by engine inlet velocities of approximately 70 feet per second (40 mph) in the vicinity of the forearms. On three occasions the pilot incurred first degree frostbite injuries to the hands despite wearing double insulated "Simpson" nomex driving gloves with wool thermal liners. Additional thermal protection to the hands reduced control feel making it difficult to properly manipulate the controls. At temperatures warmer than +15°F, in bright sun light, solar radiation effects provided some improvement to the debilitating effects of exposure to extreme cold, however, total operating time remained limited to approximately 10 minutes due to hypothermia. Inadequate pilot thermal protection, particularly of the hands, at temperatures colder than +15°F presents a physiologically debilitating condition which adversely restricts flight operations.

Naturally, aircraft engine noise represents a general problem, but tends to be much more severe for VTOL configurations because of large installed power and often close operation to large groups of people. WASP II sound pressure level measurements and frequency spectrum analysis were made concurrently with flight testing to determine compliance with MIL-STD-1474B (Ref 9). Primary emphasis was placed on external environmental sound conditions since measurement of in-flight internal pilot helmet sound pressure levels was impractical. Results of these tests are presented in Table 6. An intense sound pressure level and resonnance was found to exist about a foot above the ground at the vehicle. At this height a sound pressure level of 137.5 (A) decibels (dBA) was recorded at a resonnance that produced dominant tones in the 800 Hz and the 1000 Hz bands with some harmonic in the 2000 Hz band. The intensity of the sound decreased gradually to 127.5 dBA at a radius of 30 feet from the vehicle. The 85 dBA contour was determined to be in excess of 250 feet while the vehicle was within 5 feet AGL. Test data provided by the US Army Aeromedical Laboratory, Ft. Rucker, Alabama, indicated the SPH-4 helmet with soft cushion earphones and conformal foam earplugs would provide adequate hearing protection (at least 34.4 dBA per dominant noise attenuation at 1000 Hz) to permit a maximum of 80 minutes of operation in each 24 hours (Ref 10). Within 3 feet of the ground, however, the SPH-4 with conformal earplugs was considered inadequate because of difficulty in understanding communications with the radio at full volume. Ground support personnel exposed to the noise of the WASP II while wearing hearing protection have described it as intense, fluctuating and extremely irritating. During operations over compliant surfaces (sod) at altitudes greater than 8 feet AGL the apparent cockpit sound level decreases appreciably and communications are clear and understandable. The system noise of the WASP II exceeded the maximum design limit (108 dBA) of paragraph 5.1.1.2E of MIL-STD-1474B by at least 20 dBA. The number of personnel exposed to the intense noise levels of the WASP II should be limited and mandatory ear protection be required for personnel within 250 feet of the vehicle during operations.

Vibration characteristics of the WASP II were qualitatively evaluated throughout the test program at the conditions listed in Table 1. On the ground, at ground idle, vibration levels were perceived as extremely high frequency causing a localized numbing effect in the feet and ankles. As turbine speeds were increased to power required for takeoff (approximately N_2 = 58,000 + RPM) the intensity increased. Immediately upon takeoff and within 3 feet of the ground, the intensity increased significantly. Within this region, the vibrations were perceived as a "buzzing" sensation within the helmet. The excessive high frequency vibration characteristics in close proximity to the ground is a shortcoming.

At heights from 3 feet to 10 feet AGL a heavy repetitive low frequency beat which caused the pilot's helmet to "pop" and intermittently break the ear seal formed by the soft cushion earphones was noted. The low-frequency vibration was extremely irritating and distracted the pilot. Higher than 10 feet the vibration levels decreased to an insignificant level. The low frequency beat oscillation generated within 3 to 10 AGL may be due to induced pressure effects and forces of the jet efflux impinging upon the ground. An analysis should be conducted to ascertain the physiological effects of the WASP II vibration characteristics.

Employment Considerations

Ground erosion and debris ingestion by the engine inlet is a problem for almost all VTOL configurations; but erosion and reingestion for lift-jet VTOL configurations are more severe. Ground erosion and the forces on objects in the vicinity are porportional to the dynamic pressure of the jet efflux and the recirculation effects associated with its impingement on the ground.

During the WASP II evaluation the greatest potential for ground erosion or debris ingestion was incurred during hover operations at altitudes of less than 10 feet. On three occasions the bypass fan received foreign object damage (FOD) by spalling of the concrete landing pad surface. During other operations over unimproved areas the primary cause of debris ingestion were small pieces of rock, rock salt, and mud.

Concluding Remarks

The Preliminary Airworthiness Evaluation of the WASP II was the first flight test engineering performance and handling qualities evaluation of a direct thrust individual lifting device employing a kinesthetic control principle. And although extensive pilot compensation was required for control, the technical feasibility of the concept with a modified directional control system has been demonstrated throughout the limited flight envelope tested with adequate control margins available for normal flight maneuvers. Open issues remain, however, to improve performance and handling qualities characteristics discussed in this paper. Further testing is anticipated with a growth version of the WASP II to resolve deficiencies.

Additionally, the test results indicate that present day direct thrust lifting aircraft can be evaluated with conventional rotary-wing flight engineering test techniques with meaningful results.

References

1. Letter, AVRADCOM, DRDAV-D,25 August 1981, subject: Preliminary Airworthiness Evaluation (PAE) of the Individual Lift Device (ILD) (WASP II), Project No. 81-12.

2. Letter, AVRADCOM, DRDAV-D, 20 October 1981, subject: Airworthiness Release of the Individual Lift Device (ILD) (WASP II), USAAEFA Project No. 81-12.

3. Letter, AVRADCOM, DRDAV-D, 8 January 1982, subject: Airworthiness Release for the Preliminary Airworthiness Evaluation of the WASP II, US Army Aviation Engineering Flight Activity, Project No. 81-12

4. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance* 28 June 1968.

5. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control,* 10 June 1968.

6. Final Report, USAAEFA Project No. 81-12, *Preliminary Airworthiness Evaluation, William's Aerial Systems Platform II (WASP II), Individual Lifting Device (ILD),* June 1982.

7. Technical Report, TACOM, No. 12553, *WASP II Concept Feasibility Program,* December 1980.

8. Detail Specification, Williams Research Corporation, Specification No. 24235WR9508, *System Specification for WASP II,* 24 September 1980.

9. MIL-STD-1474B, Noise Limits for Army Material, 18 June 1979, with notice 1, 10 October 1980.

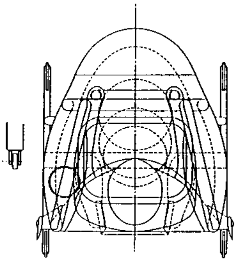
10. Technical Bulletin, Headquarters Department of the Army, TB-MED-501, *Hearing Conservation,* March 1980.

11. Final Report, Bell Aerosystems Company, Report No. 2099-928006, *Jet V/Stol Ground Effects Technology,* June 1966.

12. Technical Report, AIAA-83-0169, A Method for Estimating the Propulsion Induced Aerodynamic Characteristics of STOL Aircraft in Ground Effect, V.R. Stewart, Rockwell International Corp., R.E. Kuhn, V/STOL Consultant, and M.M. Walters, Naval Air Development Center, January 1983.

13. Introduction to V/STOL Airplanes, Kohlman, David L., Iowa State University Press/Ames, 1981.

Photo 1. WASP II vehicle



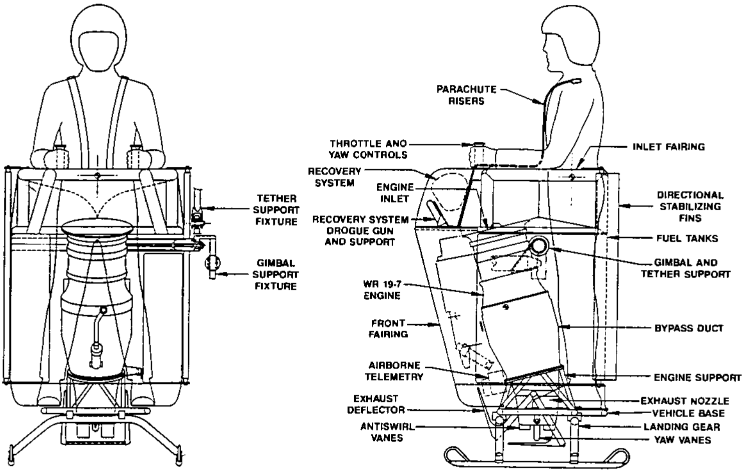


Fig. 1. Vehicle and controls subsystems

Photo 2. Engine blade and rotor containment shield

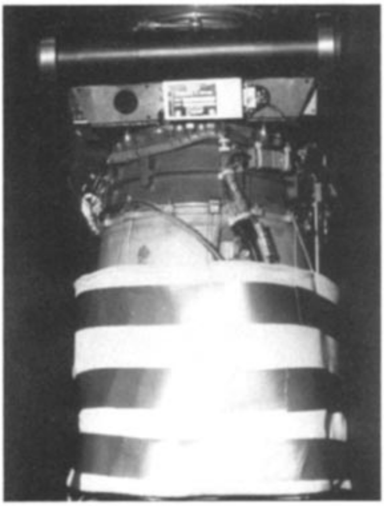


Photo 3. Layers of KEVLAR 29 used for engine blade and rotor containment

Table 1. WASP II System Weight Summary

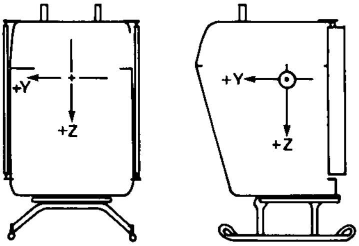
ITEM	WEIGHT (LB)
VEHICLE (PAINTED)	
- INLET ASSEMBLY	14.5
- RECOVERY SYSTEM	12.6
- FUEL TANKS	22.4
- FRONT FAIRING	1.5
- GIMBAL AND TETHER SUPPORT	3.5
- ENGINE SUPPORT AND BASE	8.1
- LANDING GEAR	4.6
- EXHAUST NOZZLE	3.7
- ROTOR CONTAINMENT (KEVLAR)	27.0
- INSTRUMENTS AND RADIO	7.0
- BATTERY AND BRACKET	3.0
- MISCELLANEOUS	8.1
	116.0
ENGINE	135.0

CENTER OF GRAVITY

(75 LB FUEL)
X = 0.30 INCHES
Y = 0.21 INCHES
Z = +3.98 INCHES

POLAR MOMENT OF INERTIA

(75 LB FUEL)
ABOUT X = 458 IN. - LB - SEC^2
ABOUT Y = 468 IN. - LB - SEC^2
ABOUT Z = 116 IN. - LB - SEC^2



REFERENCES AXES

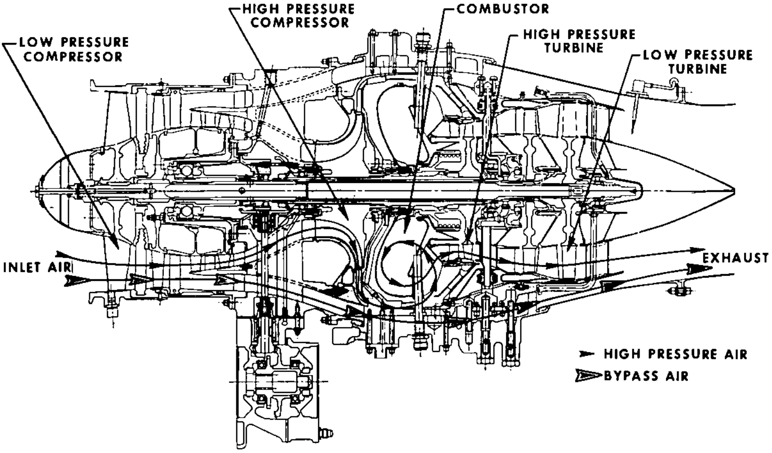


Fig. 2. WR 19-7 engine and engine air flow

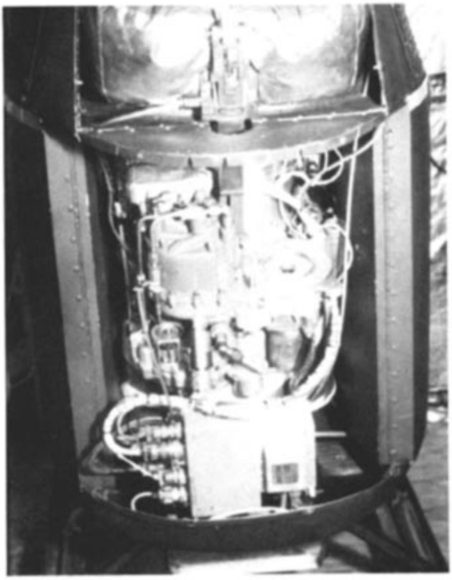


Photo 4. WR 19-7 engine and vehicle interface

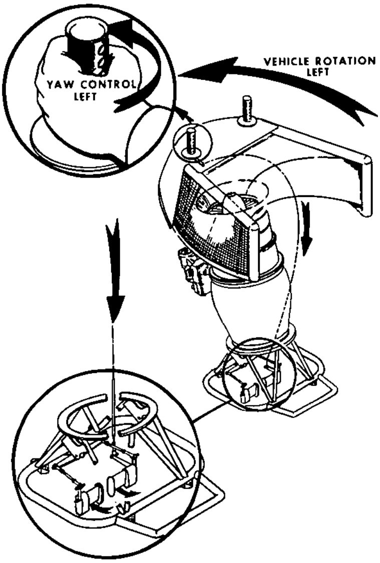


Fig. 3. Vehicle yaw control

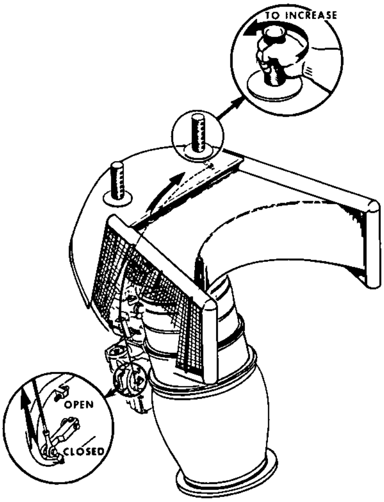


Fig. 4. Throttle operation

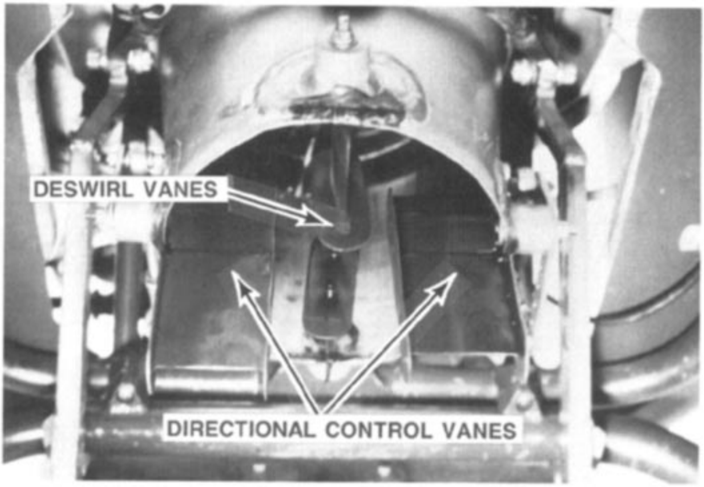


Photo 5. Original directional control design

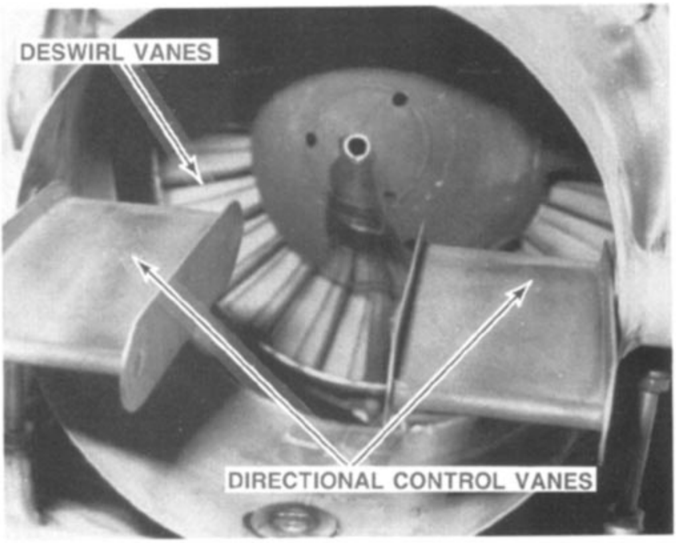


Photo 6. Modified directional control design

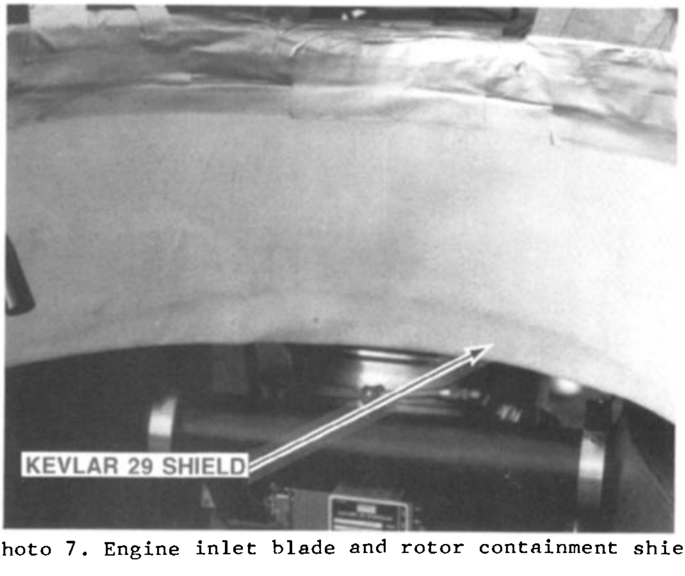


Photo 7. Engine inlet blade and rotor containment shield

Table 2. Test Conditions[1]

Test	Average ESGW[2] (lb)	Engine Start (T/W)[3]	Average OAT (°C)	Average Density Altitude (ft)	Avg Long. CG (in.)[4]	Remarks
Cockpit Evaluation	N/A	N/A	N/A	N/A	N/A	Static and gimbaled
Flight Control Evaluation	504	1.16	10.5	600	0.09	Tethered and free flight
Engine Assessment	590	N/A	14.0	1000	N/A	Gimbaled
Vehicle Performance	570	1.20	-1.0	-800	0.05	Hover performance (ground reference method, Specific Fuel Consumption (SFC)
Vehicle Handling Characteristics	530	1.14	3.0	-350	0.05	Takeoff and landing characteristics, control margins, control cross-coupling, static and dynamic stability, controllability response
Low Speed Flight	560	1.15	-6.5	-1540	-0.03	Forward, rearward, left and right sideward flight
Mission Maneuvers	550	1.11	-0.5	-760	0.04	Stable hover in calm and gusty wind, accelerations/ decelerations, bob-ups, nap-of-the-earth (NOE), "S" turns, figure 8's
Acoustic Noise Survey	490	1.20	1.5	-280	0.05	Tethered flight sound level and frequency analysis (MIL-STD-1474B)

NOTES:

[1] a. Maximum N_2 speed: 61,800± 100 rpm
b. Maximum airspeed: 15 mph or 13 knots
c. Maximum skid height above ground: 15 feet

