Test Plan for Rotorcraft Precision Visual Flight Rules (PVFR)

Simultaneous Non-Interfering (SNI) Human Factors Project

Prepared for

Federal Aviation Administration (FAA)

Human Factors Division (AAR-100) and

General Aviation and Vertical Flight Office (AAR-432)

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May 2003 Revision 1.3

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BACKGROUND

The concept of Precision Visual Flight Rules (PVFR) and Simultaneous Non-Interfering (SNI) Routes for rotorcraft is based on the hypothesis that rotorcraft with Global Positioning System (GPS) navigation capabilities can stay within narrow, defined horizontal airspace limits while operating under Visual Flight Rules (VFR). If the pilot maintains the aircraft within the confines of a PVFR route and if these routes can be designed to keep rotorcraft separated from fixed-wing traffic then PVFR routes offer rotorcraft the possibility of operating in congested airspace simultaneously with fixed-wing aircraft on a non-interfering basis, hence the term SNI operation.

Both helicopter operators and air traffic service providers at busy terminal areas recognize a need for PVFR routes and SNI operations. However, at present there are no standards or flight test data that address issues of the width of PVFR routes or the ability of pilots to follow GPS routes while performing the tasks necessary to operate their aircraft under VFR. While GPS use during VFR operations is common practice in the NAS, the required use of GPS on VFR routes to keep an aircraft within defined airspace has not been validated.

The objective of this project is to evaluate the ability of GPS to provide lateral guidance for helicopters flying on a PVFR route while using barometric altitude for vertical guidance. A secondary objective is to develop and demonstrate PVFR routes and ATC procedures that use GPS to enhance the helicopter pilot's ability to navigate more efficiently in the National Airspace System (NAS). The results of this research and development will be used by the Federal Aviation Administration (FAA) to determine airspace requirements, air traffic control procedures, and pilot operational and training considerations.

The rotorcraft industry and FAA recognize that significant benefits are available from PVFR routes and SNI operations. FAA Flight Standards, Flight Operations Branch (AFS-410) conducted an investigation in the summer of 2000 to identify needs of the rotorcraft industry for operating in the National Airspace System (NAS). This investigation included visits to California, Texas, and Louisiana, to meet with representatives of the rotorcraft industry to learn of their need for operating in the NAS. An important element of this investigation was to understand the operational benefits that can be achieved through increased use of the Global Positioning System (GPS) by helicopter operators. AFS-410 personnel visited four Emergency Medical Services (EMS) operators, two flight schools, three helicopter manufacturers, one electronic news gathering operator, four offshore [oil and gas] operators, FAA's Rotorcraft Directorate-Aircraft Certification Service, the Dallas Vertiport, and the Helicopter Safety Advisory Council (HSAC). The results of FAA's study were reported by AFS-410 to the Vertical Flight Satellite Operations Implementation Team (VFSOIT) and published in their Vertical Flight Satellite Navigation (SATNAV) Concept of Operations (CONOPS), from which the following quotes are taken:

> "Future changes to the NAS must integrate instrument flight rules (IFR) and VFR Satellite Navigation (SATNAV) vertical flight procedures into everyday operations to accommodate user needs and help mitigate some of today's operational and capacity problems. Helicopters are often given unsuitable delays or circuitous routing to avoid fixed-wing air traffic, often making IFR flight an unsuitable option. Given the unique flight characteristics of helicopter operations, varied differences in speed from fixed-wing aircraft, limited fuel endurance, and high hourly operating cost, it is imperative that

SATNAV procedures be developed that encourage efficient use of airports and airspace, and complement user needs with increased air traffic support."

"A vast majority of helicopter operations are conducted VFR. A portion of the fleet is well equipped with navigation equipment but the airframe is not certified for IFR flight. Operators who use GPS as an aid to VFR navigation may obtain significant advantages' *[with PVFR-SNI]*. 'This use of GPS can increase efficiency and safety. In the future, helicopter access to certain airspace may be dependent on the use of Global Navigation Satellite Systems (GNSS) based VFR navigation using IFR type of GPS units in an aircraft certified for VFR operations only."

TEST METHODOLOGY

The FAA has determined that PVFR route width and human factors assessment will be performed through a combination of flight test and simulation methods. The flight test environment allows evaluation of PVFR flights in realistic situations encountered by pilots operating their aircraft while using GPS navigation. Real-time piloted simulation allows evaluation of a number of human factors issues related to using the GPS navigation system while operating other aircraft systems. Simulation provides an environment whereby weather and operational circumstances can be assessed in controlled situations that cannot be duplicated (or are too expensive to duplicate) in the flight test environment.

A key element of the test methodology is to provide means to correlate results of the flight-testing and the simulation. This allows simulation to support areas that were not adequately addressed by flight-testing and vice versa. Agreement between the flight-testing and simulation results will significantly expand the range of validity of the overall assessment of PVFR routes.

ROLES AND RESPONSIBILITIES

The flight-test evaluation is the responsibility of Satellite Technology Implementation, LLC (STI) of Orange Beach, AL. STI will be supported by the University of Tennessee Space Institute (UTSI) to provide a test helicopter, maintenance support, safety pilot, and technical assistance.

The simulation evaluation is the responsibility of the Naval Postgraduate School (NPS) in Monterey, CA. NPS is being supported by the National Aeronautics and Space Administration (NASA), Ames Research Center at Moffett Field, CA. NASA Ames is providing a head and eye tracking system that will be used in both the flight test and simulation portions of the testing.

Overall test coordination and technical direction for the PVFR route evaluation project is provided by FAA Human Factors Division (AAR-100) located at FAA Headquarters in Washington, DC and FAA General Aviation and Vertical Flight Office (AAR-432) located at the William J. Hughes Technical Center, Atlantic City, NJ. AAR-100 and AAR-432 are supported by the FAA's Flight Technologies and Procedures Division (AFS-400), the sponsoring organization for the project.

PURPOSE

Potentially, PVFR routes and SNI operations can be applied to enhance VFR helicopter operations in the NAS. Specific operations that may be enhanced include helicopter transitions through control zones and flights through mountain passes. The flight tests are intended to assess the flight technical error (FTE), navigation system error (NSE), total system error (TSE), and human factors associated with operating GPS-equipped helicopters during typical PVFR/SNI operations. These system error and human factors assessments will be used by the FAA to develop policy, criteria and guidance to support implementation of PVFR/SNI operations in the NAS.

This plan, as currently configured, describes the flight test portion of the PVFR route assessment. It identifies areas of coordination and information transfer to the simulation test portion of the PVFR route assessment project. The simulation portion of the PVFR route assessment is the responsibility of NPS, but will be coordinated with this Test Plan between STI and NPS.

HELICOPTER AND AVIONICS REQUIREMENTS

A number of factors must be considered in the selection of the flight test aircraft:

1. Flight test aircraft must be representative of helicopters performing PVFR en route flight operations,
2. Subject pilots should be familiar with the basic operation of the test aircraft to eliminate potential human factors issues associated with operation of an unfamiliar aircraft,
3. Results of flight test and simulation must be compared and correlated under controlled test conditions. Use of a single aircraft for the flight test and a single aircraft model for the simulation facilitates a controlled test environment, and
4. Flight test aircraft must be capable of carrying test personnel and equipment needed to perform all flight operations and collect all flight test data required to meet the test objectives.

Based on these factors, STI has selected the Bell 206 Jet Ranger/Army OH-58/Navy TH-57 type helicopter as the aircraft for the flight test portion of the PVFR/SNI assessment. STI has contracted with UTSI to use their Bell OH-58A+ model helicopter as the test aircraft. Specifications for the OH-58A are presented in Appendix A. Use of this helicopter clearly addresses a number of the factors identified above. The Bell 206 is a very popular VFR aircraft for civil use, the OH-58 is widely used by the Army, and Navy pilots perform basic flight training on the TH-57. This means that factors 1, 2, and 3 are addressed by use of the OH-58. This type of helicopter is large enough to carry all test personnel and test equipment, which addresses factor 4. Therefore the OH-58 meets all the basic requirements for the flight test aircraft.

The test helicopter will be equipped with a GPS receiver that is certified to meet the standards of the FAA’s Technical Standard Order (TSO) C129 Class A1. UTSI is installing a Bendix-King Model KLN89B, a panel-mounted TSO’ed GPS receiver, in the OH-58A test aircraft. Details of the KLN89B are presented in Appendix B.

The TSO C129 Class A1 receivers have different course deviation indicator (CDI) sensitivity levels depending on the flight domain. For en route operations the full-scale CDI sensitivity is ±5.0 nautical miles (NM); for terminal operations (within 30 NM of the airport/heliport) the full-scale CDI sensitivity is ±1.0 NM. It is believed that the more sensitive CDI (±1.0 NM full-scale) will produce smaller system errors and narrower route widths. Therefore the more sensitive CDI scale factor will be used for the PVFR test.

In normal en route operation, the GPS receiver operates at the low sensitivity level (±5.0 NM full-scale CDI deflection). In order to have the test GPS receiver operate at the increased sensitivity level, the aircraft must be within 30 NM of the destination airport/heliport, the active GPS route must have coded GPS waypoints, the route must terminate in a coded GPS approach at the destination, and the GPS receiver must be armed for the approach mode. These factors will be addressed during the route development and shakedown testing tasks.

AIRCREW REQUIREMENTS

Testing will be completed using up to 10 subject pilots. Pilots will be a mix of VFR- and IFR-rated pilots with a target of 5 VFR and 5 IFR rated pilots. This mix of pilots is representative of the population of licensed helicopter pilots 'at large'. Some subject pilots (a target of 2) will be selected from Navy instructor pilots that will later be available to participate in the PVFR route evaluation simulation tests at NPS. Other subject pilots (civilian pilots from industry) may be invited to participate in the simulation tests as well. The use of Navy pilots (and civilian pilots, if available) will provide a subset of subject pilots for correlation of the flight-testing and simulation results.

A safety pilot (project pilot) will be supplied by UTSI. The safety pilot will be designated pilot-in-command (PIC) for the evaluation flights and be responsible for the safe operation of the aircraft.

An STI flight test engineer/observer will act as mission director, operate the data recording systems, and maintain a written flight log.

In order to correlate flight test and simulation results, each subject pilot will be required to wear a head-mounted head and eye tracker during some or all of the test flights. Pilots will be given instruction on the use of the head and eye tracker. The head and eye tracker has been designed to be unobtrusive to the subject pilot. It involves wearing of a sports headband and eye shield with two miniature video cameras attached. Any difficulties with the use of this equipment that are identified by the subject pilot or detected by the safety pilot and/or flight test engineer/observer will be noted in the flight logs for later analysis.