[2] ESGW = Engine start gross weight

[3] T/W = Thrust to weight ratio computed for ambient conditions at engine start

[4] Inches from the exhaust centerline

operational envelope (fig. 6, app B) for safety of flight. The

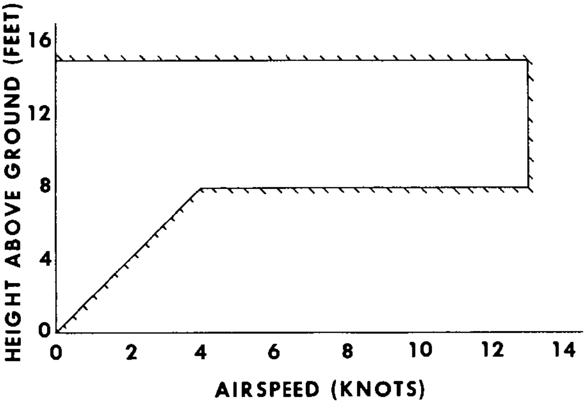


Fig. 5. Operational envelope

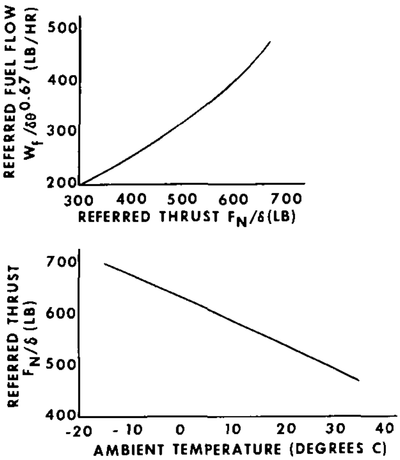


Fig. 6. Engine characteristics

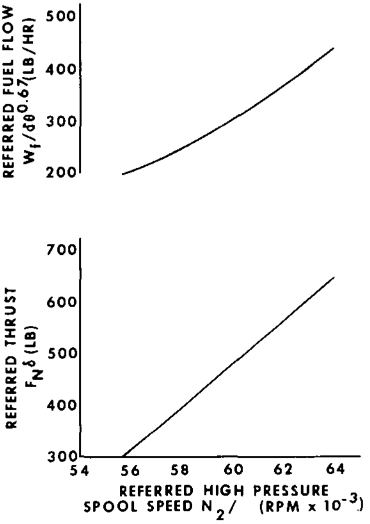
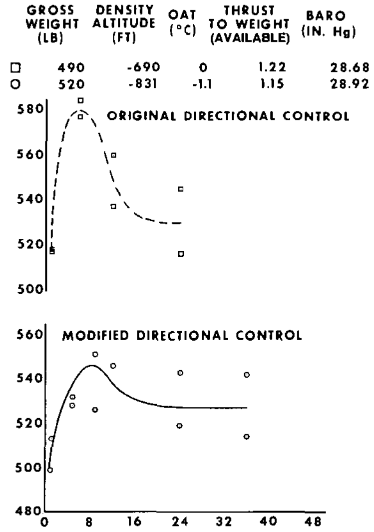


Fig. 7. Engine characteristics



	GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	THRUST TO WEIGHT (AVAILABLE)	BARO (IN. Hg)
□	490	-690	0	1.22	28.68
○	520	-831	-1.1	1.15	28.92

Fig. 8. Hover thrust required

Table 3. Effective Jet Nozzle Area Influence[1]

Condition	N_1 - Corr ($N_1/\delta\sqrt{\theta}$ ~ rpm)	N_2 - Corr ($N_2/\delta\sqrt{\theta}$ ~ rpm)	Thrust - Corr (F_N/δ ~ lb)	Delta Thrust - Corr ($\Delta F_N/\delta\sqrt{\theta}$ %)
Original Design[2]				
Full left yaw	32,279	62,241	592	(-)3.0
Neutral yaw	32,964	62,301	608	----
Full right yaw	32,954	62,291	614	(+)1.0
Modified Directional Control System[3]				
Full left yaw	35,051	63,623	637	(-)0.5
Neutral yaw	35,226	63,643	640	----
Full right yaw	34,958	63,602	632	(-)1.0

[1] a. Test cell analysis, ASME Inlet
b. Exhaust nozzle area: 33.94 square inch

[2] Meteorological data: Barometer: 28.89 inch Hg
OAT: 74° F ≡ 23.3° C

[3] Meteorological data: Barometer: 29.04 inch Hg
OAT: 29° F ≡ -1.7° C

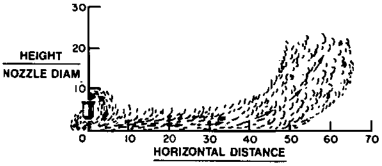


Fig. 10. Pattern of typical hot gas cloud in still air

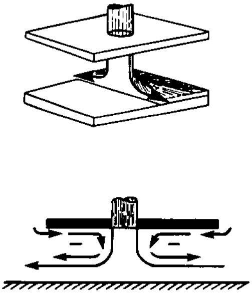


Fig. 9. Patterns of typical flow near the ground

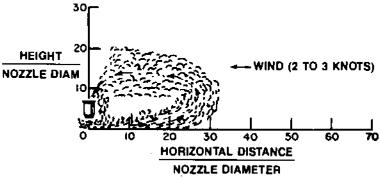


Fig. 11. Pattern of typical hot gas cloud with wind

Table 4. Endurance Summary[1]

OAT (°C)	Useable Fuel Loading[2] (lb)	Fuel Flow[3] (W_F lb/min)	Endurance (min)
-10	154	7.2	18.6
0	121	6.4	15.8
10	81	5.9	10.3
20	41	5.5	3.8
25	19	5.5	0.0

NOTES: [1] Min T/W = 1.1; Basic weight = 256 lb; Operator weight = 180 lb (equivalent to 50th percentile aviator with flight equipment and clothing); Barometer = 29.00 inch Hg

[2] Including 3 min fuel reserve = 20 lb

[3] Computed for maximum thrust at N_2 = 61,800 rpm at ambient conditions.

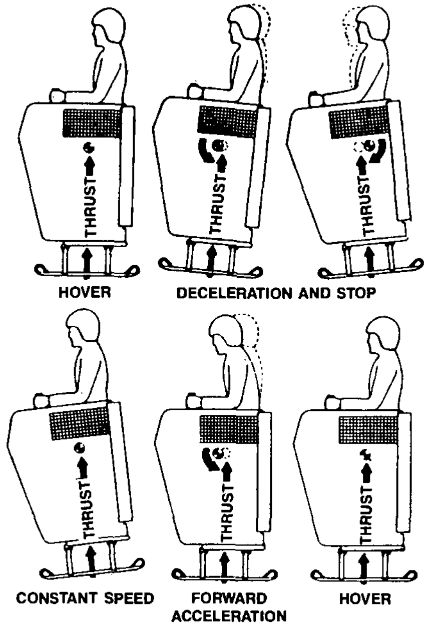


Fig. 12. Kinesthetic control principle

Table 5. Control System Mechanical Characteristics (S/N 1-102)

TEST PARAMETERS	CONTROL SYSTEM		
	THROTTLE	ORIGINAL DIRECTIONAL	MODIFIED DIRECTIONAL
Breakout Moment (Plus Friction)(in.-lb)	8.5 FWD, 2.7 AFT	1.2 Left, 1.5 Right	0.25 Left, 2.5 Right
Full Control Travel (deg)	52 GRD IDLE to Full	20 Left, 20 Right	20 Left, 20 Right
Free Play (deg)	0.6	1.6	1.6
Mechanical Coupling	None	None	None
Control Force at Maximum Displacement (lb)	36	10	10
Control Centering	(Note)	None	None
Control Forces Trimmable to Zero	No	No	No
Moment Gradient (in.-lb/deg)	0.03 FWD, 0.03 AFT	0.13 Left, 0.17 Right	0.14 Left, 0.20 Right

NOTE: Spring loaded toward ground idle

NOTES: 1. VEHICLE ON GIMBAL PLATFORM
2. AMBIENT TEMPERATURE = 15° C
3. BARO = 29.29 IN. Hg

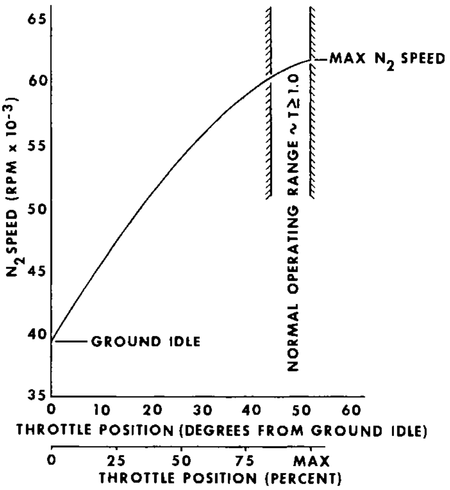


Fig. 13. Throttle position VS N_2 speed

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	THRUST TO WEIGHT (T/W)	BARO (IN. Hg)
510	-2311	-12.5	1.3	29.15

NOTES: 1. DENOTES YAW RATE MEASURED AT 90 DEG DISPLACEMENT
2. DENOTES YAW RATE MEASURED AT 360 DEG DISPLACEMENT

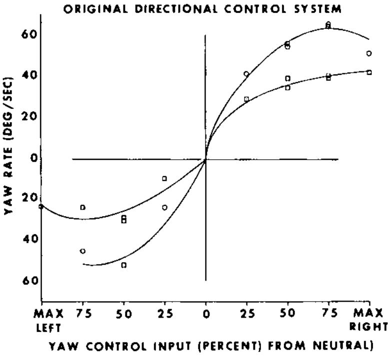


Fig. 14. Yaw control characteristics

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	THRUST TO WEIGHT (T/W)	BARO (IN. Hg)
555	-690	0	1.1	29.02

NOTES: 1. DENOTES YAW RATE MEASURED AT 90 DEG DISPLACEMENT
2. DENOTES YAW RATE MEASURED AT 360 DEG DISPLACEMENT

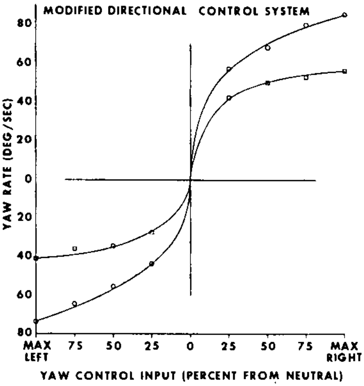


Fig. 15. Yaw control characteristics

Table 6. WASP II - Acoustic Noise Measurement[1]

Condition[2]	Six inches from ear		30 feet from vehicle	
	dBA	category[3]	dBA	category[3]
Ground Idle	102.8	A	97.9	B
Flight, 1 ft above ground[4]	137.5	exceeds A (108)	127.5	exceeds A (108)
Flight, 5 ft above ground[4]	128.0	exceeds A (108)	123.4	exceeds A (108)

NOTES:

[1] Performed by TACOM Industrial Hygiene Laboratory - 3 December 1981.
[2] Meteorological data: Sky condition: 1500 ft broken
Density altitude: (-) 275 ft
OAT: +1.6° C
Relative humidity: 35%
Wind: Southwest - 4 - 15 knots
[3] "Maximum design limit," MIL-STD-1474B
[4] Average resonant frequencies: 800 - 1000 Hz; 1250 Hz; 2000 Hz

ReflеXtions

The UK's Farren Mission of 1945

Eric Brown (HF)

In the early summer of 1944 reports began to appear of new rocket and jet aircraft conducting operations against Allied aircraft over Germany. This was followed in June, by the assault on London and South-East England of the V.1 flying bombs, of which 9,782 were successfully launched by the Germans over some three months. This phase was followed by the arrival in London of 1,403 V.2 supersonic ballistic missiles.

By the end of 1944 Prime Minister Winston Churchill was deeply concerned by this avalanche of advanced German technology against the UK, and consulted with the Royal Aeronautical Establishment (RAE) at Farnborough, the country's main aviation research centre. As a result it was decided to set up the Farren Mission (W S Farren was the Director of the RAE) tasked with investigating Germany's advanced aviation technology on the successful conclusion of the War War II.

This mission was to consist of specialised aeronautical scientists and test pilots to enter Germany as the capitulation became imminent. They were given three priorities:

1 Find, and if possible dismantle, any supersonic wind tunnels and transfer to the UK for reassembly.

2 Find and prepare for test flight, advanced rocket and jet aircraft.

3 Interrogate German aircraft designers, top aviation scientists and test pilots.

I was appointed Chief Pilot, largely because I spoke fluent German and served in Aerodynamics Flight at RAE, as well as in the High Speed Flight and was C.O. of the Enemy Aircraft Flight. We started our preparations for the coming tasks in January 1945, and then awaited a first alert from the British 2nd Army in Germany.

This came on 14 April from 2nd Army Intelligence to say one of their units had overrun an airfield called Fassberg, located north-eats of Hannover and had found two jet aircraft, which had been flown in just before our troops had arrived and the two pilots had fled, apparently relieved to have evaded the Russians.

I flew to Fassberg on the afternoon of 14 April and was delighted to find two Messerschmitt Me 262 jet fighters sitting there in apparently good condition. With the permission of Army unit commander Brigadier Glynn Hughes I briefed some Luftwaffe prisoners of war to keep a watch on the machines until I returned to fly them to Farnborough.

Brigadier Hughes seemed surprised at my fluency in German, and asked if I could spare him a couple of days to help in a special operation nearby. I said I could only give him one day, and asked what the operation was. He replied that it was to liberate the concentration camp at Bergen-Belsen and I was to be ready to join him early the next day.

On 15 April I found myself joining a column of utility vehicles and asked the Brigadier why we were not using armoured cars. He then told me his, was a medical unit and the situation was that there were 20,000 cases of typhus in Belsen, and the Germans fearing a widespread plague if the inmates and guards fled the camp, had ring-fenced the perimeter with troops. Then under a white flag truce meeting between the 2nd Army and the German High Command, it was agreed to give free passage to a British medical unit to take over the camp, and so release the German soldiers to go off to fight elsewhere.

We thus arrived to find the German and Hungarian troops ready to make a co- ordinated hand over. While this was underway I had a look around, clad in a surgical mask, but quite unprepared for the horrors I was about to witness. There were mounds of dead bodies, most female, all bulldozed grotesquely into pits. Other inmates, dressed in prison garb shuffled around like zombies and barely seemed aware of the new activity around them. There were some long huts which I later learnt had been built to house 60 inmates on three-tiered, open slatted bunks, with just one toilet for all. They now held 250 dying women in indescribable filth. The stench of these huts has never left my nostrils to this day.

In the afternoon I was to interrogate the camp commandant, Joseph Kramer, and the senior female guard, Irma Grese. The Brigadier wanted to know what made these people tick. They are probably the worst human beings I have ever encountered and were inevitably executed.

The Farren Mission's next alert came on 3 May when the 2nd Army reported they had captured Husum Airfield on the west coast of Schleswig-Holstein and found a wing of Messerschmitt Me 163B rocket fighters virtually grounded for a lack of rocket fuels. Next day I flew some of our team to Husum in an Anson, and found the Me 163 unit based there was JG 400 commanded by the German test pilot Rudolf Opitz. He was in a nearby hospital having severely injured his spine making a forced landing after engine failure on take-off. Having made sure the Army would guard this treasure trove, including Opitz, I decided to move on to Denmark. I had learned from the JG 400 pilots that there were likely to be some Arado Ar 234 jet reconnaissance bombers at Grove Airfield.

The 2nd Army at Husum assured me that their troops would already be there by the time we arrived at Grove, which is about halfway up Denmark. This proved to be wishful thinking. When we arrived we were met by a Luftwaffe Lieutenant-Colonel, who was the most senior officer left, together with some 2,000 personnel. After a few tense moments of my assuring this officer that the 2nd Army was virtually on the doorstep, he surrendered the airfield. He then lodged my team of 6 (four boffins, co-pilot and myself) in the house previously occupied by the Colonel in command, who had already fled.

After a somewhat disturbed night, my team set about discovering what prizes of war Grove had to offer, and there were many. Besides the half dozen Ar 234s, there were a number of Heinkel 219 night fighters fitted with the dreaded 'Schräge Musik' upward firing 30mm cannon which plagued RAFs Bomber Command for the last two years of the war. There were also a considerable number of Focke- Wulf 190 fighters and to my joy they included a single Fw 190-D9 which had been the personal aircraft of the airfield commander. I decided to appropriate this for the next urgent requirement of my task, to find an airfield to act as a collection and maintenance base for our captured enemy aircraft. I had already spotted a likely candidate in Schleswig-Jagel, and so it proved. It was centrally placed in Schleswig-Holstein, and had an adjacent flying boat base at Schleswig-See near the Baltic. With this staging-post settled, I made contact with my American counterpart Colonel Harold Watson of the USAAF and his team of 'Watson's Whizzers' based at Lager-Lechfeld, near the city of Augsburg. I had previously met Colonel Watson in London and found we were very much on the same wavelength, which then led to a fair amount of horse-trading of our war prizes once we got to Germany.

Next door to Schleswig was the airfield of Leck where we uncovered a wing of Heinkel He 162 single-seat jet fighters, still undertaking operational training. This was the only one of Germany's advanced jet/rocket aircraft to be fitted with an ejection seat, but like the Me 163 it was, in my opinion a tool of desperation. On the other hand the Me 262 was certainly the most formidable aircraft of World War II, being 125mph faster than the top Allied fighters of the era.

With the capitulation on 8 May 1945, the proposed Occupation Zones of Germany became a reality, and Britain gained West Germany where three of its foremost aviation research centres were located at Völkenrode, Göttingen and Brunswick. Our scoop from this lot amounted to 7 supersonic wind tunnels and 26 top aeronautical scientists. On the interrogation side, I dealt with Willy Messerschmitt, a card-carrying member of the Nazi Party, Kurt Tank of Focke-Wulf, Germany's best aircraft designer, Dr Heinkel, Dr Vogt of Blohm and Voss, the rocket scientist Dr Walter and Werner Von Braun, who was the most self-confident human I have ever met.

The test pilots I interrogated in depth were Joachim Carl (Arado), Hans Dieterle (Heinkel), Fritz Wendel (Messerschmitt) and Hanna Reitsch (Freelance). The Farren Mission continued its task until the end of 1945 and brought hundreds of German aircraft – rocket, jet, piston-engined, helicopters and gliders – back to Farnborough for testing. They were all exhibited to the public at a major display in October 1945.

During the course of my stint with the Mission, I flew 53 different types of German aircraft and we lost two test pilots, killed while testing a Dornier 335A and a Heinkel He162A. In spite of this, the Mission was judged to have been highly successful and its greatest legacy was the splendid supersonic Concorde airliner, whose aerodynamics stemmed directly from the Mission's investigatory work.

70 Years and Beyond
The USAF Test Pilot School Story
By Karl Major, Associate Fellow
USAF TPS Liaison to SETP Board of Directors

70th Anniversary Painting by Mike Machat.
Unveiled at USAF TPS on 13 Jun 2014 (courtesy of USAF TPS)

Last September, the United States Air Force Test Pilot School celebrated 70 years educating flight testers of the world. Its current mission is to produce highly adaptive, critical-thinking flight test professionals to lead and conduct full-spectrum test and evaluation of aerospace weapon systems. To meet this mission, the school takes aircrew members, puts them through an intense 48-week educational experience, and produces a graduate who can conduct efficient and effective evaluations on unfamiliar aircraft while performing precise technical tasks.

The Building Need

In the years following World War I, the need for such an institution like the Test Pilot School was slowly coming into focus. The Army Air Service stationed their test pilots at McCook Field in Dayton, Ohio. New test pilots learned their trade through on-the-job training. Only a few attended the forerunner of the Air Force Institute of Technology, the Air Service Engineering School. This meant that most test pilots of the era became masters in the art of flying, but they lacked an understanding of the basic scientific principles of flight. Lt James "Jimmy" Doolittle, a rare test pilot who had a doctorate in aeronautical science, saw this discrepancy between piloting skills and engineering skills. Many years later, Doolittle stated, that at the time, he "thought there should be a better rapport between the aeronautical engineer and the pilots… [and he] thought from a philosophical point of view that it would be good to have engineers and pilots understand each other."

The concept of loosely structured training for new test pilots continued through the twenties and thirties even as test operations moved to Wright Field in 1927. Hand selecting test pilots and on-the-job training with experienced test pilots and engineers continued to suffice.

An engineering background was a plus, but flying skill and experience dominated. Many thought the test pilot didn't need technical training, since all he was expected to do was to fly the test cards provided by the engineers, not understand them. However, dissenters like Maj Leslie MacDill, an early experimental engineer and aviator, "argued that with the rapid pace of technological change in aeronautics, test pilots would increasingly require systematic, highly specialized training on a level at least approaching that of aeronautical engineers."