PVFR ROUTE REQUIREMENTS

STI has designed a PVFR route to be used in the flight-testing. This route is representative of VFR routes found in use in the NAS. The route represents a full range of operational conditions, which include:

- Test area criteria
  - Area contains terrain and obstacles consistent with that which would be found in a VFR route environment
  - Area is near an airport or heliport where the aircraft can be supported logistically
  - Fuel and light maintenance services are available
  - Facilities are available to house the crew and test personnel
  - Facilities are available to support the data collection personnel.
- Flight times – Day and night operations will be tested (approximate 70/30 percent ratio)
- Altitude – altitude for route segments will be at least 500 feet above the surface in areas that are not congested; en route altitude changes (step-up and step-down waypoints) will be evaluated; pilots will be expected to see and avoid manmade obstructions and other aircraft

along the route segment; all routes and flights will comply with Paragraph 91.119 of the Federal Aviation Regulations (FARs), which defines minimum safe altitudes for fixed-wing and helicopter operations.

- Waypoints – VFR waypoints[1] will be identifiable by terrain or manmade features during day and night operations; waypoints will be connected by straight segments so routes can be defined by overlaying GPS waypoints on the VFR waypoints.
- Route Segments – Route segments are representative of typical VFR route segments. In addition, the entire route is representative of a typical VFR flight.
- Test Conditions/Events – Lengths of route segments and magnitudes of turn angles are representative of those found on typical VFR routes.
- ATC environment – The test route includes a simulated restricted area around Arnold Engineering Development Center (AEDC) (about 8 NM east of Tullahoma) and designed with waypoints and ground features to be used by the pilot to circumnavigate the simulated restricted area.

The flight test area is the region located around Tullahoma, TN Regional Airport (THA), the home airfield of the test aircraft. A map of the test area and Final Draft PVFR route is shown in Figure 1. A table containing the list of waypoints, waypoint coordinates, segment lengths, segment true bearings, and turn angles at the waypoints is presented in Table 1.

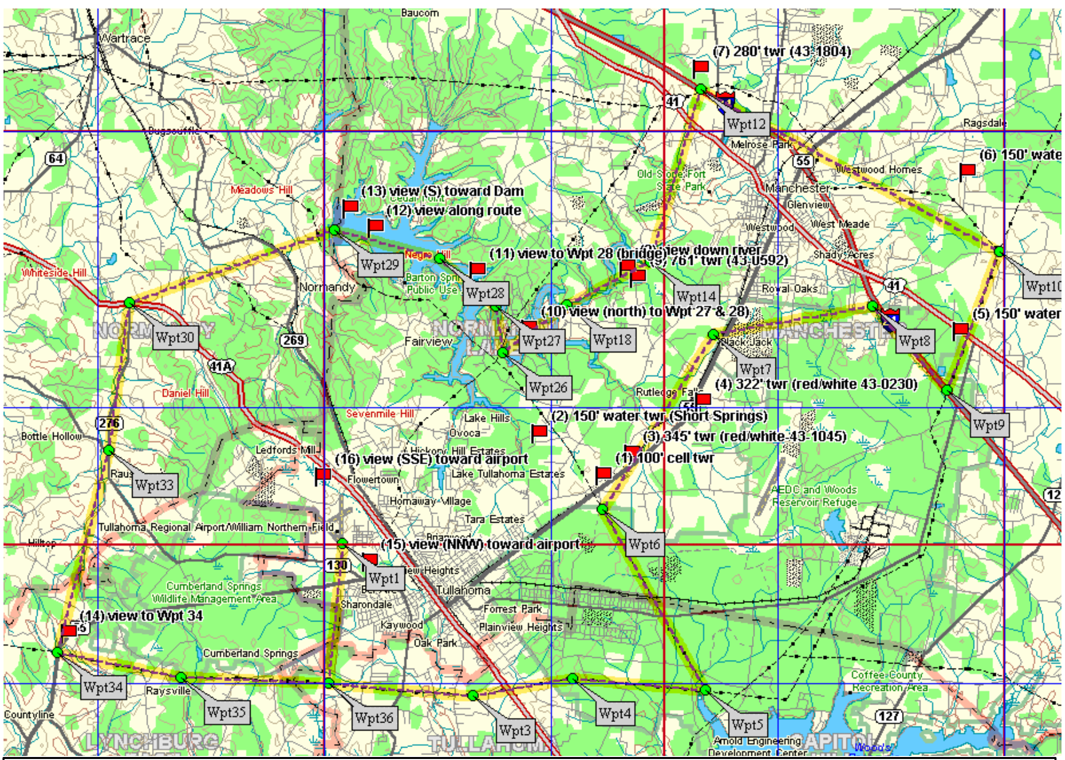


Figure 1 PVFR Test Route (Final Draft)

[1] For purposes of this test, a VFR waypoint is defined as a natural or manmade feature, recognizable to the pilot, which marks the intended path of the aircraft. A GPS waypoint is defined by latitude and longitude coordinates that can be entered manually or automatically in a GPS receiver to define the intended path of the aircraft through electronic means. A GPS waypoint that overlies a VFR waypoint indicates that the latitude/longitude coordinates of the terrain feature are used to define the GPS waypoint coordinates.