The build-up to World War II challenged the prevailing training paradigm. By 1940, training, by necessity, became more structured. Pilots selected for test pilot duty flew 3 hours in the A-17 doing a performance flight test profile. The accuracy of the candidate's data reflected his aptitude for flight test. If the pilot passed, he spent the next 2-3 months checking out in all the aircraft on the field with periodic monitoring from experienced test pilots. Flight test engineers tutored the pilots on the technical aspects of the job. After about six months, a new test pilot would be considered experienced enough to train newcomers.

By 1941, the need to fill test pilot roles with experienced aviators quickly surpassed supply. A request went out for 15 inexperienced pilots to fill Wright Field's needs. Training these novices to become new test pilots shifted the paradigm slightly. Instead of an initial test in the A-17, the new pilots would collect as much time as possible in the available training aircraft; pairing them, when possible, with experienced test pilots in multi-engine aircraft. After this break-in period, the pilot entered the training already established for the more experienced pilots.

Training evolved into delineated stages by 1943. All pilots started as Functional Test Pilots for 3-6 months where less than half made it through to the next level. Then, as Training Test Pilots, they would informally learn about all aspects of performance flight testing. When sufficient knowledge and experience was attained, they passed to the next level, Limited Test Pilots. There, they broadened their experiences in a wide variety of aircraft. Those few that consistently earned high marks at this level were eventually promoted to full fledge Test Pilots. Though more structured than before, this ad hoc training system proved far from optimum for the excessive workload the organization was experiencing. Out of 60 pilots assigned in the fall of 1943, less than a third were Test Pilots or Limited Test Pilots. Thus, the Army Air Force's high flight test workload encouraged rushed or incomplete training. This poor training environment showed up as a lack of preparation, as well as undisciplined, unproductive flight tests. More tragically, it also showed up as a sharp increase in fatal mishaps.

Col Ernest Warburton, Chief of the Flight Test Branch, realized that the status quo was unacceptable. He decided to commit dedicated manpower and resources to a more formal training approach. The British had similar concerns and had just created the Empire Test Pilot School (ETPS). This gave Warburton a template to establish his own vision. He enrolled two of his experienced test pilots in Class II of ETPS to learn as much as possible about their curriculum. At the same time, he charged Maj Ralph Hoewing with the development and establishment of a similar educational institution.

The Early Years

In 1944, The Air Technical Service Flight Test Training Unit was established with Maj Hoewing as its chief on 9 September, three years before the United States Air Force came into being. The initial 3-month academic curriculum was devoted entirely to performance flight test theory and piloting techniques. The pilots flew the AT-6 to translate their academic education into practical experience.

The first class was just graduating as Lt Col Richard "Dick" Muehlberg returned from Empire in January 1945. He took over, from Maj Hoewing, the unit now dubbed the Flight Section School Branch. Hoewing went off to Class III at ETPS and would return to the school as its second commandant. Muehlberg had the privilege earning the title as the school's first commandant. Around the same time, the Flight Test Branch became independent from the Engineering Division. In this change, the school moved to Vandalia Municipal Airport (now Dayton International Airport) and renamed the Flight Performance School.

The school changed significantly during this early period placing more and more emphasis on academic theory. The curriculum expanded to include short courses on all-weather flying and blind landing, spin testing, and stability and control. As the British demonstrated to their American students at ETPS, stability and control was a major missing piece in the school's curriculum. This omission was rectified by 1946, when the subject became a permanent feature of the school's long course. During this period, the school's fleet also expanded to include the P-51, B-17, and B-25 to support the new academics.

Col Albert Boyd was assigned as the Chief of the Flight Test Division in 1946, a year that proved pivotal for the flight test pilot profession. Boyd took a personal interest in the test pilot selection process. He needed pilots that could adapt to the flight test domain, an environment that required careful preparation and close attention to detail. As the school moved to nearby Patterson field, Boyd wanted test pilots that were true professionals and the best in the business. With his watchful eye, only a few earned a spot in what had become a 4-month curriculum. Part of the selection process looked at the educational backgrounds of perspective students. Although not a formal requirement, most students now had at least some college-level training in the engineering sciences.

The school's curriculum and training aircraft evolved as technology advanced. In 1947, its first jet aircraft, the F-80 Shooting Star, was added to its fleet. And, in 1949, as it prosecuted three classes, the school was renamed the Air Materiel Command Experimental Test Pilot School. However, frequent bad weather made it very difficult for students to complete the flying portion of the curriculum within the allotted time. As a result, Col Boyd pressed hard to move the school to Muroc Air Force Base in the Mohave Desert, where clear, un-congested skies ruled most days of the year. It didn't hurt that most flight test programs in the Air Force were being moved to California for this same reason.

The Edwards Era Begins

In September 1949, Boyd sent a Maj John Amann, a future commandant, to Muroc to prepare facilities and resolve issues that might affect the school. On 4 February 1951, the school, soon to be named the Air Research and Development Command Experimental Test Pilot School, moved to what was now called Edwards Air Force Base. Three months later, the first class began. The school was housed in an old wooden hangar along what is currently the South Base flight line. Its fleet of aircraft now included B-25's, B-26's, F-80's and two new T-28's.

The move proved immediately successful. The desert weather allowed classes to graduate on time with only two flying days lost in the first seven months. By this time, the curriculum was fairly evenly split between the performance and stability phases. The course load included 480 academic classroom hours and around 70 hours of flight instruction. To ensure high quality students, the selection process became even more discriminating. A candidate now needed 1500 hours of diverse flying time, as well as knowledge of algebra, plane geometry, differential calculus, theory of flight, aeronautical mechanics, and aerodynamics.

The educational requirements were difficult to assess since no college transcripts were required in the application process. That discrepancy led to many students dropping out of the school in the early fifties for academic deficiencies. This situation improved to a certain degree when the school became the United States Air Force Experimental Test Pilot School on 1 January 1953. This action increased the number of potential applicants beyond the Command's pool of candidates, which significantly improved the quality of students. With four classes a year, word quickly spread about the tough academic requirements. By 1955, applicants like Lt William "Pete" Knight could not expect serious consideration until they had completed a college education.

The fifties also saw the school continue its transition into the jet age. In 1953, the T-33 and F-84 entered the curriculum. The T-33 would become the workhorse of the school for 23 years. Three years later, more jet aircraft arrived, the F-86 and F-100. The following year, the school received its first delta wing aircraft, the TF-102. By 1957, the school also received its first jet powered stability and control trainer, the NB-57.

The school quickly outgrew its facilities at South Base resulting in a move to its current location on 14 March 1956. Along with a brand new building, the school was allowed to use one of two large hangars that had been hoisted up and transported from South Base. These curved-roof hangars are still in use today located next to the school along the flight line.

The Space Age

By 1957, the test pilot course had grown to 6 months in length. Some noted its curriculum was now equivalent to the last two years of an engineering degree. But, more was required of the school as the world entered the space age. Sputnik would launch later in the year. The United States had started development of the X-20 "Dyna-Soar" space vehicle and the X-15 was being built. To meet these new demands, the school expanded its curriculum to include subjects like rocket engine performance and human factors in space flight. These classes increased the total length of the course by 2 months.

Air Force pilots would operate the Dyna-Soar while it flew in space. The school thought it had a responsibility to prepare these future astronauts. So, in 1960, the school started development of an Aerospace Research Pilot School. The next year saw the first ARPS class admitted. The school eliminated TPS class 61B to make room, but still executed two regular TPS classes that year. The students of ARPS Class I had to master the courseware while it was still in development for they were slated to be the instructors for future classes.

To assist the research pilot course, the F-104 entered the curriculum in 1961 and the T-38 started to slowly replace the T-33 as the workhorse of the school. To reflect the new vision of the school, on 12 October, the school was rechristened the USAF Aerospace Research Pilot School. To support space flight training and education, the school needed simulators, but none existed. In late 1962, contracts went out to build a multi-storied addition to the school. This addition would eventually hold a ballistic simulator and a futuristic, motion-based T-27 space flight simulator.

In all, the school conducted only four unique ARPS classes, displacing TPS classes 61B, 62B, 63B and 63C. Then, at the mid-year point in 1963, the school combined the research pilot course and the test pilot course into one year-long course starting with Class 63A. This seemed a logical development. The planned Manned Orbital Laboratory was on track to provide research pilot graduates guaranteed access to space.

The new yearlong course made planning for 3 classes a year difficult. So by 1965, the school began conducting only two classes per year, a pattern continued to this day. To account for the added rigor in the curriculum, the minimum educational requirement was raised to a bachelor's degree in engineering, physical science or mathematics. Many took notice of the educational prowess of the school. A famous journalist of the time, Hunter S. Thompson, referred to the school as the "military version of Cal Tech or MIT".

The stability course with its many stability derivatives had always been challenging to the students. To help the student makes sense of the mathematics, the school leveraged current technology and integrated its first variable stability aircraft trainer, a B-26, into the curriculum in 1964. Cornell Aeronautical Laboratory (now Calspan Corp) modified and maintained the aircraft. Then in 1968, two, variable stability NF-106's also entered the curriculum.

Space flight training and education at the school ended as quickly as it began. In 1969, the Manned Orbital Laboratory along with the X-20 were cancelled. NASA would now be the sole proprietor of manned space flight. The school adapted by de-emphasizing the space flight training mission in favor of aircraft systems testing. The T-27 simulator was dismantled and sold to NASA.

The School Resets

System and test management courses slowly displaced most of the aerospace course. By 1971, the 44-week, yearlong course now consisted of 3 phases; a performance phase, a stability and control phase, and the new systems and test management phase. The flying curriculum saw gradual change, too. In 1969, gliders, up in the Tehachapi Mountains, were added to teach high lift-to-drag concepts to counter the low lift-to-drag training received in the F-104. The A-7 with its advanced aircraft systems was added to the fleet. As the school changed focus, it was time for another name change. This time, the name would stay fixed for 42 years and beyond. On 1 July, 1972, the school became known as the United States Air Force Test Pilot School.

The mid-seventies saw a refresh of the curriculum aircraft with the NKC-135 replacing the B-57 as the large aircraft stability and control laboratory, and the F-104 leaving in favor of the RF-4. The school also incorporated the A-7 and A-37 for systems and high angle-of-attack training. As a result, the school could finally retire the T-33, although it did not leave the curriculum entirely. Calspan would provide the school with a variable stability NT-33 to supplement the variable stability B-26 in 1974. The NT-33 not only complimented the stability and control phase, but the systems phase as well with the inclusion of a programmable heads-up display. In all, these changes defined a gradual evolution of the school's curriculum, not a radical re-thinking of the school's mission.

TPS made great strides over its first 28 years bridging the language gap between the discipline engineers and test pilots, but more could be done. Thus, Flight Test Engineer students were brought into the school with Class 73A and Navigators in Class 74B. Pilots, engineers, and navigators were integrated into a single class. However, each group had their own distinct track. Most of the academics were the same, but the type and number of inflight laboratories differed significantly between the pilots and the engineers or navigators. The Flight Test Engineer and Flight Test Navigator tracks differed only slightly.

The integration of the Test Pilot, Flight Test Engineer and Flight Test Navigator tracks saw the curriculum grow slightly. The "one-year" course went from 44 weeks to 46 weeks in 1975. The stability and control phase was expanded and renamed the flying qualities phase in 1978. New data collection resources became available in the mid to late seventies to include the installation of a mini main frame computer for analyzing data and two control rooms that received telemetered data from school aircraft.

Stability

As the decade ended, the school settled into a relatively stable period. Coinciding with the start of this era was the christening of the school's building as Boyd Hall on 19 May 1979. The dedication honored Gen Albert Boyd who had proved instrumental in developing the school and moving it to Edwards AFB.

Continuous improvement permeated the school for the next 14 years until the next significant refresh of curriculum aircraft started in 1993. The variable stability B-26 became increasingly difficult to maintain and negotiations for a replacement began in 1980. A replacement became absolutely mandatory when the B-26 crashed in 1981. In 1982, a variable stability Learjet became the primary stability and control aircraft for the school.

Three other significant improvements to the school occurred during the eighties. In 1981, TPS began a joint program with the Air Force Institute of Technology, selecting around two students per year to complete the course work for a Master's degree prior to attending Test Pilot School. The student would then finish his thesis at Edwards. The first of these students graduated with Class 82B. The second improvement was the inclusion of the NC-131 as an Avionic Systems Test Training Aircraft (ASTTA) in 1985. The third involved unshackling the test management portion of the curriculum from the system phase.

In 1990, test management became an independent phase, shaping the long course into a four-phase curriculum, as it exists today. This new phase would be accomplished in parallel with the other phases culminating with a final "thesis" project that involved planning, executing and reporting on a real-world flight test project.

A Refresh to Today

The school had to maintain relevance to the modern Air Force. An aging fleet meant students increasingly flew aircraft not in operational use. So starting in 1991, TPS started a much-needed refresh by replacing the UV-18 with the C-23. The UV-18 was brought in 10 years earlier to offload training in the NKC-135. The Mighty Sherpa only lasted seven years before being replaced by the C-12. The year after the C-23 came into the curriculum, the NC-141 replaced the NKC-135 until the KC-135R entered the curriculum in 1997. For the workhorses of the fleet, the T-38 remained, but the RF-4's and A-7's were replaced with F-16's and F-15's in 1993. During this refresh cycle, the yearlong course grew to 48 weeks, the length it is today.

TPS lost its primary spin trainer, the A-37, in 1995. This led to a slow de-emphasis in spin training. Initially the T-2 at the Navy Test Pilot School and then the MB-326, Impala, from National Test Pilot School took over the role as the school's jet aircraft spin trainer. However, this all ended in 2002. This left only the gliders to introduce the students to spin testing along with an occasional, a spin-capable qualitative evaluation aircraft.

A robust stability and control aircraft laboratory continued to be an important part of the flying qualities curriculum. Variable stability Learjets play this role to this day. Additionally in 1994, the NT-33 was retired and replaced by the NF-16D Variable-stability Inflight Simulator Test Aircraft (VISTA) the following year. Without these inflight simulators, students would have great difficulty learning to identify handling qualities issues, since production jets had become so very well behaved compared to those of decades past.

The last refresh in the nineties occurred when the NT-39 replaced the NC-131 as the ASTTA in 1997. With refreshed avionics and sensors, the systems phase continued its push into the 21st century with modern avionics.

The New Century and Beyond

Technological advancements kept the pressure on the curriculum. To meet these stresses, the ASTTA morphed into the Airborne Systems Test and Research Support (ASTARS) aircraft, first in the P-3, and then finally to the SAAB 340. Each aircraft had slightly more capability than the last. Ground laboratories advanced in both flying qualities and systems. The school's flying qualities simulator gained enough fidelity to fly the variable stability Learjet as a remotely piloted vehicle.

The rapid rise of remotely piloted aircraft (RPA) in the Air Force established a need for trained and educated operators to conduct flight test on them. In response, TPS introduced the RPA Pilot track that ran parallel with the other three yearlong tracks in 2010. Shortly thereafter, TPS renamed the Flight Test Navigator course the Flight Test Combat System Officer (CSO) track. All four courses shared essentially the same classroom academics. The significant differences showed up in the airborne laboratories and practical exams. After the first RPA pilot course, the CSO course was tied to the RPA pilot track with only minor differences between them. In its current iteration, the RPA pilot course mimics the manned test pilot track very closely. However, significant differences remain to reflect the differing backgrounds of RPA test pilot candidates.

The new century also brought formal recognition of the college-level education that the school had been giving its graduates since its beginning. The school made the case for a Master's degree to the Department of Education, Air University and the Southern Association of Colleges and Schools accreditation organization. Upon review, each stated the 48-week curriculum at the USAF Test Pilot School easily exceeded the requirements for a Master's degree. The review culminated in Congress imparting degree-granting authority to TPS in December 2007, retroactive to 2006. Class 97B became the first class earn a Master's of Science in Flight Test Engineering upon graduation.

More than 2870 students have graduated from the USAF Test Pilot School. Students have come from all 3 branches of the service (military and civilian), the FAA, contractors and 24 allied nations. As the school moves into the future, it will, at a minimum, continually improve and update its curriculum to ensure the quality of its graduates never waivers. However, the need for trained and educated testers in the areas of space and cyberspace is becoming apparent. Whether TPS assists in the establishment of independent schools in these disciplines or TPS acts as the centerpiece of a Test and Evaluation University is yet to be determined.

No matter what the future holds, TPS will continue to produce outstanding graduates who remember the school as the most challenging year of their lives. In a recent public forum, NASA astronaut Lt Col Jack Fischer, Class 03B, was talking to high school students about becoming an astronaut. A student asked him what the hardest part of astronaut training had been. He responded, without hesitation, "TPS was harder". Although intense, the school's training and education in the past seventy years has led to the development of a professional flight test corps that is worldwide. Countless aircraft programs, military and civilian, foreign and domestic, owe their success to the graduates of the USAF Test Pilot School.

References

1. Cheryl Gumm, Dr. Jim Young, et al., …50 Years and Beyond (USAF Test Pilot School, 1994)
2. Various Histories of the Air Force Flight Test Center (AFFTC History Office, 1979 – 2011)
3. Integrated Schedule Class 90A (USAF Test Pilot School, 1990)
4. Master Syllabus Class 14A (USAF Test Pilot School, 2013)
5. USAF Test Pilot School 2024 10-Year Strategic Plan (USAF Test Pilot School, 2014)

2015 SYMPOSIUM INFORMATION AND CALL FOR PAPERS

The Society of Experimental Test Pilots East Coast Section Symposium ~ 10 April 2015

Call for Papers

The 31st Annual East Coast Section Symposium will be held on 10 April 2015 at the Bay District Volunteer Fire Department Company 3 Social Hall, Lexington Park, Maryland as part of the weekend-long USNTPS Reunion. The Chairman for this event is LCDR Allan "Kreepy" Jespersen, USN (AM).

This is an official call for papers. Presentations should be limited to 30 minutes, including the discussion period. No proceedings are published for this Symposium therefore formal written papers are not required. Those interested in presenting should submit an abstract by 20 February 2015 to Laurie@setp.org.

****

5th Northwest Section Regional Symposium
Seattle, Washington
24th April 2015

CALL FOR PAPERS

The Pacific Northwest Members of the Society of Experimental Test Pilots will convene our fifth annual Regional Symposium on Friday, the 24th of April at The Museum of Flight. Aviation interests of this region are very diverse, from Large Transport Aircraft to Light Sport Aircraft and from unmanned aircraft to avionics, navigation systems, aviation sensors, and displays.

The purpose of this Symposium is to share the knowledge gained in the course of planning, execution and documentation of flight test activities. The intent of the Symposium is to help prevent re-learning of hard lessons through cross pollination of the ideas and discoveries from our seemingly different, yet similar and related areas of flight test. Following the same formula of our successful previous Symposia, we continue to solicit presentations and attendance from both members and non-members.

This is an official Call for Papers. Presentations should be limited to 30 minutes, including the discussion period. No audio or video recordings will be made, nor will proceedings be published for this Symposium; therefore formal written papers are not required. Those interested in presenting should submit an abstract by 20 February 2015 to:

Jennifer Henderson; Symposium Chair
C/O Laurie Balderas (Laurie@setp.org)

For further information, contact Jennifer at:
Jennifer.l.henderson2@boeing.com
206-226-1282

Flight Test Safety Workshop
4 ~ 7 May 2015
The Scottsdale Plaza Resort
7200 N. Scottsdale Rd.
Scottsdale, Arizona 85253

Arizona has more parks and national monuments than any other state, more mountains than Switzerland, and more golf courses than Scotland. Testimony to advantageous flying weather: Arizona is home to the Barry M. Goldwater Range, Davis-Monthan AFB, Luke AFB, Camp Navajo, Fort Huachuca, Yuma Proving Ground, and MCAS Yuma; some of the most advanced flight test and training facilities in the nation.

Your FTSW planning team is working hard to meet or exceed the high standards of affordable hospitality and productive workshop gestalt set by 2014 Flight Test Safety Workshop Chairman, Mr. Tom Huff, his team, and the ever dedicated and always competent SETP staff.

Think you can't afford lovely Scottsdale during high season? Ms. Paula Smith has once again exceeded all expectations by negotiating an outstanding conference package. She has outmaneuvered the avaricious resort hotel industry and has successfully secured GSA hotel room rates for all attendees. The schedule has again been cleverly planned to avoid May holidays such as Loyalty Day, World Press Freedom Day, V-E Day, Mother's Day, Armed Forces Day, Memorial Day, Victoria Day (Canada), and the ever popular National Sea Monkey Day.

Monday, 4 May will be Check-In and Welcome Reception; Tuesday, 5 May will be a morning of thought provoking and possibly controversial Tutorial led by Chief Pilot Boeing Commercial Airplanes, Keith Otsuka, followed by an afternoon Panel Discussion. Wednesday, 6 May will be a day of Technical Sessions and Dinner with an exciting presentation and keynote speech by Airshow Pilot and Legend Sean D. Tucker. Thursday, 7 May will be a morning of Technical Sessions and Presentation of the Bombardier Aerospace FTSW Best Presentation Award, followed by an afternoon tour of the Boeing Mesa Rotorcraft Flight Test Facility led by the esteemed 2015 FTSW Co-Chairman Tom Macdonald.

The theme of the 2015 workshop is:
"LESSONS LEARNED (ARE THEY REALLY?)".

The reduction of flight test risk to a level of as low as reasonably practicable has been the oft stated goal of the flight test profession. When lessons from previously identified risks have been learned, incidents and accidents relating to those same risks should not reoccur. So why do accidents continue to occur?

The goal of this workshop is to share personal, team or program experience of methods to identify, document, record, and apply lessons learned in a way that meaningfully contributes to an enduring reduction of flight test risk.

Presentations should be limited to 25 minutes. Please send paper/presentation proposals to the 2015 Flight Test Safety Workshop Chairman, Richard Lee via Susan@setp.org. If you should have any questions regarding submitting an abstract please contact Richard Lee at K2avn@yahoo.com .

The deadline for abstracts is 2 February 2015 to allow time for appropriate consideration and inclusion in the program.

A limited block of rooms has been reserved at the U.S. government rate of $113.00 per night for all attendees. To book your hotel reservation, please call 1-800-832-2025 or visit http://www.setp.org/symposium/meetings/workshop/

The deadline to book your room is Tuesday, 14 April 2015.

****

47th European Symposium
10 -13 June 2015
Lucerne, Switzerland

CALL FOR PAPERS

The Swiss Chapter of the SETP is pleased to welcome you to the 47th European Symposium in Switzerland.

Four technical sessions are planned with a number of interesting and informative papers. They will mainly be devoted to the following areas:

Reports on actual projects in military and commercial aviation for fixed wings, rotary wings and UAV.
Experiences in testing and certification of new technology applications with an emphasis on flight test safety.
The purpose of this Symposium is to share the knowledge gained during planning and execution of flight test activities and help prevent relearning of hard lessons by sharing flight test experiences.

This is an official call for papers. Presentations are limited to 30 minutes, including the discussion period. Papers and/or PowerPoint presentations will be posted on the symposium's website, downloadable for all the participants. Those interested in presenting a paper should submit an abstract by 15 March 2015 to:

Bernhard Berset (AF), armasuisse Chief Testpilot
47th European Section Symposium Paper Committee
papers@setp-switzerland.ch

The Great Lakes Symposium
14 May 2015
Wright-Patterson AFB Banquet Center in Ohio (formerly known as the Officer's Club).

Call for Papers

The Great Lakes Symposium will be held 14 May 2015 at the Wright-Patterson AFB Banquet Center in Ohio (formerly known as the Officers' Club).

This is an official call for papers. Presentations should be limited to 30 minutes, including the discussion period. No proceedings are published for this Symposium therefore formal written papers are not required. Those interested in presenting should submit an abstract by 30 March 2015 to:

Eric Fitz, Symposium Chairman
C/O SETP Headquarters - Email: Laurie@setp.org
Post Office Box 986
Lancaster , California 93584-0986

****

The Society of Experimental Test Pilots
Central Section Symposium
Hotel at Old Town ~Wichita, Kansas
19 June 2015

Call For Papers

The 7th Annual Central Section Symposium will be held 19 June 2015 at Hotel at Old Town in Wichita, Kansas. This is an official call for papers. Presentations should be limited to 30 minutes, including the discussion period. No proceedings are published for this Symposium therefore formal written papers are not required.

Those interested in presenting should submit an abstract by 18 April 2015 to:

ATTN: Chairman, Dave Marten

C/O SETP Headquarters
Post Office Box 986
Lancaster, California 93584-0986

Email: Laurie@setp.org

****

THE SOCIETY OF EXPERIMENTAL TEST PILOTS
59th SYMPOSIUM & BANQUET
The Grand Californian Hotel
Anaheim, California
23-26 September 2015

CALL FOR PAPERS

The Society was founded with the simple but critical goal of improving the safety and efficiency of flight test. Fundamental to that goal is the exchange of lessons learned between flight test professionals engaged in varied and unique programs across the world. SETP's annual Symposium and Banquet is our cornerstone event and the technical papers presented serve as the catalyst for analysis and application of best practices both by members of our organization and the larger test communities they represent.

Towards that goal, I encourage each one of you to consider submitting an abstract. As flight test professionals we all have a responsibility to invest in the future of flight test by contributing our lessons learned to both the Society and test community at large. I can personally attest that on many occasions the insights presented at the Symposium prevented me from making similar mistakes on other programs. I trust that this year's event will be no different.

Your insight and time is required to make this goal a reality.

Papers for the 2015 Symposium will be selected on the basis of their potential to educate and enlighten Symposium attendees. Technical content is paramount; tailor your submission to provide value to a diverse international audience. Papers that describe your solutions to new problems or new solutions to old problems are especially welcome. Manuscripts will be gratefully accepted for online publication, but will not be required.

Abstracts should provide, in no more than 150 words, both the one or two critical ideas or lessons you hope your audience will remember and how your lessons will be explained and/or defended in the presentation. The deadline for abstract submission is 31 May 2015. Titles should not exceed ten words.

Please feel free to contact Mr. Todd Ericson at todd.ericson@virgingalactic.com should you have any questions regarding content, themes, or the process. Your story is probably more valuable than you think; ask before you self-eliminate!

PLEASE NOTE: PAPERS MUST BE TECHNICALLY ORIENTED, NOT SALES ORIENTED. AVOID DIRECT REFERENCE TO COMPETING SYSTEMS.

Email or mail all abstracts to:
Attn: Mr. Todd Ericson
Symposium Chairman
C/O SETP Headquarters
P.O. Box 986
Lancaster, California 93584-0986
Email: Laurie@setp.org

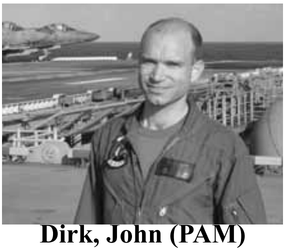
NEW MEMBERS AND UPGRADES

The Society would like to welcome the following new Members:

Bernard, Michael (M)
LT, USN
Joined 15-Oct-14

Brandon, Jay (M)
NASA
Joined 10-Sep-14

Dickerson, Brian (M)
Gulfstream
Joined 16-Jul-14



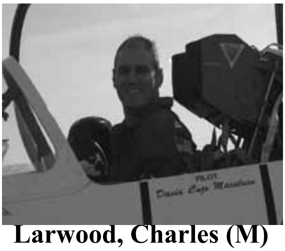
Dirk, John (PAM)
Maj, USMC
Joined 16-Jul-14

Erker, Kevin (M)
LtCol, USMC
Joined 15-Oct-14

Janjua, Jameel (PAM)
Maj, RCAF
Joined 16-Jul-14

Jordan, Michael (M)
Capt, RCAF
Joined 10-Sep-14

Langumier, Raphael (M)
ARL Aviation
Joined 15-Oct-14



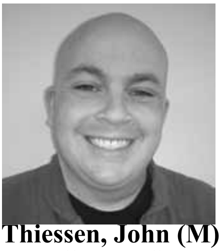
Larwood, Charles (M)
LCDR, USN
Joined 10-Sep-14

Latvala, Bruce (AM)
Textron Aviation
Joined 15-Oct-14

McMullen, Charles (AM)
Maj, USAF
Joined 10-Sep-14

Neubert, John (PAM)
LT, USN
Joined 19-Nov-14

Roberson, William (AM)
Boeing
Joined 10-Sep-14



Thiessen, John (M)
LCDR, USN
Joined 10-Sep-14

Vautier, Franco (PAM)
Maj, Brazilian AF
Joined 15-Oct-14

Wierzbanowski, Jason (M)
Lt Col, USAF
Joined 16-Jul-14

PHOTOS NOT AVAILABLE FOR THE FOLLOWING NEW MEMBERS:

Atkinson, Nathan (PAM)
LT, USN
Joined 10-Sep-14

Bell, Clifton (PAM)
Maj, USAF
Joined 16-Jul-14

Bowes, Paul (PAM)
FltLt RAAF
Joined 10-Sep-14

Brown, Mark A. (AM)
Boeing
Joined 10-Sep-14

Davis, Michael(AM)
Lt Col, USAF
Joined 15-Oct-14

Dean, Jeffrey (PAM)
Maj, USMC
Joined 16-Jul-14

Florendo, Corey (PAM)
Capt, USAF
Joined 16-Jul-14

Francis, Paul (PAM)
Capt, RCAF
Joined 16-Jul-14

Fruchtnicht, Chrisopher (PAM)
CW3, USA
Joined 16-Jul-14

Hafez, Adam (PAM)
Maj, USAF
Joined 16-Jul-14

Hartman, Travis (PAM)
LT, USN
Joined 16-Jul-14

Haywas, Luke (PAM)
Capt, USAF
Joined 16-Jul-14

Jovanovich, Marija (PAM)
Flt Lt, RAAF
Joined 16-Jul-14

LaPlant, Nicholas (PAM)
Maj, USAF
Joined 16-Jul-14

McMeeking, James (PAM)
Sqn Ldr, RAF
Joined 16-Jul-14

Merrill, Sean (PAM)
CW4, USA
Joined 16-Jul-14

Nations, Christopher (PAM)
Maj, USAF
Joined 16-Jul-14

Ng, Swee Hoe (PAM)
Maj, Republic of Singapore AF
Joined 16-Jul-14

Trask, Barrett (AM)
Textron Aviation, Cessna
Joined 19-Nov-14

Vance, Travis (PAM)
Capt, USAF
Joined 16-Jul-14

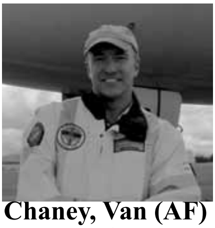
Wilson, David (PAM)
Sqn Ldr, RAF
Joined 15-Oct-14

Congratulations to those members who have upgraded their membership!

Bearce, Maynard (AF)
Boeing
Upgraded 10-Sep-14

Bredenbeck, Kevin (AF)
Sikorsky
Upgraded 10-Sep-14

Brownlee, Joe Allen (AF)
FAA
Upgraded 15-Oct-14



Chaney, Van (AF)
Boeing
Upgraded 15-Oct-14

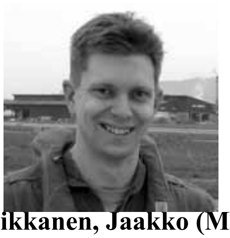
Crockatt, Stephen (AF)
CDR, RN
Upgraded 15-Oct-14

Debbink, John Paul (M)
LCDR, USN
Upgraded 19-Nov-14

Edwards, John Paul (AF)
AgustaWestland
Upgraded 19-Nov-14

Henderson, Jennifer (M)
Boeing
Upgraded 10-Sep-14


Leveron, Troy (M)
LT, USN
Upgraded 19-Nov-14


Nikkanen, Jaakko (M)
Capt, Finnish AF
Upgraded 19-Nov-14


Ohman, Klas (AF)
CDR, USN (Ret)
Upgraded 10-Sep-14


Pacini, Michael (M)
Capt, USAF
Upgraded 10-Sep-14


Richardson, Casey (M)
Maj, USAF
Upgraded 10-Sep-14


Ruonala, Mikko (M)
Capt, Finnish Air Force
Upgraded 10-Sep-14


Schlappi, Kyle (M)
Lt Col, USAF
Upgraded 15-Oct-14


Schwenzel, Daniel (AF)
Eurocopter Deutschland
Upgraded 15-Oct-14

Spencer, Alec (M)
Maj, USAF
Upgraded 10-Sep-14

Sweeney, Nicholas (AM)
Maj, USAF
Upgraded 19-Nov-14

Thorbiornson, Mats(AF)
SAAB
Upgraded 15-Oct-14

Tobias, Aaron (AF)
Cessna Aircraft
Upgraded 16-Jul-14

Trickey, Charles (M)
Maj, USAF
Upgraded 15-Oct-14

PHOTOS NOT AVAILABLE FOR THE FOLLOWING MEMBERS WHO HAVE UPGRADED THEIR MEMBERSHIP:

Calhoun, Paul(AM)
Maj, USAF
Upgraded 16-Jul-14

Corrigan, Devin (M)
LCDR, USN
Upgraded 19-Nov-14

Hanley, James (AF)
Boeing
Upgraded 16-Jul-14

Holder, John (M)
LT CDR, RN
Upgraded 16-Jul-14

Masten, Dustin (M)
Maj, USAF
Upgraded 16-Jul-14

Paap, Grant (M)
Maj, USAF
Upgraded 16-Jul-14

Ropp, Daniel (AM)
LCDR, USN
Upgraded 19-Nov-14

Ross, Michael (M)
LT, USN
Upgraded 10-Sep-14

Van Kralingen, Rogier (M)
LCDR, Royal Netherlands Navy
Upgraded 19-Nov-14

Walsh, John (AM)
LCDR, USN
Upgraded 16-Jul-14

Zilberman, Eric (M)
LT, USN
Upgraded 16-Jul-14

WHO...WHAT...WHERE

Mr. Troy Fontaine (AF) was recognized as the Department of Homeland Security Test and Evaluation Professional of the Year for his work on the Multi-Role Enforcement Aircraft.

Assistant Commissioner Randolph D. Alles and Mr. and Mrs. Fontaine at the awards ceremony.

****

On 25 October 2014 The Federal Aviation Administration Western Pacific Region presented Thomas C. McMurtry (F) with the Wright Brothers Master Pilot Award, for the 50 year milestone of dedicated service in aviation safety, in recognition of the significance of Mr. McMurtry's achievements and contributions to aviation.

****

On 1 November 2014, Joe H. Engle (F) and Fitzhugh L. Fulton, Jr. (F) were inducted into the International Air & Space Hall of Fame at the San Diego Air & Space Museum's Legends of Flight celebration. Honorees are selected for their qualitative achievements and historic contributions to aviation, space or aerospace innovation. Their individual contributions are prime examples of endurance and the adventurous exploring spirit in the pursuit of knowledge and scientific advancement to benefit the world. Congratulations, Joe and Fitz!

****

The F-104G D-8244, as USAF F-104 57-913, was officially revealed at the Palm Springs Air Museum on November 8th. It was a dedication ceremony with many guests watching the cover being taken from the F-104G. A number of former USAF F-104 pilots were in attendance, including Bob Gilliland (F), who served as Chief Test Pilot of the F-104, Col. Buzz Lynch, USAF (Ret) (F), Col. Bob Lilac, USAF (Ret) (M) and Jack "Suitcase" Simpson (M). This aircraft was representing the aircraft of Norman Schmidt, who died as a POW during the Vietnam War, and his widow Marie Schmidt was also in attendance. Mrs. Schmidt and the former F-104 pilots added their signature to the aircraft to honor its role and their experiences with it in their flying careers.

The National Aviation Hall of Fame (NAHF) has announced the names of those who have been elected for enshrinement at its annual formal ceremony, Friday, October 2, 2015 in Dayton. On the list is Brig. General Robert L. Cardenas, USAF (Ret) (M). After flying WWII combat as a B-24 pilot in Europe, Cardenas graduated from test pilot school in 1945. He was instrumental as the B-29 mothership pilot and operations officer on the supersonic record-breaking X-1 program and as chief pilot on the XB-49 flying wing program. He commanded a combat wing of F-105's in Southeast Asia and later the Air Force Special Operations Force. Congratulations Bob!

****

Senior German Test Pilot Horst Philipp Received his Fellowship Insignia

When the President of the Society handed over their insignia to the new Fellows during this year's Awards Banquet, German nominee Horst Philipp could not attend due to a health problem which prevented him from going on the long flight to L.A. Therefore, German Military Chief TP Robbs Hierl accepted Horst's needle and diploma. Robbs committed himself to presenting them to Horst back home in Manching as soon as a proper opportunity was at hand.

A few weeks later, SETP Flight Test Safety Committee and SFTE carried out the 8th European Flight Test Safety Workshop at Manching. On the final evening, after the conclusion of the workshop, chairman Andrew Warner invited the participants to a social "farewell" event. This get-together which took place in the very nice setting of the Celtic-Roman Museum, was the perfect moment to present Horst Philipp with his well-deserved insignia. Former SETP president Rogers Smith gladly accepted the honor and carried out the ceremony. Under lots of applause of the other attendants, 77-year-old Horst, a leading figure of German post-war flight test, finally received his needle and diploma. Not only was he back in good shape, but he proved to be in a splendid mood; very touched by the moment, he delivered a short speech in which he expressed his gratitude to the Society for this honor.

Leroy D. “Dale” Felix (F) was inducted into the Kansas Aviation Hall of Fame on October 28, 2014. Dale was the only test pilot in Kansas to receive this honor in 2014. The award was presented at the Kansas Aviation Museum in Wichita at a ceremony which also honored a doctor and aviation photographer, Paul Bowen. Congratulations Dale!!!

****

On December 9-10, Drury W. Wood (F) was a guest of honor at the 100th Anniversary of the Dornier Company celebration and the 1st International Symposium of Aviation and Aerospace Museums in Friedrichshafen, Germany. He was invited to attend because he was Chief Pilot of Dornier during the development of the world’s only vertical takeoff jet transport, for which he received the German Federal Cross of Merit.

WANTED: MEMBER and CORPORATE MEMBER INFO AND PHOTOS!

Keep the members up to date on your Individual and Corporate news, events, and happenings!! The Society is soliciting flight test related news about SETP members and Corporate members for publication in the WHO...WHAT...WHERE section of COCKPIT Magazine. If you know of some interesting information about an SETP Member(s) or Corporate Member, please send it in. If you have some photos to accompany the news, all the better! All information and photos submitted will be given serious consideration for publication in COCKPIT Magazine. Flight Test events, awards, promotions, gatherings, etc. should be reported and shared.

To submit news and photos please contact Susan Gron at:
Susan@setp.org

BOOK NEWS

SETP President's Review –

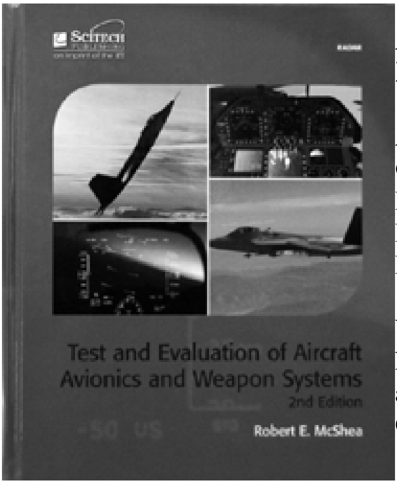
As test pilots we have all wished for the perfect single-source document that lays out with the proper detail a soup-to-nuts plan for conducting flight test. And although there are great sources out there (such as SETP's Pilot's Handbook for Critical and Exploratory Flight Testing), flight testing as a whole cannot be boiled down to a series of recipes to be incorporated into an ultimate flight test cookbook. The life cycle of modern aircraft and weapons systems continues to expand and it is the lucky few that get to perform critical first flights and envelope expansion sorties; increasingly, the vast bulk of a flight test program involves the testing of the aircraft avionics and weapons systems.

With the publication of the 2nd edition of the Test and Evaluation of Aircraft Avionics and Weapons Systems, noted National Test Pilot School instructor Robert McShea has authored an outstanding primer that serves both as a textbook and practical reference for all personnel involved in such flight testing. The author has a great knack for explaining the various technologies in sufficient detail yet in a language that is very readable and understandable.