Table 1 PVFR Route and Waypoint Characteristics

From	To	Distance (NM)	Bearing (Degrees)	Turn (Degrees)	Condition/ Event	Waypoint Coordinates (D.M.M.)		
Wpt1	Wpt2	2.6	186			Wpt1	N35° 22.525'	W86° 14.594'
Wpt2	Wpt3	2.6	95	91	3	Wpt2	N35° 19.992'	W86° 14.904'
Wpt3	Wpt4	1.8	80	15	1	Wpt3	N35° 19.762'	W86° 11.717'
Wpt4	Wpt5	2.4	95	15	1	Wpt4	N35° 20.082'	W86° 9.514'
Wpt5	Wpt6	3.8	330	125	4	Wpt5	N35° 19.870'	W86° 6.588'
Wpt6	Wpt7	3.8	32	62	3	Wpt6	N35° 23.141'	W86° 8.863'
Wpt7	Wpt8	2.9	80	48	2	Wpt7	N35° 26.328'	W86° 6.415'
Wpt8	Wpt9	2.0	139	59	2	Wpt8	N35° 26.833'	W86° 2.893'
Wpt9	Wpt10	2.7	20	118	4	Wpt9	N35° 25.309'	W86° 1.262'
Wpt10	Wpt12	6.1	299	82	3	Wpt10	N35° 27.822'	W86° 0.111'
Wpt12	Wpt14	3.3	196	103	4	Wpt12	N35° 30.760'	W86° 6.705'
Wpt14	Wpt18	1.7	242	46	2	Wpt14	N35° 27.647'	W86° 7.816'
Wpt18	Wpt26	1.4	233	9	1	Wpt18	N35° 26.848'	W86° 9.662'
Wpt26	Wpt27	0.8	352	119	4	Wpt26	N35° 25.999'	W86° 11.065'
Wpt27	Wpt28	1.3	311	42	2	Wpt27	N35° 26.830'	W86° 11.208'
Wpt28	Wpt29	2.0	285	25	1	Wpt28	N35° 27.701'	W86° 12.459'
Wpt29	Wpt30	3.9	250	35	2	Wpt29	N35° 28.211'	W86° 14.780'
Wpt30	Wpt33	2.7	188	63	3	Wpt30	N35° 26.894'	W86° 19.309'
Wpt33	Wpt34	3.8	194	6	1	Wpt33	N35° 24.217'	W86° 19.760'
Wpt35	Wpt36	2.7	93	9	1	Wpt35	N35° 20.110'	W86° 18.169'
Wpt36	Wpt1	2.6	6	87	3	Wpt36	N35° 19.992'	W86° 14.904'
Total Distance		59.1						

The Tullahoma area allows testing of the PVFR/SNI concept in a feature-rich region where PVFR routes could potentially be used to navigate through valley areas. Features found along the test route include highways, cell and water towers, power lines, bridges, a river, a lake, a dam, a factory complex, and a power plant. The topology in the area varies from flat plains to forest-covered hills. The test area also has populated areas [the towns of Tullahoma (population 18,000) and Manchester (population 8,300)], villages, and rural areas.

The initial design of the PVFR route was undertaken during a trip to Tullahoma by the STI project manager. During the trip, the STI project manager first conducted a map study to locate desirable features and topography representative of typical VFR routes, and then flew the route to verify and identify the visual features appropriate to the PVFR evaluation. The flight track was recorded using STI's Airspace Engineering Software (AES) Tools©. During the post-flight analysis, an initial PVFR route was created using the recorded flight and digital photos taken during the flight, and the initial preliminary PVFR route was completed. Some segments of the initial-preliminary route were designed to follow the Duck River as closely as possible for several miles. Because the river system has many turns, the route had many short segments. This initial preliminary route was later evaluated by STI for flyability and adequate segment lengths for turn anticipation function using flight simulation and standard turn-distance calculations. As a result of these analyses, 14 of the original waypoints were eliminated and 4 waypoints relocated. A list of the changes to the initial-preliminary PVFR route is provided in Table 2.

Table 2 Description/Explanations of Changes to PVFR Route				
Change	Wpt(s)	Flyability	Matrix/Events	Turn-Anticipation
Deleted	Wpt 11		X	
Deleted	Wpt 13		X	X
Moved	Wpt 14	X	X	X
Deleted	Wpts 15-17	X		X
Moved	Wpt 18	X	X	X
Deleted	Wpts 19-25	X		X
Deleted	Wpts 31-32		X	X
Moved	Wpt 33		X	X
Moved	Wpt 36		X	

Table 3 Test Conditions - Events per Flight		
Condition/ Event	Turn (Degrees)	No. of Events
1	0-29	6
2	30-59	5
3	60-95	5
4	>95	4

The final-draft PVFR route is designed to test pilot performance in straight segments and turns. Straight segments range from 1 to 6 NM in length. Numerous turns (20 in all) ranging from 6 to 125 degrees are provided in the PVFR route. For analysis, the turns will be divided into 4 conditions, as shown in Table 3. The number of conditions per flight is also shown in Table 3.

The route segments and waypoints comprising the PVFR route are designed to evaluate several test conditions. Some route segments follow well-defined visual features; some route segments are near (but do not overlie) visual features; some route segments do not follow any defined visual features. It is expected that pilots who rely heavily on visual features for navigation will have a greater deviation from the PVFR route on segments that are defined only by GPS waypoints and lesser deviation from the route on segments that are defined by visual waypoints. It is expected that pilots who rely heavily on GPS for navigation will have approximately equal deviation from the route on GPS and visual segments. Of particular interest are those routes that are near, but do not overlie, visual features. It is expected that visually oriented pilots will follow visual features and GPS-oriented pilots will follow the GPS route segments. These hypotheses will be tested during the data analysis. Tables 4 and 5 describe operational characteristics of the route segments and waypoints.