This 1000 page treatise is a must-have for anyone desiring a working knowledge of modern flight test. SETP members can save 20% off the list price by using the below link and using promotional code SETP5 (offer expires March 1, 2015).

https://sci.presswarehouse.com/Books/BookDetail.aspx?productID=369686

-- Forger



Test and Evaluation of Aircraft Avionics and Weapons Systems, 2ND EDITION

Author: Robert McShea
Copyright: 2014
Binding: Hardcover
ISBN: 978-1-61353-176-1
List Price:$175.00 (see above for SETP discount)

You may order using the link:
https://sci.presswarehouse.com/Books/BookDetail.aspx?productID=369686.
Offer expires on March 1, 2015

DESCRIPTION

Truly successful flight engineers know there is no “cookbook” for avionics and weapons systems testing. They know the ground rules, possess knowledge of past tests, and remember the lessons they learned (good and bad). The first edition of Test and Evaluation of Aircraft Avionics and Weapons Systems was a highly successful book because it served as both textbook and practical reference for all personnel involved in evaluation and testing, from pilots in the air to engineers and technicians on the ground. While there are several books for evaluating an aircraft’s handling and flying qualities, this is the only known book for evaluating avionics and weapons systems.

Now in its Second Edition, this is a primer on the basics of test and evaluation using methods gleaned from a multitude of programs and test engineers over the past 30 years. Comments from readers and users of the first edition indicated a desire to include materials on Unmanned Aerial Vehicles (UAV) as well as EO/IR evaluations. A complete chapter has been added on evaluating UAV systems (expanding on previous information in the first edition) and Night Visions Systems and Helmet Mounted Displays have also been given a full chapter. Other reader comments on issues unique to helicopter test have been addressed, as well as the significant changes in civilian regulatory and advisory material.

This book is written to accompany a six month course of instruction in Avionics and Weapons Systems Evaluation which was developed by the author and currently presented at the National Test Pilot School in Mojave, California. The book reflects the culmination of this course as accredited by ABET and approved by the State of California as a requisite for a Master of Science Degree in Flight Test Engineering.

TABLE OF CONTENTS

1. What is Avionics Flight Test and Why Do We Need It?
2. Time, Space, Position Information TSPI
3. Mil-Std-1553 and Digital Data Busses: Data Reduction and Analysis
4. Communications Flight Test
5. Navigation Systems
6. Part 23/25/27/29 Avionics Civil Certifications
7. Electro-optical and Infrared Systems
8. Radio Detection and Ranging – RADAR
9. Electronic Warfare
10. Air-to-Air/Air-to-Ground Weapons Integration
11. A Typical Avionics Integration Flight Test Program
12. Unmanned Aerial Vehicles (UAVs)
13. Night Vision Imaging Systems (NVIS) and Helmet Mounted Displays (HMD)
14. Acquisition, Test Management, and Operational Test and Evaluation

SECTION NEWS

CANADA

The Canadian Section held a well attended dinner in Montreal on Oct 16 with guest speaker Rogers Smith (F) who presented a highly informative lecture on "Lessons To Be Learned ….Again". The evening was also used to thank the outgoing committee and welcome the new team, consisting of Muz Colquhoun (M) (Chairman), Rich Ling (M) (Vice Chairman), Brad Koskie (M) (Secretary), and Constantin Stan (M) (Treasurer).

Outgoing Section Chairman Andy Litavniks presents CSeries model to Rogers Smith.

Montreal contingent of the new Canadian Section Committee: Muz Colquhoun (right), Rich Ling (centre), and Constantin Stan (left).

Rogers Smith with gifts.

Andy Litavniks hands over control of The Canadian Section to Muz Colquhoun.

GREAT LAKES

The SETP Great Lakes section closed out summer with fantastic weather, great food and sides of bourbon at our annual picnic on September 7th, once again very graciously hosted by Peet and Carol Odgers. A picnic is a great way to lead into a business meeting where longtime Section Chairman Robbie Robinson relinquished controls to newly elected chairman Eric Fitz. Joining Eric as new section officers are Ryan Smith as Secretary and Ed Conant as Treasurer (a trend of Eagle drivers?).

Our section Educational Outreach representative Gary Konnert hosted a highly successful outreach and pizza party with the University of Dayton (UD) engineering students on October 16th. Six section members presented videos and war stories on past test events while approximately 25 engineering students enjoyed free pizza. The students were enthusiastic (and hungry) and everyone had a great time talking aviation. The meeting proved a great way to generate interest and enthusiasm for both aviation and engineering. A hearty thank you to the members who were able to turn out and support this fun event!

Many of the students who attended the pizza party were in an aircraft design course, with projects ranging from light general aviation airplanes (4-seat single, LSA, 6-seat twin) to a jet trainer, a super mid-size business jet, a fire water-bomber and even a Red Bull racer. And of course, they needed test pilots to fly the various designs on the UD engineering simulator and provide handling qualities feedback to the student designers. UD has a Merlin engineering flight simulator using a six-DOF, non-linear, transonic model with fully adjustable aircraft flight models allowing control modeling and shaping, along with aerodynamic and propulsion modifications. So three eager section members jumped in and spent eight hours in the simulator evaluating 12 different designs on November 14th and 21st, providing great insights to the students who learned a good deal about making difficult design tradeoffs. Both students and pilots had a great time sharing their enthusiasm for flight.

Meanwhile, another A-team of UD students is working on the real-world Wright B Flyer lookalike replacement project, developing the aero model for the Wright B in order to forecast handling qualities for design improvements to be made over and above what was the Silver Bird tragically lost several years ago. SFTE engineers are working with the students on developing the model, and during the week of November 3rd three section members assisted by flying the UD simulator and providing feedback on flying qualities. It's quite humbling to fly it right where Orville and Wilbur designed and built it.

Again this year, the Great Lakes SETP and SFTE Wright Chapter teamed up for a shared Holiday Dinner on Friday, December 5th at the historic Engineers Club in downtown Dayton. The Engineers Club is on the National Register of Historic Places, containing a plethora of patented historical inventions and artifacts, and is where Orville Wright spent a good deal of his leisure time dining and enjoying the company of other standout innovators.

And finally, the Great Lakes Section Symposium is not far away. Join us on May 14th, 2015 at the Wright-Patterson AFB Banquet Center in Dayton, Ohio. We're looking for your presentations! No proceedings are published for this Symposium so formal written papers are not required. Those interested in presenting should submit an abstract by 30 March 2015 to:

Eric Fitz, Symposium Chairman C/O SETP Headquarters - Email: Laurie@setp.org
Post Office Box 986 Lancaster , California 93584-0986

EAST COAST

In 2015 the East Coast Section plans to break away from the Naval Air Station Patuxent River-centric operation it has become in recent years. The Section plans to hold three "offsite" events along with our more regular meetings centered around USNTPS activities. Please spread the word that membership is not required for any of our activities- drag anyone willing with you. Each event is planned to support fly-in options.

Here's the tentative calendar; save the dates and watch for details:
* 15 January- By the time you're reading this we expected to have held a beer call and brief on the Textron AirLand Scorpion at NAS Patuxent River.

* February or March- Targeting a tavern in Hampton, VA for camaraderie and a lecture on NASA Adaptive Compliant Trailing Edge projects.

* 10 April- Our annual East Coast Section Symposium near NAS Pax in conjunction with the USNTPS Alumni Association Reunion. We considered holding the event away from Pax, but with government travel budgets the way they've been Section officers were very concerned that we'd lose the USNTPS students who get initial exposure to SETP at the Symposium. Allan "Kreepy" Jespersen has a great day planned for us.

* 9 June- USNTPS Welcome to Flight Test at NAS Pax co-hosted by several associations and societies. This is the where we formally offer the new pilot graduates Provisional Associate Membership in our Society over beer and pizza.

* June or July- Todd Lardy plans to invite us to Boston, MA for a tour of Lincoln Laboratories.

* August or September- Looking forward to an educational meeting in Philadelphia, PA, possibly with a tour of the AgustaWestland 609 Tiltrotor.

Depending on how accurately addresses are recorded with headquarters, the East Coast Section is about 500 strong throughout the region from Virginia, West Virginia and Pennsylvania to the northeast to Maine. It is clear that not everyone is receiving e-mails, so please spread the word to check your SETP.org profile.

Fly safe,
Brian Sandberg
East Coast Section Chairman

WEST COAST

SETP West Coast Section held a winter beer call and Provisional Associate Member (PAM) recruiting drive on Friday, 21 November. The event was graciously hosted by the National Test Pilot School, and was well attended by SETP members from Edwards AFB and Mojave. Most importantly, all pilots in the graduating classes from NTPS and USAF TPS were present. After a short presentation by the West Coast Section Chairman, Lt Col David Kern (M), on the heritage of SETP and benefits of membership, Mr. John Fergione (F) gave an informative update on the status of the SETP Foundation. As a result of this event, SETP WCS collected 17 initial applications for Provisional Associate Membership in the society – a 100% recruiting success with both TPS classes. With the formalities concluded, the group enjoyed cold beer, conversation, and Mojave's finest pizza. Many thanks to Greg Lewis (F) and Nicola Pecile (AF) for making this beer call and recruiting event a great success!

SETP SECTION CHAIRMEN

CANADA William Colquhoun william.colquhoun@aero.bombardier.com	**CENTRAL** Steve Stowe stephen.stowe@aero.bombardier.com
EAST COAST Brian Sandberg sandbag23@hotmail.com	**EUROPEAN** Rudolph Engeler rudolf.engeler@armasuisse.ch
GREAT LAKES Eric Fitz eric.fitz@wpafb.af.mil	**NORTHWEST** Jennifer Henderson Jennifer.l.Henderson2@boeing.com
SOUTHEAST David Wright wrightdj@earthlink.net	**SOUTHWEST** Dan Wells paxwells1@yahoo.com
WEST COAST David Kern divotkern@gmail.com	

SCHOLARSHIP FOUNDATION NEWS

The following notes were received from Scholarship recipients:

Dear Sirs,

As I finish up this semester, I want to take a moment and express my gratitude for your generosity this year. For the first time in many years, I have been able to focus solely on my studies as I pursue my degree that will one day allow me to be a Physician's Assistant. Due to my background in Information Technology as well as my passion for the biological sciences, I have also been able to secure a position as an intern in a research lab on campus. I have been working with a team of graduate students and scientists from a robotics company on a machine that automates liquid-based assays for use in both research and clinical settings. This research experience is adding greatly to my academic resume and I would not be able to do so without your help. I am extremely grateful for your generosity in facilitating my university degree.

Thank you, and I hope you have a wonderful Christmas season.

Sincerely,
Juliana Brohmer Hansen

SETP,

Thank you so much for your continued scholarship support. Your generous assistance will help me with my Mechanical Engineering studies at the University of Florida. I hope to be able to use my education to work for our country and its military in the future. I am also extremely honored and grateful to receive the Salmon Scholarship. I have been incredibly fortunate to receive all of the invaluable assistance from SETP throughout my academic career. Thank you again for all of your amazing support.

Regards,

Andrew Simpson

Dear Sirs/Ma'am:

When I saw Aaron's letter with the new amount granted to him for his next quarter at the University of Washington, my first thought was "Wow!" And then, "Thank you, thank you".

You all continue to be incredibly generous and your support is deeply appreciated.

Thank you and best wishes for a New Year blessed with much happiness and great health.

Sincerely,
Sheyla C. Cooley
Widow of Dave Cooley

I can't even begin to say how much the increased financial aid from SETP has helped me. Thank you all so much. I hope that my grades are able to prove that your investment in me is worthwhile!

Jake George

Dear SETP,

I am writing to sincerely thank you for the financial assistance your organization provided me during my time as a student at Embry Riddle Aeronautical University, Prescott, AZ. Thanks to your kindness in sponsorship of my education and belief in my goals and abilities, I graduated in May of this year with a B.S. in global Security Intelligence Studies. I also received my commission and entered into active duty as a Second Lieutenant in the United States Air Force. I hope to continue passing your goodwill along through my organization, which supports the efforts of those who wish to enter the special operations community.

I am currently stationed at Goodfellow AFB, attending the USAF Intelligence Officer's Course, which I will complete in January 2015. Thanks to the support of family, friends, mentors, and organizations like yours, I was able to secure a position supporting special operations out of Hurlburt Field, FL upon my graduation. I am excited to continue pursuing my dreams of protecting our nation through support of the men and women of this elite group, and continue to work harder than ever to bring my efforts to fruition.

Without the support of SETP, none of my recent accomplishments would have been possible. Throughout the years, your role in my education has played a major part in continuing to write my own story of service for our great nation. For this I will always be grateful.

Very respectfully,
2d Lt. Aaron T. Evenson

Dear SETP Members,

I am writing to thank you for supporting me during my time at the University of Florida. I have graduated with a Bachelor of Science in Mechanical Engineering and an thrilled to complete it. I am excited to stay another year her at UF to obtain my Master's. I am looking forward to this summer after accepting an internship offer with Northrop Grumman, and hope to serve our country by working in the Defense industry full-time. Thank you again for your amazing support. I know my father would have been humbled by the assistance SETP has shown my brother and me in his absence.

Regards,
Andrew Simpson

Report from the Chairman
The SETP Scholarship Foundation

I am pleased to report that, at the July, 2014 Board of Trustees' meeting, the Trustees awarded $192,500 in scholarships to our ten students. This is a significant amount, and what is not shown in that figure is that eight of our students are funded at 100% of their College/ University financial requirements, which includes tuition, books and living expenses. Since that meeting, one of our members passed away with a child already attending college. The Board of Trustees and the SETP Staff immediately began working on the request for scholarship assistance from the family. The Trustees were notified of this request, our normal due-diligence was completed, and the voting commenced. As a result of the voting, the amount of educational assistance the SETP Scholarship Foundation is providing to our {now} eleven students increased to **$209,100.00, and nine of these students are funded at 100% of their financial requirements for the 2014 – 2015 academic year.**

So, why are some of our students funded at 100%, and some are not? The answer to that question is very simple. A couple of our students are attending a pretty expensive school. The SETP Scholarship Foundation does not place any restrictions on the college or university attended, nor does it place any guidelines on the course of study pursued. Once one of our students is accepted to a college or university, we then help them out, to the best of our ability, by providing financial assistance.

Our procedure is to distribute the money allocated for the year evenly until the 100% funding level of one of our students is achieved. Any remaining funds are then distributed evenly to the remaining students until another 100% funding level is reached. This process continues until the total money allocated for the college year is spent. We try to allocate 4.5% – 5.5% of the average value of our fund, calculated over the previous 12 – 16 months, which is the standard of practice for most charitable organizations with substantial endowments. For the 2013 calendar year, which is our most current data from our accounting firm, this value is $4.41M {Averaged over the past sixteen quarters}. Based on this number, our allocations calculate to 4.74% of our average value.

This issue of Cockpit will be distributed before the 2014 accounting data is available, so I will give you an updated financial status report of the Scholarship Foundation in the next issue. The average value of our fund is calculated as of December 31, so that will even give you a ball-park number for what we will distribute next year. Until then, our investment remains secure, and our overhead costs remain low. I have every expectation that the report I provide in the next issue of Cockpit will be uplifting.

The Scholarship Foundation Board of Trustees is presently composed of sixteen dedicated men and women. If you would like to be a Trustee, there is a relatively easy process involved. The first step is to let the SETP know of your desire. We'll be glad to work with you in making this desire a reality. Residence in or near the SETP Headquarters is definitely not required. All we desire is your commitment to engage, learn, and enjoy the great feelings we realize by providing scholarships to the children of our deceased and disabled members.

My sincerest thanks to all of you for your generous donations over the years. These donations make it possible for us to fund our children at these substantial levels. I wish all of you a prosperous new year.

John A. Fergione
Chairman, the SETP Scholarship Foundation
Past-President and Fellow, the Society of Experimental Test Pilots

THANK-YOU!!

Thank-you sir (Mr. McDonald), and thank-you Ms. Schell, for making it possible for me to attend the SETP Symposium, as a student as well as an exhibitor.

I was hoping to meet you and Mr. Kevin Prosser at the Symposium to thank both of you personally for extending the invitation for me to attend the SETP Symposium.

I also had hoped to meet up with Lt. Col. Jack Fisher and Lt. Col. Mr. Mark Stucky again, to thank them for selecting me for the SETP Award at the Intel ISEF, and to solicit from their judging comments on my projects for further improvement.

I, however, got to meet Mr. Andre Gerner again since Intel ISEF, and he was very hospitable in ensuring that I had a meaningful time and respectable presence throughout the event in a sea of industry professionals. His thoughtful introduction and timely interposition was very much appreciated.

I had the pleasure of being in the company of Mr. Chad Lundy and Mr. Paul Newton for lunch on the day of the Technical Tour. They gave me a glimpse into the selectivity and the activities of SETP members in rigorous qualification process and remarkable professional achievements. They maintained frequent meet and greet with me throughout the event, which was very assuring to me as a young neophyte among industry giants.

I was honored to share the table with the family of Mr. George Cooper for the Lunch Reception on Friday. They were affable and very embracing, given their stature and accomplishments. I was thrilled to learn that Mr. George Cooper was a fighter pilot in WWII, a NASA test pilot, and a developer of the Cooper-Harper Rating Scale. All that he had been and done were beyond my admiration, and he is an alumni of Cal Engineering, the college I am attending right now!

And among those who visited my exhibit, some had asked for my project abstract, and some even expressed interest to receive my resume! I was encouraged and excited for the determination and direction of my aspiration.

As an aerospace enthusiast since young and an engineer at heart, I have been devising test plans and building test rig to conduct experiments and evaluations of parameters in plane designs that would improve flight efficiency. My science and engineering study projects had included measuring efficiency of circular action of propeller designs by their linear movements on a track, converting flapping energy of ornithopters to linear travel on a rail, and constructing 3D vector models to illustrate and compute the net effect of the forces at work with different combinations of incline/decline, bank angles, turn directions, and load placements. Additionally, and more recently, my projects had been exploring methods to “print wingtip vortices”, to mathematically determine the optimal winglet length and angle, and to forge novel wingtip designs that would greatly reduce wingtip vortices while improving flight efficiency.

The SETP Symposium was a very illuminating and inspirational experience for me. It impressed upon me that engineering is a way of life, and forward thinking and modeling solutions is a state of mind for a test pilot. Test piloting is the pinnacle of aerospace engineering!

Please extend my appreciation to all who concerned, especially to those I mentioned above. Thank you very much once again.

Sincerely,
Loren Newton

58th ANNUAL SYMPOSIUM & BANQUET REPORT

24-27 September 2014

Grand California Hotel, Anaheim, California

The Society's 58th Annual Symposium and Banquet (S&B) was held at Disney's Grand Californian Hotel from 24 to 27 September 2014. Overall, the event was a great success due to the efforts and dedication of the SETP and Disney staffs and the professionalism and hard work of the multitude SETP members who participated in the event as event chairmen, judges, speakers, and engaged attendees. The military was back in attendance in significant numbers, thanks to sponsorship from our DoD test leadership, and superior staff work on the part of many of our members. Overall, 520 registrants were in attendance, which is back to our pre-sequester level!

The Technical Tour, led by David "Divot" Kern, kicked off the week. Members were treated to an exclusive tour of the Space Shuttle Endeavour at the California Science Center. It was awe-inspiring to see the massive shuttle up close, and some of our members with intimate knowledge of the vehicle added insights and details to the tour that made it a once-in-a-lifetime event. After the Shuttle Tour, participants enjoyed lunch at Buca di Beppo, then continued to The California Institute of Technology, where they were treated to tours of the University's Nanotechnology Laboratories and Hypersonic wind tunnel. A "rolling reception" on the bus ride home completed the event.

The technical sessions were orchestrated by Symposium Chairman Rob "Skid" Rowe, and his team of Session Chairmen and Judges. Twenty six papers were presented in all, spanning topics from The Loss of the R101 Airship, to Cyber-Vulnerability testing, to Automatic Air Collision Avoidance. All the presenters did an exceptional job relating flight test lessons learned and sharing new ideas. Feedback on the sessions was overwhelmingly positive. Our speakers also left us with many memorable quotes, such as, "In testing, everything is the same, except for what is different," and "Every test pilot's worst nightmare is two FTEs in the back seat with unfettered access to the controls!" Podcasts of the papers are available to members on the SETP website, and the Proceedings CD will be published shortly, which will include the Podcasts as well as the technical papers.

The luncheon, organized by Troy "Hollywood" Fontaine featured an outstanding presentation on the past and future of Hypersonic testing by Doctor Mark Lewis, the longest serving U.S. Air Force Chief Scientist. Dr. Lewis presented a roadmap for the future of atmospheric hypersonic flight, progressing from weapons to manned vehicles, and highlighted recent success in the demonstration of new technology on the X-51 that will help make it possible.

The Educational Outreach Program, led for the second year in a row by Tim "NiCd" McDonald, was firing on all cylinders. Seven High Schools and one University were represented. New for this year, the students were hosted in small groups by assigned SETP mentors. They enjoyed Friday's Technical Sessions, a private discussion with Dr. Lewis, and the Friday Luncheon.

The corporate displays were arranged for the ninth year in a row by Dan Vanderhorst. The displays provided an exceptional backdrop for the event, and included several novel additions to previous years' line-ups to include a B-2 Chopper built by Orange County Choppers and displays of Intel ISEF award-winning student projects in the field of aerospace. As always, our corporate sponsors delighted us with displays of the latest technology and gadgets available to the profession.

The week was capped-off with the gala Awards Banquet, organized by Regis "Spoons" Hancock with Master of Ceremonies Ricardo Traven. Guests were treated to an amazing meal, background entertainment that included an Oshkosh review, and a dinner slideshow of aircraft photos from Jim Mumaw.

The critiques for the event were overall very positive, but also highlighted areas where we can improve. The critiques are extremely helpful in planning the event, so thanks to all who took time to fill them out!

Preparing for and participating in the 58th Annual S&B was a great experience, most notably due to the multitude of exceptional people who are in, and who support the Society of Experimental Test Pilots. A special thanks is due again to Disney. This was the 10th year the event has been held at the Grand Californian, and the Disney staff pulled out all the stops to make it an event to remember.

Colin R. Miller (AF)
General Chairman
58th Annual SETP Symposium and Banquet

Technical Tour

The 2014 Gerry L. Morton Technical Tour visited two locations, the California Science Center and the California Institute of Technology. The tour was limited to 40 participants due to the some confined spaces at our destinations, and sold out quickly. Our first destination was the California Science Center, where we were met by Alyson Goodall and Dr. Ken Philips. They briefed us on CSC's $250 million dollar expansion dedicated to air and space. The premier exhibit at the California Science Center was space shuttle Endeavour, but their displays also featured capsules from Mercury, Gemini and Apollo 18. We were afforded private viewing of Endeavour before the facility opened for the day, with technical commentary from one of their staff that participated in development or operation of the orbiters. Of course, members of our group had similar experience with that program, which resulted in an enlightening conversation on technical characteristics of the space shuttles and variations in the orbiter fleet. It was especially interesting to learn about the flight test modifications that continued throughout the Shuttle program, including various instrumentation installation under the thermal tiles.

After completing our time at the California Science Center, the group traveled to Pasedena for lunch and the second half of the tour. We were met at CalTech by Dr. Guy DeRose of the Kavli Nanoscience Institute, and Dr. Emilio Graff of the Graduate Aerospace Laboratories (GALCIT). The group split up for separate tours of the nanotech and aero labs, then switched tour guides after an hour. The Kavli Nanoscience tour was especially unique, since the group had to suit up to enter the cleanroom. Although nanotech may seem a bit tangential to flight test, it was fascinating to learn about how this frontier of engineering is changing the materials that will go into developmental aircraft.

The GALCIT aero lab tour was an opportunity to see both their adaptive wall wind tunnel and the T5 hypervelocity shock tube. The rich history of this institution was presented to us, including the World War II era "Cooperative Wind Tunnel" and such well-known figures as Dr. Theodore von Kármán. At the wind tunnel, Dr. Graff showed an active flow control experiment that employs sweeping jets of air along the vertical tail of an aircraft. This technology could be powered by auxiliary power unit bleed air, and allow for a smaller empennage while retaining low speed directional control. At the time of this writing, Dr. Graff's team was recently presented with a NASA Group Achievement Award. The T5 hypervelocity shock tube is a free piston design that provides Mach 5.2 speeds at 2000 Kelvin, with the atmospheric mixture of your choice. Unfortunately, we didn't get to witness a test event!

This highly successful 2014 technical tour was great for both education and fellowship. Despite heavy LA traffic on the return route to Anaheim, on-board refreshments and conversation made the trip easy, capping off a thoroughly enjoyable day.

LtCol David "Divot" Kern, USAF (M)

Welcome Reception Photos

New Member Luncheon

SETP President Kevin Prosser (F) was delighted to welcome the 15 new members and 2 spouses attending the 58th Annual Symposium in Anaheim to his New Members' Reception at which they were afforded the opportunity to meet Directors, Charter Members, and Historians of the Society. Held this year on the Parkview Terrace, and generously sponsored once again by the Thomas family in memory of the late David Thomas (F), the buffet lunch had a distinctly informal and personal air to it, with each new member being individually hosted by regional chairmen and presenters drawn from 2014's programme of national and European conferences and workshops.

The photographs are testament to the warm welcome given by existing members young and not-so-young to their new compatriots in the searing heat of the hottest afternoon of the Symposium.

In addition to being presented with a welcome voucher to spend in the SETP shop, the new members were also presented with a bottle of "Test Pilot" red wine generously donated by George Cooper (Charter member and Fellow) from his Cooper-Garrod estate, and presented by himself in the company of Dr Bob Harper (F), making for some wonderfully memorable individual photographs for each of the new members. SETP welcomes all the new members who have joined the Society since last year's symposium, whether or not they were at Anaheim this year, and looks forward to continuing the Society's drive, together with them, towards improved safety and strengthened relationships in flight test.

Tim Below (AF)

President's Dinner Photos










Friday Luncheon

This year's Friday Luncheon was attended by over 470 members and guests. In addition to the outstanding meal provided by the Grand Californian Resort, SETP's guest speaker for the event was Dr. Mark Lewis; the longest serving Chief Scientist for the USAF and a foremost authority on Hypersonic Flight. Dr. Lewis, presently the Director of the Science and Technology Policy Institute, gave an impressive presentation entitled, "Flight Test in the Hypersonic Regime: Relearning What We Once Knew." Again this year, SETP's STEM outreach program hosted students from many local area high schools for Friday's technical presentations and provided a private, low key, question and answer session with Dr. Lewis prior to the luncheon.

Luncheon Speaker, Dr. Mark Lewis, Emphasizing a Point on Hypersonic Flight

Local Area High School Students Gather for A Group Photo Following Friday's Luncheon

Friday Night Reception

The Friday Night Reception was held on the Lawn of the Disneyland Hotel for the second year in a row. The food was excellent, the weather was great, and the fellowship was second-to-none. Members and their guests enjoyed a night under the stars (and floating aerostat lights) catching up, networking, and telling stories.











Awards Banquet

The 57th Annual Awards Banquet was Chaired by Regis Hancock (M) with Ricardo Traven (F) as Master of Ceremonies.

This year the 58th Annual SETP Symposium concluded once again with the Annual Banquet and Awards Ceremony. According to the 2014 Banquet Chairman, Regis Hancock (M), the Banquet was a huge success due to the dedicated hard work from Disney, the SETP Staff, Fred Johnsen, Claude Pasquis and the audio video team. Mr. Ricardo Traven (F) added his special flare to the evening as the Master of Ceremonies. In addition to presenting the annual awards during the evening's festivities, the Society inducted eleven new Fellows.

Steve Lewis
Friend of the Society Award

(L to R) President Kevin Prosser (F)
and award winner
Robert Moreau (AF),
Federal Express

“Flight Testing EFVS Lessons Learned.”

Herman R. Salmon
Technical Publications Award
(Sponsored by Symbolic Displays)

(L to R) President Kevin Prosser (F) and award winner Capt Michael Pacini , USAF (M).
Not Present: Maj Casey Richardson, USAF (M) and P. Travis Millet.

“Lessons Learned From Automatic Air Collision Avoidance System Flight Testing”

Ray E. Tenhoff Award
(Sponsored by Aerospace Services International)

(L to R) Award Presenter Art Tomassetti (F) and award winner Maj Matt Russell, USAF (M) .

Not present: Steve Hall

“Landings You Can Walk Away From; Predicting F-16 Gear Life Fatigue”.

ETA Award
(Sponsored by Lockheed Martin)

(L to R) Award Presenters Robert Mckay,
Mark Moya,
award winner
Terry Lutz (F), and Preisdent
Kevin Prosser (F)

Tony LeVier Flight Test Safety Award
(Sponsored by Gentex Corporation)

2014 SETP Fellows

Peter Chandler

Francis Chapman

Dave Desmond

Randy Gaston

Ralph Kimberlin

Karl-Heinz Mai

Troy Pennington

Horst Philipp

Kevin Prosser

Richard ‘Dick’ Rutan

Mark Stucky

2014 SETP Fellow Class

(L - R) President Kevin Prosser, Mark Stucky, Richard Rutan, Troy Pennington, Ralph Kimberlin, Randy Gaston, Dave Desmond, and Peter Chandler.

JAMES H. DOOLITTLE AWARD

(Center Right) Award winner - George Cooper (F). Presented by (L to R)
Kevin Prosser (F), Jimmy Doolittle (F) and Dennis O'Donoghue (F).

James H. Doolittle Award
(Sponsored by The Boeing Company)

In June 1945, George was the first post-war research pilot hired by the National Advisory Committee for Aeronautics' AMES Aeronautical Laboratory. In 1953, he became AMES laboratory chief test pilot. From 1945 through 1958, he participated in nearly 30 test programs. In the mid-50s, the navy was intent on establishing the influence of handling qualilities on the minimum acceptable approach speed for landing on an aircraft carrier. George directed and obtained extensive pilot commentary on stability and control characteristics that influenced the acceptable approach speed. The program clarified in his mind the need for a standardized pilot opinion rating scale. Over the next several years, George developed and refined the Cooper pilot opinion rating scale that forced a specific definition of the pilot's task and its performance standards. After years of experience gained in flight and simulator experiments and through its use by military services and aircraft industry, it was modified and strengthened in collaboration with Robert Harper of the Cornell Aeronautical Laboratory to become the Cooper-Harper handling qualities rating scale. It remains the worldwide standard for handling qualities to this day. George was a member of NASA's advisory committee on aircraft safety and operations. He was the pilot representative on the NASA and FAA team involved in the development of a commercial supersonic transport. For a decade after his retirement from NASA in 1973, George served as a chief consultant to the AMES life sciences team seeking to develop a program in cockpit resource management. George proposed a three-stage program: first, use of a flight simulator to observe flight crews conducting pre-planned missions and feedback about any errors made or problems encountered; second, development of an aircraft incident reporting system through which pilots could report incidents based on design problems, cockpit coordination problems, or pilot error; and third, to use the reporting system to disseminate the results so that everyone in the airline industry would benefit from the lessons learned. This program became the aviation safety reporting system still in use, and has dramatically improved commercial aviation safety over the last thirty or so years.

IVEN C. KINCHELOE AWARD

(Center L to R) Award winners - Dan Wells (AF) and Paul Edwards (AF),
AgustaWestland Tilt-rotor Company.
Presented by Iven Kincheloe III, Jeannine Kincheloe, and son.

Not present: Pietro Venanzi (F)

Iven C. Kincheloe Award
(Sponsored by Lockheed Martin Corporation)

The AW609 Civil Tiltrotor recently completed all-engine-inoperative testing. Certification of the AW609 requires following a loss of all engine power in airplane mode, the aircraft must be able to convert to a safe landing configuration. That landing configuration will be an autorotation in vertical takeoff and landing or VTOL mode. The maneuver of converting from airplane mode to VTOL mode while simulating all-engines-inoperative has only been tested on two other tiltrotor aircraft. Dan, Paul and Pietro flew a total of 28 simulated all-engine-inoperative conversions from airplane mode to VTOL mode. They developed a technique to prevent rotor rpm from decaying as the rotor went through edge-on flow during the conversion. The technique proved valuable in keeping rotor rpm above the minimum, reducing loads on the rotor system and insuring the maneuver did not rely on engine power. They also performed 43 conversions from a simulated one-engine-inoperative condition to a simulated all-engine-inoperative, VTOL autorotation. That maneuver had not been performed in any tiltrotor previously. Dan, Paul and Pietro investigated the flare effectiveness of the aircraft and proved a safe landing from autorotation is not only possible but highly likely. Very little power-off testing has been conducted in tiltrotors, and almost none has been conducted since the 1980's. They greatly expanded the envelope and the knowledge-base of this type of testing for future tiltrotor aircarft."

Dan, Paul, and Pietro are most deserving recipients of the 2014 Iven C. Kincheloe award!

2014/2015 SETP PRESIDENT

2014/2015 SETP President Mark Stucky (F) accepts the "Symbol of Control" from 2013/2014 SETP President Kevin Prosser (F)



















8th European Flight Test Safety Workshop

The 8th European Flight Test Safety Workshop in Ingolstadt, Germany was attended by 63 flight test experts from 13 countries and 25 organisations. The event was hosted by Airbus Defence and Space at Manching, and kindly sponsored by Gulfstream, ETPS, German Aerospace Centre DLR and the German military flight test centre WTD61.

The technical sessions started with eight very different organisations presenting their ways of managing flight safety. This demonstrated that most flight test teams are confronted with the same challenges: buy-in by management, ownership of risks, clear responsibilities, adaptation of SMS methods to the test environment, methods of measuring risk and the success of an SMS, achieving simplicity, change of culture and, most importantly, feedback to all participants. Further presentations on diverse test campaigns all emphasised the common experience that PPPPPPP (Proper Prior Planning Prevents Precariously Poor Performance).

The ensuing discussion forums generated very open debates and provided the opportunity for all attendees to describe and discuss their own experiences. Networking opportunities permitted further fruitful exchanges of ideas on how to provide structure to and effectiveness to aviation safety initiatives.

The main hall of the Deutsches Museum Aircraft Collection provided a splendid backdrop for the dinner with a highlight of an entertaining and enlightened transfer of wisdom by Rogers Smith.

The European Flight Test Safety Awards for 2015 was presented to Gulfstream Aerospace on behalf of Heidi Biermeier (absent due to a car accident). The opportunity was also taken to hand over the 2014 award to Moe Girard.

The final reception in the Roman and Celtic Museum provided the opportunity to present the Certificate of Fellowship of SETP to that doyen of the flight test community, Horst Philipp.

The technical tour to the Airbus Helicopters plant at Donauwörth provided insight, particularly for the fixed-wing brethren, into the essentials of the current helicopter development programs and manufacturing methods.

The European Safety Workshop goes from strength to strength and we look forward to seeing you in even greater numbers at next year's event.

SW Section/SFTE International Symposium

In late October, the Southwest Section joined the local section of the Society of Flight Test Engineers in Fort Worth, Texas for a day of technical papers and an inspiring luncheon talk from NASA Astronaut Rex Walheim. The speakers included Al Norman (F) discussing the F-35, James Harris giving an overview of the new Bell Helicopter 525, and Elliot Seguin (M) of Scaled Composites presenting the evolution of an air racer of his own design. Erasmus Pinero gave an historical overview of World War I aviation and the surprising number of innovations that came about, and a student team from Texas A&M presented their Senior year project, an agricultural UAS of their own design. Jerry Singleton (M) and photographer Jay Miller gave a presentation about the Peace Jack.

After Lunch, Chris Seymour (AF) and Kevin Christensen (AF) talked about the Bell Helicopter V-280 Tiltrotor and Dan Canin (AF) reviewed F-35 High AOA testing. Randy Greene (AF) and Louis Simons presented a powerline detection system for helicopters and Ken Dorsett presented ARES or Aerial Reconfigurable Embedded System. Keith Jackson, the A-12 Chief Engineer, gave an historical paper on the A-12 Avenger, and Paul Edwards and Dan Wells presented a paper on autorotating the AW609 Civil Tiltrotor. The last paper of the day was presented by Dr. Kamesh Namuduri of the University of North Texas on using aerial base stations to restore communications during disaster recovery.

Afterward, an open bar was the site of much discussion. There was a strong attendance from five different universities plus many people from the local aerospace community.

Chris Seymour amd Kevin Christensen discussing the Bell V-280

Dan Canin discussing F-35 high AoA testing

Dr. Al Norman speaks about the F-35

Dr. Kamesh Namuduri on restoring comms after a disaster

Elliot Seguin discussing his airplane

Jay Miller and Jerry Singleton talking about Peace Jack

Keith Jackson talking about the A-12 Avenger

Ken Dorsett discussing DARPA's ARES program

Five Universities were represented at the Symposium

LT GEN Mark Shackelford opens the morning session

Kevin Dwyer opening the afternoon session

Paul Edwards giving a class on autorotation and tiltrotors

Randy Greene and Louis Simons present the powerline detection systems testing

Rex Walheim being thanked by James Sergeant of SFTE

Students from Texas A&M prsent thier senior project

The open bar afterward was the scene of lively discussions

SETP is saddened to report that our "Friend of the Society" retired AFFTC Historian Dr. James Young, passed peacefully on 19 December 2014. His wife Angie was with him, holding his hand as he took his last breath.

For many years Jim made possible the production of the corporate film clips and new Fellow videos shown at the annual Symposium and Banquet. In appreciation of his support, the SETP Board of Directors named him a Friend of the Society in 2000.

In 1980 Dr. Young arrived at the History Office at Edwards AFB and became Chief Historian in 1986 until his retirement. In addition to completing the official AFFTC annual histories, Dr. Young also produced 19 full length film and video documentaries and co-produced more than 250 shorter video briefings during his tenure at Edwards. He also authored many publications.

LAST FLIGHTS

Michael T. Alsbury (M) took his last flight on October 31, 2014 with the tragic crash of SpaceShipTwo.

Mike was born along with his twin sister Nikki on March 19th, 1975. Mike grew up in Scotts Valley near Santa Cruz California where he was an Eagle Scout and graduated with honors from Soquel High. Mike continued his education at Cal Poly San Luis Obispo and it was there in his sophomore year, that he met the love of his life, Michelle Saling. Mike graduated with a B.S. in Aeronautical Engineering and was immediately hired by Scaled Composites in Montrose, CO.

In 2000, Mike and Michelle moved to Tehachapi, CA to join the parent company where he quickly demonstrated his aeronautical engineering genius. With his technical skills and passion for flight it was a natural fit to assign him to flight test. Mike proved his aptitude as a flight test engineer, accumulated hours as a commercial flight instructor, and was eventually named a Scaled test pilot in 2007.

In his new role, Mike initially moved to the left seat of the Proteus high altitude research aircraft. He was also a test pilot for follow-on programs for the ARES light attack jet, a jet made famous in the movie Iron Eagle 3. After designing the flight control system for the Firebird Demonstrator he then served as a primary test pilot. Mike flew the first flight on Burt Rutan's last Scaled Composites project, the BiPod roadable airplane. Mike also flew other proprietary programs known only in smaller circles.

Mike was a strong believer in the founding precepts of SETP and was granted membership status in 2012. He presented multiple papers at annual symposia and was a member of the 2013 Tenhoff Award winning team. Mike worked on or led numerous milestone projects at Scaled and was part of the small team who received the 2014 Northrop Grumman Sector President's award for Innovation.

Mike had endless energy, a great sense of humor and an easy smile. He was a presence in any program he worked and perhaps this excerpt from a heartfelt letter from the Chief Test Pilot at Patuxent River's Strike Directorate says it best:

In the short time I had an opportunity to get to know Mike, I consider it an honor. I admire all of you for having the expertise and more importantly the courage to take human kind to places we've never been. There is no mission more remarkable that that of the pursuit of exploration. There is absolutely no doubt in my mind that the world is a better place because of Mike and that his legacy will carry on. Thank you for having the enduring courage to continue to push the limits of the very world we've defined.

A hero can be described as an ordinary human who chooses or is thrust into a journey that tests and teaches them, one who risks or sacrifices self for the sake of others or a greater good. Like X-15 pilot Mike Adams, the seven Challenger, and the seven Columbia astronauts, and many others; Michael Alsbury is an American hero.