Table 4 Operational Characteristics of Route Segments	
Waypoint Segment	Description of Segment
1 - 2	GPS transition segment from THA to PVFR Route
2 - 5	Visual flight along a power line
5 - 9	GPS route segments to avoid simulated restricted area over AEDC
10 - 12	GPS direct route near (but not directly over) State Highway 55
12 - 14	GPS direct route
14 - 27	GPS direct route that generally follows the Duck River
27 - 29	GPS direct route over Normandy Lake
29 - 30	GPS direct route
30 - 33	GPS direct route near (but not directly over) Highway 276
33 - 34	GPS direct route
35 - 36*	Visual flight along a power line
36 - 1	GPS transition segment from PVFR Route to THA
* Note: Waypoints 2 and 36 are coincident.	

Table 5 Operational Characteristics of Waypoints	
Waypoint	Description of Waypoint
1	GPS waypoint at THA airport
2	GPS waypoint along a power line
3	VGPS waypoint at a slight turn in the power line
4	VGPS waypoint at a slight turn in the power line
5	VGPS waypoint at a power plant at the northwest end of Wood's Reservoir
6	GPS waypoint near (but not directly over) state highway 55 and a cell tower
7	GPS waypoint near (but not directly over) state highway 55
8	GPS waypoint at Interstate Highway 24 (I-24)
9	VGPS waypoint at intersection of I-24 and power line
10	VGPS waypoint at intersection of two power lines
12	VGPS waypoint at intersection of power line and I-24
14	GPS waypoint on the Duck River near a 61-foot cell tower
18	GPS waypoint on the Duck River
26	VGPS waypoint at the intersection of a power line and the Duck River
27	GPS waypoint where the Duck River widens to Normandy Lake
28	VGPS waypoint at a bridge at narrow point in Normandy Lake
29	VGPS waypoint at dam that forms Normandy Lake
30	VGPS waypoint at intersection of US Highway 41A and Highway 276
33	VGPS waypoint at intersection of Highways 276 and 130 at village of Raus
34	GPS waypoint along a power line
35	VGPS waypoint at a slight turn in the power line
36	Coincident with waypoint 2

Notes:
1. Waypoints 11, 13, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 31, and 32 were deleted in a redesign of the PVFR route.
2. GPS waypoints are designated by latitude/longitude coordinates
3. VGPS waypoints are designated by a visual feature and latitude/longitude coordinates.

TEST MATRIX

Based on test requirements, STI has constructed a test matrix that supports the objectives of the PVFR/SNI project. This test matrix was used to guide the development of the actual test plan routes.

Up to 14 flights will be flown. Up to 10 flights are designated data collection flights during daylight hours; up to 4 flights are data collection flights during nighttime hours. Data collection will be performed on all flights including familiarization flights. Flights will:

- Originate and terminate at THA with a transition to the PVFR route,
- Be flown during VMC using VFR,
- Be hand flown (no autopilot flights),
- Fly en route segments at the standard cruise speed for the OH-58A and a speed that is comfortable to the subject pilot (typically 70 to 90 knots),
- Conduct turns using standard rate of turn, and

- ➢ Collect sufficient data samples to assure statistical significance for straight segment and turn data samples (minimum 40 data sets with a goal of 80 data sets per test condition).

The test matrix is shown in Table 6. The test matrix provides a familiarization flight to allow each pilot some time to operate the aircraft and systems for approximately 30 minutes prior to the beginning of data collection. Following the familiarization flight the data collection flight will begin. The test matrix calls for 10 data collection flights to be flown during the day and 4 data collection flights to be flown at night.

Under reasonable conditions, familiarity and testing can be completed in a 1½-day period. This allows for testing of four subject pilots per week. Assuming 10 pilots, the data collection task will require a minimum of 3 calendar weeks. A sample weekly schedule is provided in Table 7.

Table 6 PVFR Flight Test Matrix

Pilot	Rating	Event 1	Event 2	Event 3	Event 4	Total
1	IFR/VFR	6	5	5	4	20
2	VFR-Only	6	5	5	4	20
3	IFR/VFR	6	5	5	4	20
4	VFR-Only	6	5	5	4	20
5	IFR/VFR	6	5	5	4	20
6	VFR-Only	6	5	5	4	20
7	IFR/VFR	6	5	5	4	20
8	VFR-Only	6	5	5	4	20
9	IFR/VFR	6	5	5	4	20
10	VFR-Only	6	5	5	4	20
1	IFR/VFR	6	5	5	4	20
2	VFR-Only	6	5	5	4	20
3	IFR/VFR	6	5	5	4	20
4	VFR-Only	6	5	5	4	20
Data sets	**(day)**	**60**	**50**	**50**	**40**	**200**
Data sets	(night)	24	20	20	16	80
Data sets	(total)	84	70	70	56	280

10 day flights – number & makeup of subject pilots:
(1) 50% IFR/VFR
(2) 50% VFR-Only
(3) Operational pilots from private, industry, and military (Navy).

4 night flights – number and makeup of subject pilots:
(1) Two IFR/VFR pilots from military (Navy)
(2) Two VFR-Only pilots from private industry.

Note: Pilots 1 through 4 fly one night flight and one day flight.
Pilots 5 through 10 fly one day flight.

Table 7 Sample Weekly Test Schedule

	Monday			Tuesday			Wednesday			Thursday			Friday		
Activity	AM	PM	Eve	AM	PM	Eve	AM	PM	Eve	AM	PM	Eve	AM	PM	Eve
Week 1															
Pilot Arrives	P5			P6			P1			P7					
In Brief		P5			P6			P1			P7				
Fam. Flight		P5			P6			P1			P7				
Data Flight-N									P1						
Lodging			P5			P6			P1			P7			
Data Flight-D				P5			P6			P1			P7		
Out Brief				P5			P6			P1			P7		
Pilot Departs					P5			P6			P1			P7	
Week 2															
Pilot Arrives	P8			P9			P2			P10					
In Brief		P8			P9			P2			P10				
Fam. Flight		P8			P9			P2			P10				
Data Flight-N									P2						
Lodging			P8			P9			P2			P10			
Data Flight-D				P8			P9			P2			P10		
Out Brief				P8			P9			P2			P10		
Pilot Departs					P8			P9			P2			P10	
Week 3															
Pilot Arrives	P3			P4			A1			A2					
In Brief		P3			P4			A1			A2				
Fam. Flight		P3			P4			A1			A2				
Data Flight-N			P3			P4									
Lodging			P3			P4			A1			A2			
Data Flight-D				P3			P4			A1			A2		
Out Brief				P3			P4			A1			A2		
Pilot Departs					P3			P4			A1			A2	

Notes:
-D = day flight; -N = night flight
P1…P10 – Pilots 1 through 10
A1…A2 – Alternate dates in the event of weather, equipment, or personnel availability problems

Four flights (tan highlighting) have been designated as night flights. Alternate dates, Flights A1 and A2 in Week 3, are left open for catching up on data processing tasks, aircraft maintenance, weather delays, etc.

DATA REQUIREMENTS

Subject pilot Data

Each subject pilot will complete a pre-test questionnaire and post-flight questionnaires at the conclusion of each flight.

The pre-test questionnaire provides background information on experience level, currency, aircraft flown, etc. To maintain the privacy of the subject pilots, data on individual pilots, by name, will by known only to STI test personnel and will not be released or otherwise made available to the FAA. Pilot data provided to the FAA will be in summary format. Performance of individual pilots on specific flights or flight segments will not be available to the FAA.

Each subject pilot will complete a post-flight questionnaire to collect the pilot's assessment of the operation of the aircraft and the GPS receiver during the flight. Questions will be of two forms: 1) quantitative ratings to assess the level of difficulty or risk associated with flying or operating the GPS equipment during the flight, and 2) questions soliciting pilot comments on positive and negative aspects of operating aircraft and GPS equipment on PVFR routes. Pilots will be asked to identify specific visual references they used during the flight. This information will be provided to NPS for use in the simulator tests.

True Aircraft Position Digital Data

The true position of the aircraft will be determined by a Time and Space Position Indicating System (TSPI). The TSPI is a survey quality, GPS-based tracking system and it will be Government Furnished Equipment (GFE) provided by the FAA. The TSPI consists of two Ashtech Z-12 GPS receivers with antennas, power supplies, and other supporting equipment. The Ashtech system includes software to process the resulting data. One Z-12 receiver will be located onboard the test aircraft. This receiver will require a GFE L1-L2 aircraft antenna. The second ground-based Z-12 receiver will record data at a surveyed location. The TSPI is able to record data at various rates selectable by the operator. It is planned to collect TSPI data at a 1 Hz rate. Data from the two receivers will be merged post flight using the Ashtech software to produce highly accurate true position data for the aircraft. The FAA has determined that post-processed data from the TSPI has a demonstrated tracking accuracy of less than 1-meter error.

Airborne Digital Data

The specific list of digital data parameters and their resolution will depend on the specific model of receiver installed in the test aircraft. Table 8 represents a desired set of data parameters.

The parameters in Table 8 will be recorded by a personal computer (PC)-based data collection and recording system. The software for the recording system will be developed by STI. It will be based on similar PC-based data collection and recording systems built and used for previous non-precision and precision approach testing in helicopters. The PC-based system will record data parameters from the output(s) of the GPS receiver. Depending on the receiver make and model, these outputs may be in RS232, NMEA1083, or ARINC 429 format. The specific output format will depend on the data output of the KLN89B test receiver. Data will be recorded at the highest rate available from the receiver. Typically, RS232 and NMEA1083 data are output at approximately a 1-Hertz (Hz) rate. Essential ARINC 429 data is output at a 10 Hz rate, while routine ARINC 429 data, such as Flight Plan Header, are recorded at slower rates.

To support the simulation portion of the PVFR/SNI project, personnel from NASA Ames will be collecting data on the pilots' head and eye position during the test flights. STI personnel will coordinate with NASA Ames personnel to assure that digital data from the airborne GPS system, the TPSI, and the head and eye tracker are time-correlated. The ability to time-correlate all digital data provides the means to correlate the pilot's head position (inside or outside of the cockpit) with FTE values. This will allow an assessment of FTE error growth during times that the pilot's attention is focused on tasks outside the cockpit.