Above all other things, Mike enjoyed spending time with his family. He is survived by his wife Michelle and their two children, Ainsley 10 and Liam 7.

Stephan Carignan (M), dedicated test pilot since 1989, passed away September 14, 2014, following a valiant battle with cancer. Stephan was a valuable team member of the National Research Council of Canada (NRC) Flight Research Laboratory, where he had been a test pilot and researcher for almost 20 years. His contributions were much appreciated and he will be deeply missed.

Stephan was born on August 6, 1962, in Winnipeg, Manitoba, and his love of aviation was evident from an early age. Before he even learned to drive, he obtained his glider's license, and his illustrious career took flight. In 1984, Stephan obtained a Bachelor of Mechanical Engineering degree from the Royal Military College of Canada. He completed helicopter flight training on Jet Rangers in 1985 and was assigned to the 423 Maritime Helicopter Squadron with the Royal Canadian Air Force (RCAF), flying the CH-124 Sea King out of Shearwater, Nova Scotia. While stationed there, he served on the HMCS Ottawa, Skeena, Margaree and Athabaskan, and accumulated 1100 hours of flight time. He also received the Destroyer Deck Landing, Landing Safety Officer, Maintenance Test Pilot and Crew Commander qualifications.

From 1989 to 1990, Stephan attended a year-long test pilot course at the French test pilot school École du personnel Navigant d'essais et de reception (EPNER) in Istres, France. Upon graduation, he was posted to the Aerospace Engineering Test Establishment in Cold Lake, Alberta. He was involved in the testing of the Helicopter Acoustic Processor System (HAPS) and the Helicopter Towed Array Support (HELTAS), as well as numerous flight deck certifications. He was also involved in the testing of the Recovery Assist Straighten and Traverse (RAST) MK III, British ship/helicopter night visual aid, and the Helicopter Integrated Navigation Systems (HINS) navigation trials, as well as other smaller projects.

Stephan came to NRC in 1996 where he spent over 18 years becoming one of the organization's most seasoned and versatile test pilots, accumulating almost 6700 hours of flying time and over 5000 of those as a test pilot. He piloted 45 different types of aircraft and took part in a variety of high-profile projects, including flights to test many advanced vision systems and augmented control laws, and the development of the flight envelope for the NRC Advanced Systems Research Aircraft, a fly-by-wire airborne simulator.

Stephan built many bridges in the technical community. At NRC he championed the use of the variable stability helicopter as an instructional platform for test pilots. Since 1996, he taught a generation of rotary wing test pilots and flight test engineers advanced flight test techniques. Stephan had the privilege of instructing students from all major western test pilot schools and of flying with pilots and engineers from around the world.

Stephan's contributions to aeronautics garnered him many prestigious awards. In February 2005, he received the NRC Outstanding Achievement Award for his exceptional contribution to the Enhanced Synthetic Vision System project. In June of that same year, he was awarded the American Helicopter Society (AHS) Gruppo Agusta International Fellowship Award for his contributions to the Sikorsky/NRC fly-by-wire team. He was awarded The Technical Cooperation Program (TTCP) Outstanding Achievement Award in April 2008 for his role in the "Integrated Visionic, Sensor, and Mission Systems for Day, Night, All-Weather Rotorcraft Operations" project.

Perhaps his most significant accolade was bestowed upon him by the Royal Aeronautical Society (RAeS) in December 2012. He received the RAeS Bronze Medal for his work leading to advances in aerospace as well as the coveted RAeS Alan Marsh Medal for his outstanding contribution to helicopter research, development and safety, which is recognized worldwide. The Marsh Medal is reserved for the exemplary members of international flight test crews. Stephan certainly was a team player, humbly crediting his entire crew for the success of projects.

A loving husband to his wife Colleen and father to Jordan, Jacob, Samuelle and Emanuelle, Stephan's legacy will be about much more than his commendable career. He will live on in the hearts of all who knew him as an inspiration. The rotary world is a safer place as a result of the part he played in its history. As we look back on the memorable career of an esteemed colleague and remember a dear husband, father and friend, it becomes clear that for Stephan, the sky was not the limit, it was his playground.

Capt. John A. Chalbeck, USN (Ret) (M), was born on 4 September 1926 and passed away on 15 July 2014 at Mt. Sinai Medical Center in Miami, FL.

Capt. Chalbeck served his country for 33 years as a Naval test pilot. During his career, he earned two distinguished Flying Crosses (Korea and Vietnam) a Bronze Star (Vietnam) and 10 air metals. He qualified in 70 fixed wing aircraft and 8 helos. He participated in A4 armament trials, F7U special weapons evaluation and F2H Rock Air at Patuxent River. He also assisted in the design, development and testing of the RCVW-12 Carrier Lighting System.

John also served as Director, Flight Test, NATC Patuxent River.

Following his career in the military, John and his family retired to Key Colony Beach where he served his community for a time as chief pilot for Mosquito Control and served on the Key Colony Beach Utility Board and the board of Fisherman's Hospital. He has also served as past Commodore for the Marathon Yacht Club and the Florida Council of Yacht Clubs.

He is survived by beloved wife Sybil, sons Michael (Kim), Kirk, and Stephen, grandchildren John Lee (Tina), William, and Angela; great grandchildren Stephen Jack, Mikayla, Morgan and Harmony.

Colin Cruickshanks, Air Commodore AFC*FRAeS RAF (Ret) (M) was born on 7 January 1945 and passed away on 21 July 2014 at the age of 69.

Originally an Operational Lightning Pilot, Colin trained as a test pilot at EPNER before joining A Squadron at Boscombe Down. He served as a test pilot at Boscombe in every rank from Flight Lieutenant to Air Commodore, retiring from the RAF from his post as Commandant A&AEE. During these tours he flew a very wide variety of aircraft including the YF-17, EAP and F-117A.

Colin was a member of the UK Ministry of Defense's Defense Aviation Safety Board. He was elected Fellow of Royal Aeronautical Society (RAeS). He was also Chairman of RAeS Test Pilots Group.

Colin volunteered at the BDAC Museum at Old Sarum.

He is survived by his wife Lesley and children Joanna and Ian.

Donations in Colin's name may be made to Parkinson's UK, C/O IN Newman Ltd, 55 Winchester Street, Salisbury, SP1 1HL, 01722 413136.

Col Melvin Hayashi, USAF (Ret) (M) flew his last flight on July 22, 2014 and is now flying with the winds over his beloved home in Maui. A native of Hawaii, Mel was an Honor student earning a Bachelor's degree in Electrical Engineering from the University of Hawaii and a Master's Degree in Aeronautics and Astronautics from Stanford University, Palo Alto, California.

He completed pilot Training at Williams Air Force Base, Arizona; served a short time in France; then flew his RF-4C Reconnaissance aircraft to the Republic of Vietnam serving two terms flying over 350 missions. Returning stateside, he flew the F-101 and F-106 at Hamilton AFB, California and was selected to attend the U.S. Air Force Test Pilot School at Edwards AFB in 1972. After graduation, he flew test missions in the A-7; U-2 and A-37 for engine performance, high altitude sensor testing and flutter testing and later joined the School staff where he was Chief of Stability and Control.

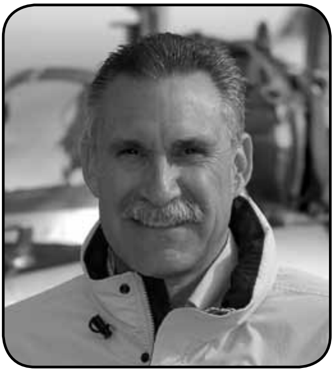
Colonel Hayashi attended the Armed Forces Staff College, Norfolk, Va, then assigned to the Pentagon in the Test and Evaluation Division, Air Force Headquarters in Washington D.C. He was also the F-16 program element monitor involved with the initial F-16C/D programming activities.

After attending the Air War College, Maxwell AFB, Alabama, he served as the LANTIRN (Low Altitude Navigation and Targeting Infrared System for Night) Test Force Director flying the F-16. He was later selected as Commandant of the U.S.A.F. Test Pilot School.

In 1985, at the Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, Colonel Hayashi was Director of Development and Integration in the F-16 program Office. He assumed the position as Director of the F-15 System Program Office where he was responsible for development and management of complex integration of advanced avionics, electronic combat systems, improved performance engines and a multitude of air-to-air and air-to-surface munitions; along with testing; production and deployment for the F-15E;

A decorated Command Pilot with 3,000 flying hours in various fighter aircraft, his decorations include the Silver Star; Legion of Merit; Distinguished Flying Cross; Meritorious Service Medal with one oak leaf cluster; Air Medal with Four Silver and one Bronze oak leaf cluster; Air Force Commendation medal; AF Outstanding Unit Award with one Oak leaf cluster; AF Organizational excellence award; National Defense Service Medal; Vietnam Service Medal with three Bronze service stars; Air Force Overseas short Tour ribbon; AF Longevity Service Award Ribbon with one Silver Oak Leaf cluster; Air Force Training Ribbon; Republic of Vietnam Gallantry Cross with Palm.

Mel lived a beautiful life with wife, Gail and sons, Dean and Brad. He loved his Country; his family and his Air Force Career which allowed him to soar through the skies at Mach speed. The Colonel volunteered with Habitat for Humanity in Texas, Honolulu and Maui and completed his dream of building his own home. He retired on Maui to fly through the waves whenever he wished, always the fastest windsurfer on the water! Mel immersed himself into the Hawaiian culture; learning to Read and speak the language; play the ukulele and singing the Hawaiian songs with Gail to his heart's content.



CDR Michael L. (Mike) Hill, USN (Ret) (AF) took his last flight on 24 October 2014. He was 68. Mike had a long and distinguished career as a Naval Aviator, Defense Contractor, and Test Pilot School Instructor. No one loved to fly more than Mike Hill, he was always up for another air adventure.

Mike was born on 1 April 1946 in Los Alamos, NM but grew up in Southern California where he attended Cal Poly graduating in 1969. Mike joined the US Navy right after graduation and attended flight training in Pensacola earning his Naval Aviator wings of gold and being designated a Fleet ASW and Combat SAR Helicopter pilot. After a couple of fleet cruises in the mighty H-3 helicopter, including serving in the Vietnam Combat theater, and a tour as a T-34C Instructor Pilot, Mike was selected for test pilot school and attended USNTPS in 1975. Upon graduation he was assigned to Rotary Wing Test at NAS Patuxent River where he worked on tests of various helicopters and systems including the AH-1J and the SH-3H helicopters. Mike was then selected for a joint test assignment with the US Army Aviation Engineering Flight Activity (AEFA) at Edwards AFB, CA. At AEFA he was one of the three primary pilots on the YAH-64 program and also got to be involved with numerous other Army flight test programs over the High Desert of Mojave and Edwards. Mike always maintained that the H-3 was his favorite helicopter but the YAH-64 Apache was a close second.

Mike's aviation career took a left turn when he was assigned to the Defense Intelligence Agency with duty as a Naval Attaché and FMS Officer in West Africa. In true Mike Hill fashion he was able to turn an embassy job into a flying assignment by flying a C-12 airplane all over Africa in support of the Diplomatic Corps and his FMS programs. Mike got to see most of West Africa from both the air and the ground. Finishing up in Africa, he went back to Pax River for his final naval test pilot tour working on several avionics and weapons systems tests and running various test ranges in support of test programs at Pax. Mike retired from the Navy as a Commander in 1994 with 25 years of service and over 5000 hours of flight time. His awards include the Army, Navy, and Joint Service Commendation Medals, the Navy Expeditionary Medal, RVN Air Gallantry Cross w/Bronze Wings, Navy Achievement Medal, the National Defense Service Medal, Republic of Vietnam Campaign Medal and the Vietnam Service Medal.

After retirement he went to work for DCS Corporation as part of the SPAWAR program in San Diego where he enjoyed 12 years supporting his beloved Navy on numerous projects. He also discovered his love of teaching by working part-time for ERAU as an adjunct professor in the College of Aeronautics. Re-bitten by the flying bug, Mike joined the National Test Pilot School in 2006 as the Head of the Rotary Wing Branch where he combined his love of flying with his love of teaching for the next 9 years. As a NTPS instructor he touched the lives of aspiring test pilots and flight test engineers from around the world leaving them with a new thirst for truth and reinforcing their love of flying. Mike was also instrumental in the founding and leading of the NTPS Flight Test Camp, a STEM program for local high school students designed to introduce them to engineering and flight test as possible fields of study and future career paths. Again he was changing lives and influencing young people with his energy, enthusiasm, and expertise. Mike was proud of the impact the flight test camp program was making on these kids' lives and on the local area and schools. Mike was an adventurer, a positive influence on friends and acquaintances, a trusted friend and shipmate, and could always be counted on for a good sea story or life lesson. Mike is survived by his wife Jill, his daughter Kindle, and his son Shawn. Fair winds and following seas Mike, may you rest in peace.

Contributions may be made in the memory of Mike Hill to the NTPS Flight Test Camp Fund in Mojave, CA or the Naval Air Museum at Patuxent River, MD.

Billy Jack "B.J." Long (M) was born on 28 February 1923 and passed away on 22 August 2014 at the age of 91.

B.J.'s flying career began at the age of 15 and includes experience in over 50 types of aircraft. He entered the Naval Aviation Cadet Program in 1943. Graduation from Pensacola was followed by operational training in OS2U Kingfishers. He then flew SC-1 Seahawks from the USS Santa Fe in the Southwest Pacific.

In 1954, B.J. returned to civilian life and pursued his education at the University of Tennessee, but remained an active pilot by flying in the Reserve at NAS Atlanta. In 1948, he was recalled to active duty and served in VU-5 at Quonset Point and VX-2 at NAS Chinocoteoque. He became active in drone operations as a control and chase pilot for the F6F-5K and the TD2C drones.

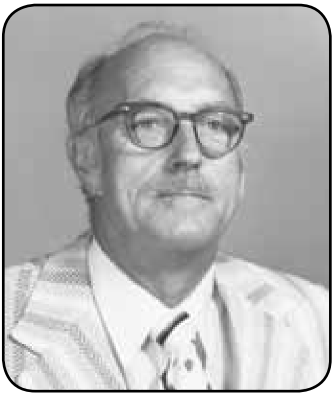
B.J. returned to the University of Tennessee in 1950 to complete his education, but was recalled to active duty again for the Korean conflict.

In 1953 he joined Convair in San Diego as a Flight Test Engineer, but maintained his flight proficiency in VF jet squadrons at NAS, Los Alamitos. His qualifications led him to a pilot position at Convair. He then became Project Pilot on the XF2Y Seadart. The culmination of this program came with the successful demonstrations of open sea landings and take-offs in 9 foot swells.

In 1956, B.J. attended the Navy Test Pilot School at Patuxent River and was then assigned to the Convair F-102A Engineering Flight Test Program at Edwards. He participated in the Convair 440 Certification Program and flew as co-pilot on the R3F Tradewind flying boat.

In 1957, B.J. gave up professional flying for a sales career with Fairchild, Sperry and Lear Siegler. He later became Assistant to the Vice President of Marketing at the Space Division of North American Rockwell Corporation. He also flew antique WWII aircraft at the Air Museum in Ontario.

B.J. is survived by his wife of 48 years, Wini, and children Susan, Steven, and Alan.



Maj Bissell Eugene ‘Mac” Mc Elyea (M) died on December 7, 2013. It seems very appropriate that a true American , as he was, should die on a day that lead him into the career of a lifetime.

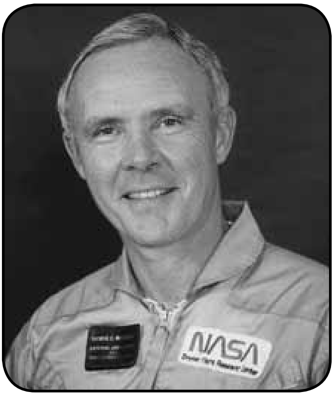
Bissell or Mac, to his friends, came from humble beginnings. He was born in Berryville, Arkansas on December 10, 1919 on the homestead that had originally belonged to his great aunt. He had to quit school at an early age to support his mother & siblings. He did manage to finish high school by going to a trade school.

He was one of the first draftees for WWII from Kansas City, Missouri. He was trained on various types of aircrafts from bombers to helicopters. He was an instructor in WWII. He retired from the Air Force and started a new career as a civilian working for the Army. He flew and tested helicopters for Raytheon.

His curiosity of flying took him on many adventures. One such story was when he was testing a helicopter out of Wright-Patterson Air Force Base. The rotor blades split in the hills of Kentucky, which brought out the locals. He duct taped them back together and flew back to base!

He knew a number of great pioneer pilots during his experimental test flying days. One of those was Chuck Yeager. He received many awards and citations during his long career, some of those came from his experiment test pilot days.

He loved people, but perhaps what he will best be remembered for is his ability to tell jokes and sing ditty’s.



Thomas C. McMurtry (F) made his last flight on January 3, 2015 of complications from a stroke. He was 79.

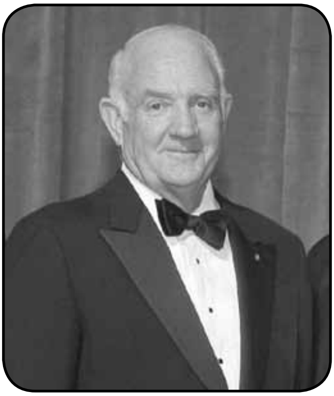
Tom was born on June 4, 1935 in Crawfordsville, Indiana. He is a graduate of Notre Dame University (1957) with a B.S. Degree in Mechanical Engineering. After college graduation, he entered the U. S. Navy. Upon completing flight training, he flew sea tours with A-3D Photographic and Heavy Attack squadrons in both land-based and carrier-based operations. Selected for test pilot training, Tom graduated from Navy Test Pilot School in 1964. He joined the Lockheed Aircraft Company in 1964 and participated in a classified flight program until 1967. He joined NASA in 1967 at the NASA Flight Research Center at Edwards AFB, CA. He participated as a project or co-project pilot on several major research/flight test programs, including the F8 Supercritical Wing Airplane, the F8 Digital Fly-by-Wire Airplane, the AD-1 Oblique Wing Airplane and the 747 Shuttle Carrier Airplane. He piloted the F8 Supercritical Wing Airplane on its first flight on March 9, 1971 and that of the AD-1 on December 21, 1979. He co-piloted the 747 Carrier Aircraft as it transported the Shuttle Enterprise to its first launch on August 12, 1977. In 1981 he was selected as Chief of the Flight Crew Branch and in 1985 became the Chief of the Research Aircraft Operations Division. He was Associate Director of Operations at NASA Dryden from July 1998 and also served as Dryden's acting Chief Engineer from February 1999 until his retirement after 32 years of service. He logged over 11,000 hours of flying time and flew many other aircraft including the U-2, X-24B, YF-12C, F-104, and F-15.

After retiring from NASA he flew for Wolfe Aire, where he piloted aircraft conducting aerial videography in the film industry and professional sporting events. He was nominated for a Screen Actors Guild Award for Transformers 3.

Tom joined SETP in 1968, served as SETP President in 1977/78 and became a Fellow in 1988. He received the Iven C. Kincheloe Award for his work with the AD-1 Oblique Wing Airplane Program in 1982 and in 1996 the President of the United States conferred on Tom the rank of Meritorious Executive in the Senior Executive Service for sustained superior accomplishment in management of programs of the United States government and for noteworthy achievement of quality and efficiency in the public service. He was awarded three NASA Exceptional Service Medals, and in 1999 was awarded the NASA Distinguished Service Medal. Tom was inducted into the Lancaster Aerospace Walk of Honor in 1998. On 25 October 2014 The Federal Aviation Administration Western Pacific Region presented Tom with the Wright Brothers Master Pilot Award, for the 50 year milestone of dedicated service in aviation safety, in recognition of the significance of Mr. McMurtry's achievements and contributions to aviation.

Throughout his life, Tom owned antique airplanes and enjoyed spending time with his family, especially through aviation and sports-related activities. He is survived by his loving wife of 47 years, Mary Louise Endres, eight children, nine grandchildren, and his brother George and wife Margaret.