TABLE 8 AIRBORNE DIGITAL DATA PARAMETER LIST

PARAMETER	UNITS	RESOLUTION
Universal Coordinated Time (UTC) *	seconds of the day	0.01 seconds
Cross Track Deviation (Course Deviation Indicator – CDI)*	feet (signed)	1 foot
Distance to Waypoint (DTW)*	NM	0.01 NM
GPS Latitude*	degrees, minutes of arc	0.01 minutes of arc
GPS Longitude*	degrees, minutes of arc	0.01 minutes of arc
GPS Altitude (relative to geoid or ellipsoid) *	Feet	1 foot
GPS Groundspeed*	Knots	0.1 knot
Actual Magnetic Track*	degrees	0.1 degree
Actual True Track*	degrees	0.1 degree
Active Waypoint*	Text	Not Applicable
Magnetic Variation*	degrees	0.1 degree
Desired Magnetic Track*	Degrees	0.1 degree
Desired True Track*	Degrees	0.1 degree
Flags and/or Annunciators	Dimensionless	Not Applicable
Barometric Altitude**	Feet	100 feet
* Derived from airborne GPS receiver ** Derived from aircraft systems		

Note that while it is desirable to obtain head and eye tracker information on as many flight segments as practicable, a failure of this system will not cause any flight to be delayed or postponed, nor will it impact the validity of the flight test data and test results obtained independent of the head and eye tracker information. For this reason, the airborne digital data and the head and eye tracker data will be recorded on separate data recording systems. If appropriate, these separate data recording systems may be electronically connected for time correlation purposes.

Flight Log

The onboard flight test engineer/observer will maintain a flight log. The observer will record details of the flight including as a minimum: subject pilot number; test run number; start and end flight time; pilot verbal comments; reported temperature and winds; and any other information considered necessary by the flight test engineer/observer. See Appendix C for a sample flight log.

Data Reduction

Data from the PC-based onboard digital data recording system will be time-merged with TPSI data. Data processing software will be developed by STI to determine time series of cross track error. The components of cross track error will be broken down into Navigation System Error (NSE), Flight Technical Error (FTE) and Total System Error (TSE).

Time series of NSE, FTE, and TSE will be determined at approximately one-second increments assuming this rate is available from the airborne GPS receiver. The resulting data will be summarized for each straight and turning segment of the flight. The data will be formatted in standard plots showing the mean and two standard deviations (2SD) and 6 standard deviations (6SD) for NSE, FTE, and TSE. Maximum cross track distance for each straight and turning route segment will be calculated from flight test data. While this methodology is familiar and the traditional standard deviation levels used by FAA for the establishment of IFR criteria, it is not envisioned that the same Required Obstacle Clearance (ROC) conditions will be applied to obstacles located within primary (2SD) and secondary (6SD) segments for the PVFR criteria.

Information from the subject pilot questionnaires will be tabulated in summary form. Summary statistical data (mean, standard deviation, and bar charts) will be calculated from the numerical rating questions. Summaries of pertinent comments will be taken from the pilot comment portion of the subject pilot questionnaires. This information will be provided to NPS for use in simulator tests.

TEST EXECUTION

Bench Tests and Shakedown Flights

Prior to the beginning of data collection, the test personnel will conduct several preliminary tests and flights to assure that all elements of the flight test project are in good working order. Specifically, the following test elements will be tested, demonstrated to the FAA and declared ready to test:

- Aircraft and aircraft systems (including the GPS receiver)
- Test routes and test procedures
- Data collection systems (TSPI, airborne digital data, and head and eye tracker)
- Quick-look data analysis software
- Data archiving procedures
- Data merging software
- Data processing and analysis software
- Pilot briefings

The qualifications (but not the names) of candidate subject pilots will be reviewed with the FAA and determined to be a representative sample for purposes of the PVFR/SNI project. When all elements of the flight test project have been reviewed and approved by the FAA, the flight test project will be declared ready for data collection.

Pre-Test Briefing

Subject pilots will be given a local area orientation and a pre-test briefing in accordance with briefing guide provided in Appendix D. The subject pilot will also be asked to complete the Pre-Test Questionnaire (draft provided in Appendix E).

Familiarization Flight

To establish a baseline experience level for all subject pilots, each pilot will fly a familiarization flight with as many flight segments as needed to become familiar with the test routes and the avionics interfaces. The subject pilot will fly all flights at airspeeds and turn rates consistent with the aircraft's performance limits and the pilot's normal flight operating procedures. The familiarization flight route will be different than the PVFR test route used for data collection.

Data Collection Flights

After completing the familiarization flight, the subject pilot will fly the data collection flight. Data collection flights will consist of a VFR departure from THA. The flight then will then transition to a PVFR route for the en routes segment. The flight will conclude with a VFR transition from the PVFR route to THA.

Prior to departure the safety pilot or flight test engineer/observer (acting as a base operations center or dispatch center) will instruct the subject pilot to depart THA in accordance with the prevailing traffic and join the prescribed PVFR route. During the progress of the flight, the subject pilot will operate the aircraft in accordance with standard single-pilot VFR operating practices. The subject pilot will handle routine Air Traffic Control (ATC) communications during the flight. The subject pilot must look for traffic and obstacles along the PVFR route. If the subject pilot encounters traffic or obstructions, he (she) will make appropriate modifications to the flight path to "see and avoid" other traffic and obstructions.