In lieu of flowers, please consider donating to the Carmelite Sisters of Alhambra on line at http://www.carmelitesistersocd.com/gifts-in-memoriam/ or by mail to Carmelite Sisters of the Most Sacred Heart of Los Angeles, ATTN: Gifts in Memoriam, 920 E. Alhambra Rd., Alhambra, CA 91801 or to Father Serra Parish, 42121 60th Street West, Quartz Hill, CA.



Col David W. Milam, USAF (Ret) (F) a Fellow of the Society and past Chairman of the Great Lakes Section, has had his last flight; he passed away on Thursday, September 11.

Dave grew up in Pueblo, Colorado and graduated from the US Air Force Academy in 1963 with a BS Degree in Aeronautical Engineering. He graduated from Pilot Training in Class 65B and checked out in the F-100 Super Saber. After 3 years at RAF Lakenheath, he flew 176 combat missions in the F-100 from Ben Hoa South Viet Nam. He earned an MS Degree in Aeronautical Engineering in 1973 from the University of Arizona before being assigned as an instructor in Aerodynamics and Fluid Mechanics at West Point.

He graduated from the USAF Test Pilot School in Class 73. He was then assigned to Test Operations at Edwards AFB where his duties included the project pilot on the A-7 DIGITAC Fly-by-Wire program and program manager for the F4E Austere HUD. He developed a keen interest in aircraft handling qualities and flight control system development. He applied this interest to optimizing the F4E Lead Computing Optical Sight (LCOS) and the F4E Historic Tracer gun sight. The result was a vastly improved air-to-air gunnery system. Colonel Milam then joined the TPS staff as a specialist in flight control theory and aircraft handling qualities. In 1978, he reported to the F-16 CTF where he led the High Angle-of-Attack program. This flight control program involved resistance to departure, recovery from "deep stalls" and the design of unique mission related limiters. He also developed and taught a unique High AOA characteristics and recovery techniques course for operational pilots. David was instrumental in incorporating improvements to the F-16 gun sight that resulted in vastly improved accuracy for F-16 A/A gunnery. David also led a flight control law improvement program to improve the F-16 handling qualities in the power approach configuration. Colonel Milam's talents made him the ideal pilot to lead the F-16 Advanced Fighter Technology Integration (AFTI) basic Research program. The AFTI program demonstrated the blending of a new flight control computer, new control laws, aircraft sensors, and new control surfaces to improve fighter aircraft performance.

After a tour in the Pentagon in Classified Programs in RDQ, Colonel Milam joined the B-1 System Program Office at Wright-Patterson as the Deputy Director. In this position he was instrumental in the redesign of the B-1 flight control system and the defensive electronic warfare system. He retired from the USAF in 1993 as the Chief of Staff for the Aeronautical Systems Center.

He then became President and CEO of the Wright Technology Network, a technology transfer company working with the Aeronautical Research Laboratory to transfer new technology to private industry. He has been instrumental in High Performance Computer Program introducing new Super Computers to the USAF.

Colonel Milam held the Legion of Merit with 2 OLC, the Distinguished Flying Cross, 8 Air Medals and the Bronze Star. He had over 3000 hours of flying time in 60 types of aircraft. While at Wright-Patterson he helped to establish the Great Lakes Chapter of SETP, and was its first Chairman.

Dave dearly loved God, his family and his country. Dave is survived by his wife Donna, daughter Julie (Sayer), son David Jr, granddaughter (Ceana), brother, Jack (Jodie), mother-in-law Bernadette, many sisters and brothers-in-law, nieces, nephews and cousins. Dave was active in Boy Scout Troop 516, the Centerville Noon Optimist Club, and board member of the Mound Street Academy.

In lieu of flowers, donations can be made to Noon Optimist Club of Centerville, P.O. Box 750492, Centerville, OH 45475-0492. Online condolences may be sent to www.tobiasfuneralhome.com.

Col Steven R. Nagel, USAF (Ret), NASA Astronaut, (M) made his last flight on 21 August. He was 67.

Nagel graduated from Canton Senior High School, Canton, Illinois, in 1964; received a Bachelor of Science Degree in Aerospace Engineering (high honors) from the University of Illinois in 1969 and a Master of Science Degree in Mechanical Engineering from California State University, Fresno, California, in 1978.

Nagel received his commission in 1969 through the Air Force Reserve Officer Training Corps (AFROTC) program at the University of Illinois. He completed undergraduate pilot training at Laredo Air Force Base, Texas, in February 1970, and subsequently reported to Luke Air Force Base, Arizona, for F-100 training.

From October 1970 to July 1971, Nagel was an F-100 pilot with the 68th Tactical Fighter Squadron at England Air Force Base, Louisiana. He served a one-year tour of duty as a T-28 instructor for the Laotian Air Force at Udorn RTAFB, Udorn, Thailand, prior to returning to the United States in October 1972 to assume A-7D instructor pilot and flight examiner duties at England Air Force Base, Louisiana. Nagel attended the U.S. Air Force Test Pilot School at Edwards Air Force Base, California, from February to December 1975. In January 1976, he was assigned to the 6512th Test Squadron located at Edwards. As a test pilot, he worked on various projects, including flying the F-4 and A-7D.

Colonel Nagel logged 12,600 hours flying time; 9,640 hours in jet aircraft.

Nagel became a NASA astronaut in August 1979. His technical assignments included backup T 38 chase pilot for STS-1; support crew and backup entry Spacecraft Communicator (CAPCOM) for STS-2; support crew and primary entry CAPCOM for STS-3; software verification at the Shuttle Avionics Integration Laboratory (SAIL) and the Flight Simulation Laboratory (FSL); representative of the Astronaut Office in the development of a crew escape system for the space shuttle and Acting Chief of the Astronaut Office. Nagel is a veteran of four space flights (STS-51G and STS-61 in 1985, STS-37 in 1991 and STS-55 in 1993).

Nagel first flew as a mission specialist on STS-51G, which launched from the Kennedy Space Center, Florida, on June 17, 1985. The crew aboard the Space Shuttle Discovery deployed communications satellites for Mexico (Morelos), the Arab League (Arabsat) and the United States (AT&T Telstar). They used the Remote Manipulator System (RMS) to deploy and later retrieve the SPARTAN satellite, which performed 17 hours of X-ray astronomy experiments while separated from the space shuttle. In addition, the crew activated the Automated Directional Solidification Furnace (ADSF) and six "Getaway Specials," participated in biomedical experiments and conducted a laser tracking experiment as part of the Strategic Defense Initiative. After completing approximately 170 hours of space flight, Discovery landed at Edwards Air Force Base, California, on June 24, 1985.

Nagel then flew as pilot on STS-61A, the West German D-1 Spacelab mission, which launched from Kennedy Space Center, Florida, on October 30, 1985. This mission was the first in which payload activities were controlled from outside the United States. More than 75 scientific experiments were completed in the areas of physiological sciences, materials processing, biology and navigation. After completing 111 orbits of Earth, Space Shuttle Challenger landed at Edwards Air Force Base, California, on November 6, 1985.

On his third flight, Nagel was commander of STS-37, which launched into orbit on April 5, 1991, from Kennedy Space Center, Florida, and landed on April 11, 1991, at Edwards Air Force Base, California. During this mission, the crew aboard the Space Shuttle Atlantis deployed the Gamma Ray Observatory (GRO) for the purpose of exploring gamma ray sources throughout the universe and conducted the first scheduled spacewalk in more than 5.5 years. Also, the crew performed the first successful unscheduled spacewalk to free a stuck antenna on GRO.

Nagel also served as commander of STS-55, the German D-2 Spacelab mission. After launching on April 26, 1993, on the Shuttle Columbia, the crew landed 10 days later on May 6, 1993, at Edwards Air Force Base, California. During the ambitious mission, 89 experiments were performed in many disciplines, such as materials processing, life sciences, robotics, technology, astronomy and Earth mapping.

With the completion of his fourth flight, Nagel logged a total of 723 hours in space.

Nagel retired from the Air Force effective February 28, 1995. He retired from the Astronaut Office effective March 1, 1995, to assume the full-time position of deputy director for operations development, Safety, Reliability, and Quality Assurance Office, Johnson Space Center, Houston, Texas. In September 1996, Nagel transferred to the Aircraft Operations Division where he performed duties as a research pilot, chief of aviation safety and deputy division chief. He retired from NASA on May 31, 2011.

He is survived by his wife, Linda, and two daughters, Lauren and Whitney.

Donations may be made to:

National Patient Travel Center (Provides charitable long-distance medical transportation for patients)
patienttravel.org

Child Fund (Steve has sponsored a child there for many years)
childfund.org

Memorial Baptist church (Columbia MO – Steve's church)
memorialbaptist.org

James McCurdy Patton, Jr (F). I've had such a great life that I decided to skip a step and write my own obituary. Born in Lockhart, Texas in 1927, I pursued a lifelong dream of flight, first just dreaming, then doing, first in high school when I learned to fly, then as a U.S. Naval aviator for 6 years (including day and night flying from carriers – the best and most challenging flying I ever did). Then it was back to school to earn an Aeronautical Engineering degree in 1956 from the University of Colorado. During this period I flew fighters as a Weekend Warrior in the U.S. Naval Reserve for 11 years. From 1956, I had a long and happy 46-year career in flight testing: 2 years as Flight Test Engineer at Vaught Aircraft, 8 years as Flight Test Pilot in the Federal Aviation Agency (during which time I attended and graduated from the U.S. Naval Test Pilot School), 21 years as a NASA Research Pilot, Chief Test Pilot and Head of Flight Operations at the NASA Langley Research Center, Hampton, Virginia, and then after I retired from NASA, 15 years as an independent test pilot, testing experimental airplanes, finally hanging it up in 2002. Throughout, I flew more than 9,000 hours in piloting 157 types of aircraft, including fighters, transports, helicopters, and many experimental craft, and became an internationally-recognized expert in spins and high angle-of-attack flight. An elected Fellow of the Society of Experimental Test Pilots (SETP) in 1980, I received many awards, including the Iven C. Kincheloe Award in 1978 from the SETP for outstanding accomplishment in flight testing, and from NASA their Exceptional Service medal in 1979, for outstanding service and contribution as an engineer/test pilot. In 2009 I was inducted to the Virginia Aviation Hall of Fame.

I was equally fortunate in my personal life. During Naval flight training, I was a roommate for a time with Cleo Swartz. After we got our wings we were both stationed in the Norfolk, Virginia area. On weekends, we'd drive to Philadelphia in my trusty '41 Chevy to visit his parents and his kid sister Marcie, who was very pretty, but at 17 and a buddy's sister, off limits. Well, things changed, Five years later, we were married (in 1954). It took. In all this time, she's been my love and the best friend I've ever had. We were blessed with three wonderful girls and two fine grandsons, Kathi (son Brendan), Dana (son Christopher) and Ellen. In accepting the Kincheloe Award from the Society of Experimental Test Pilots, the professional recognition I prized above all other, I gave Marcie credit for her willingness to endure long separations and many household moves so I could follow my dream with airplanes while she played a major role in raising our 3 lovely girls and keeping the household together.

In many ways Marcie made me a better person. During our time in Virginia she was active in volunteer activities. After NASA retirement, I began following her lead, into Meals on Wheels and Hospice volunteer work (patient care).

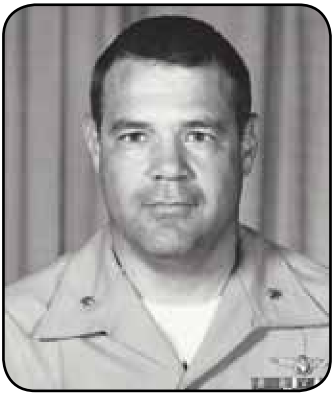
My parents, James M. Patton and Nan L. Patton, went before me. I am survived by Marcie our girls our two grandsons and my beloved sister Nancy Patton Wilson.

I did my share of screw-ups, but I couldn't have asked for a happier life. I was a dreamer but it was much more than I have ever dreamed of or had the temerity to wish for. This being an obituary, if you knew me and cared, raise a glass. It's really a celebration, and I've departed a winner. - Jim Patton

Col Thomas M. Sumner, USAF (Ret) (M), was born on 29 October 1922 and passed away on 18 May 2014 at the age of 91 in Honolulu, Hawaii.

Tom was born in Louisville, KY where he attended the University of Louisville and received a BSEE degree in Electrical Engineering in 1948. He graduated from the U.S. Air Force Test Pilot School in 1954 and joined USAF ARDC WADC Bomber Operations Directorate of Flight Test as an experimental test pilot. In 1964 he became Chief, Flight Crew Operations Division at USAF AFSC SSD Manned Orbiting Laboratory SPO. Tom served as 6594th Test Group Commander at Hickham AFB, Honolulu, HI, and Space Shuttle Director. During his career he conducted flight tests on many aircraft including the B-17, B-26, B-25, B-29, B-36, B-45, B-47, B-50, B-52, B-57 and B-66.

Tom is survived by his son Timothy, daughter Sheryl Zen Ruffinen, five grandchildren and five great-grandchildren.



Col John Townsend Tyler, USMC (Ret) (M) was born on 26 February 1932 and passed away at 82 years old in his home with family and friends on 9 June 2014.

John was born in New York City, N.Y. and lived with his sister, Wanda, and his parents, Al and Ruth, moving to Swarthmore, PA for high school where he first met his wife, Alice DeCaindry Tyler. He graduated from the United States Naval Academy in Annapolis in 1955 and married Alice in 1958, a bond surviving 53 years and countless moves and new assignments while serving the Marines, until her passing in 2011.

John was a dedicated US Marine, proudly serving more than 35 years as a naval aviator and an officer before retiring from active duty in 1985. One of his proudest achievements as an aviator and officer included being the commanding officer of the VMA-231 squadron deploying AV-8A Harriers from an aircraft carrier. He carried out flight testing on various aircraft including the F-4, F-4A, F-4B, F-4G, F-1E, AF-1E, A-4, A-7 and S-2E.

John is survived by his children, Matthew McClain Tyler and his wife, Kerstin, and their two children in Germany, and John Benjamin Tyler and his wife, Kathy, and their four children in Arizona.

Donations in his memory be sent to Covenant Hospice, 107 West 19th Street, Panama City, Florida 32405 or The Science and Discovery Center of North West Florida, 308 Airport Road, Panama City.

LTC Donald L. Underwood, US Army (Ret) (AF) took his last flight on 18 October 2014 in Spring Lake, MI. Don was born to Vernon Lee and Margaret Underwood on 11 June 1946 in Hickory, NC. He had fought long and hard for over a year battling pancreatic cancer with great courage, faith and dignity. Don's life was filled with enormous accomplishments both in his military career and his second career with industry.

Don attended the University of Southern California pursuing a degree in Industrial Engineering prior to entering the US Army. He attended Rotary Wing flight school and became a Warrant Officer upon completion of his training in 1968. As with most flight school graduates during this timeframe. Don was sent to Viet Nam where he flew Medevac missions with the 283rd Medical Detachment/ Air Ambulance (Dust Off) in the UH-1 helicopter. On one fateful day, while attempting to evacuate wounded soldiers from a mountain top fire base, his helicopter was hit by heavy enemy fire resulting in loss of aircraft control and subsequent crash. He and the second pilot (his Commander) were both severely injured. WO Underwood was evacuated to the 71st Evacuation Hospital in Japan where he quickly recovered and was back in his combat unit in only a month's time. Dust Off 61 completed a year-long combat tour in spite of his injuries. Don's second Viet Nam tour (1971) was far less stressful in that he was now flying fixed wing aircraft in the Command Airplane Company (CAC).

In 1971 Don accepted a commission as a 2LT in the Air Defense Artillery branch of the US Army where he commanded a Hawk Missile Battery and served as assistant Battalion Operations Officer. Don completed his BS in Industrial Engineering while in the Army and returned to USC in 1976 to earn a Master's Degree in Operations Research Systems Analysis. Don graduated from the US Naval Test Pilot School in 1980, class 78. His next four years saw him working as an experimental test pilot and Integrated Systems Division Chief in the US Army Aviation Engineering Flight Activity (AEFA) at Edwards AFB, CA. The project for whom Don is most famous was a flight test of the Williams Aerial Surveillance Platform (WASP). The vehicle was essentially a cruise missile engine mounted vertically and stabilized only by the pilot shifting his weight. He was one of only two uniformed service members to achieve sufficient proficiency to operate the WASP in free flight. After graduation from the Air Command and Staff College in 1985, Don returned to AEFA as the Director of Fight Test and Deputy Commander. He accrued over 3700 flight hours in 35 models of 24 different types of aircraft.

Don retired from the Army in 1989. His military awards and decorations include: Purple Heart, Legion of Merit, Meritorious Service Medal (2nd award), Air Medal (17th award), Army Commendation Medal (3rd award), National Defense Service Medal, Viet Nam Service Medal, Army Service Medal, Overseas Service Medal, Republic of Viet Nam Campaign Medal, Republic of Viet Nam Gallantry Cross Unit Citation (with palm), and Master Army Aviator Wings.

Don's career did not end following military service. He continued to work in the research and development field on advanced aircraft and ground combat vehicle systems concept design, development and multi-disciplinary integration of electronics, software, hybrid-electric technologies and advanced energy management systems for military and industrial markets. He held numerous program leadership positions. Initially with the McDonnell Douglas Helicopter Company as the Long Bow Apache Program Manager for Test and Evaluation. Later as Director, Airborne Programs at Litton Guidance and Controls, then Director, Advanced Concepts for the DRS Technologies Incorporated, and also in a number of positions with L-3 Communications Combat Propulsion Systems culminating as Vice President of Engineering. Don kept close to the technical world he so loved by establishing X-Winged Consulting, LLC.

A strong supporter of SETP, Don served on the Membership Committee for six years and presented papers at several technical symposia. He was presented the Fairchild Award, now called the Jack Northrop Award, at the 16th San Diego Symposium for best paper.

Don is survived by his wife Becky, his son Christopher Underwood, daughter Kelly Underwood, sister Drenda Randell, step children Kristin Fisch, Jennifer Hayter, Ben Dewitt, Jeff Dewitt, Abby Moulatsiotis, and six grandchildren.

Donations may be made in Don’s memory to the charity he strongly supported, the Central Indiana Teen Challenge, CITC, PO Box 564, Lebanon, IN 46052.

The Society of Experimental Test Pilots
P.O. Box 986
Lancaster, CA 93584-0986

SETP CORPORATE MEMBERS

Advanced Training Systems International
Aerospace Services International
AeroTEC
Air Force Test Pilot School (India)
Airborne Systems Group
Airbus SAS
ALCAT, Inc.
Alenia Aeronautica S.p.A.
Aviation Partners, Inc.
Bechtel National, Inc.
Bell Helicopter - A Textron Company
Butler Parachute Systems, Inc.
Calspan Corporation
Clay Lacy Aviation
Cruz Associates, Inc.
David Clark Company Incorporated
DCS Corporation
Denmar Technical Services
EADS Deutschland GmbH
ETPS
eXAQT Consultant Group
ForeFeathers Enterprises
FXC Corporation
GE Aviation
General Atomics Aeronautical Systems, Inc.
Gentex Corporation
Gulfstream Aerospace Corporation
Honda Aircraft Company
Honeywell Aerospace Flight Test Operations
International Test Pilot School Canada Ltd.
IPEV - Flight Test and Research Institute
JT3, LLC
Krings Corporation
Lockheed Martin Corporation
Marinvent Corporation
Martin-Baker Aircraft Company Ltd.
MIT Lincoln Laboratory
Modern Technology Solutions, Inc.
Mojave Air and Space Port
National Aerospace Laboratory NLR
National Test Pilot School
Northrop Grumman Corporation
Raisbeck Engineering, Inc.
Saab Aeronautics
Safe Flight Instrument Corporation
Sage Cheshire, Inc.
Scaled Composites, LLC
Sikorsky Aircraft Corporation
Software Engineering Institute
Sunshine Aero Industries, Inc.
Symbolic Displays, Incorporated
Test Flying Academy of South Africa (TFASA)
Textron Aviation
Thales VISIONIX, Inc.
The Boeing Company
The Johns Hopkins Univ./APL
The Spaceship Company, LLC
Thornton Corporation
Tiger Century Aircraft, Inc.
Universal Avionics Systems Corp.
Virgin Galactic, LLC
Wyle
XCOR Aerospace