On some flights the subject pilot will continue along the PVFR route to the intended destination. On some flights the safety pilot or the flight test engineer/observer, acting as an air traffic controller, may instruct the subject pilot to hold at a specified waypoint to allow traffic to arrive or depart from THA. Note that the traffic may be an actual aircraft arriving/departing THA or a fictitious aircraft used to simulate a request from ATC. The subject pilot will then be required to operate the GPS navigation system to hold at the specified waypoint until the safety pilot or the test engineer/observer tells the pilot to continue along the PVFR route.

The safety pilot will coordinate mission conduct with the flight test engineer/observer. The safety pilot will oversee ATC communications during the flight to ensure compliance with ATC requests. The safety pilot will verify avionics are properly configured prior to and during the flight.

Post-Test Questionnaire and Debriefing

Upon completion of his/her data collection flight(s), the subject pilot will be required to complete a Post-Test Questionnaire. This questionnaire will have the pilot provide quantitative ratings and subjective assessments of various aspects of the pilot's experience flying the PVFR routes. The Post-Test Questionnaire is presented in Appendix F.

The subject pilot, safety pilot, and flight test engineer/observer will discuss subject pilot comments (if any) from the flight log in addition to any general comments on the test program. In particular, the subject pilot will be asked to discuss areas of concern or uncertainty regarding operational use of PVFR routes. To protect the privacy of the subject pilots, these comments will be treated with confidence by the interview team and will not be attributed to specific pilots. Only summary comments will be provided to the FAA and the identity of the subject pilot making such comments will not be released to the FAA.

The flight test engineer/observer will ensure the subject pilot has met all the administrative requirements associated with any expense reimbursements that may be due to the subject pilot. In particular the flight test engineer/observer will go through a checklist to ensure that the subject pilot has performed all necessary technical and administrative tasks.

COORDINATION WITH THE SIMULATION PHASE OF THE PROJECT

At numerous times during the execution of this test plan and the execution of the flight test, the flight test personnel (STI) will coordinate with simulation test personnel (NPS and NASA Ames) and will provide information pertinent to the development and conduct of the simulation effort. To the extent possible these coordination and information transfer activities will be handled by telephone calls, emails, and air express shipments in order to minimize project costs.

Items and/or events that require handoff of information from STI to NPS include:

- Description of the test routes including airports, waypoints, and altitudes,
- Description of the aircraft used for flight testing,
- Description of the airborne GPS receivers used for flight testing,
- Test procedures and scripts used by the flight test engineer/observer during the test flights, and
- Test matrix used to manage and control the flight test execution.

Items and/or events that require handoff of information from NPS or NASA to STI include:

- General description of the head and eye tracker,
- Technical details of the components of the head and eye tracker, their location during flight, their weight and power requirements, and any details such as that could affect the safe operation of the aircraft,
- Operational details of the head and eye tracker in sufficient detail to allow development briefing materials for the subject pilots, and
- Required interfaces to assure that all digital data can be time correlated.

PARTICIPANTS

STI and their subcontractor will provide the following participants:

- Flight test project manager,
- Flight test engineer/observer,

- Safety pilots, and
- Subject pilots.

Subject pilots will be invited from various civilian and governmental organizations. A target number of 4 pilots will be designated to participate in both the flight test and simulation portion of the project. Navy instructor pilots from Pensacola Naval Air Station are likely candidates for participating of both portions of the project. These pilots are thoroughly familiar with the TH-57, which is a Navy training variant of the OH-58, and some of these instructor pilots will be taking courses at the NPS. If they are available, civilian subject pilots from industry may also be asked to participate in the simulation tests at NPS.

FAA organizations participating in this test include:

- AAR-100, Human Factor Division, and AAR-432, General Aviation and Vertical Flight Office, will provide oversight and technical direction to the flight test project, and
- AFS-410/420, Flight Technologies and Procedures Division, will review test plans and test reports and provide information to AAR-100/432 as to whether the test plans and test data address appropriate issues and requirements to establish policy, criteria and technical guidance for the implementation of PVFR routes into the NAS.

SCHEDULE

The overall PVFR/SNI project schedule is shown in Figure 1. Key schedule milestones are shown below:

- Test Plan Completion and Signoff by FAA: June 30, 2003
- Test Readiness Demonstration and Signoff by FAA: September 30, 2002
- Data Collection Flights Completed: October 31, 2003
- (Reserved Period) Backup Data Collection Flights Completed: January 31, 2004
- Draft Flight Test Report Completed: August 31, 2004
- Final Flight Test Report Completed and Project Completed: December 31, 2004

FAA CONCURRENCE WITH TEST PLAN

A signature page indicating concurrence with this test plan by the sponsoring and technical performance offices of the FAA is presented in Appendix G.

RELATED DOCUMENTATION

Documents and technical direction related to this test include:

1. FAA Aeronautical Information Manual (AIM).
2. Krebs and Knopp, Minutes of PVFR/SNI Meetings and Teleconferences.
3. Hickok, Notes from FAA – STI telecom, December 12, 2002.
4. AFS-400 via Krebs, Questions & Answers Regarding the Construction of the PVFR Test, January 9, 2003.
5. FAA Order 7110.65 N; Air Traffic Control

Federal Aviation Administration (FAA) Rotorcraft Precision VFR (PVFR) Simultaneous Non-Interfering (SNI) Human Factors Project

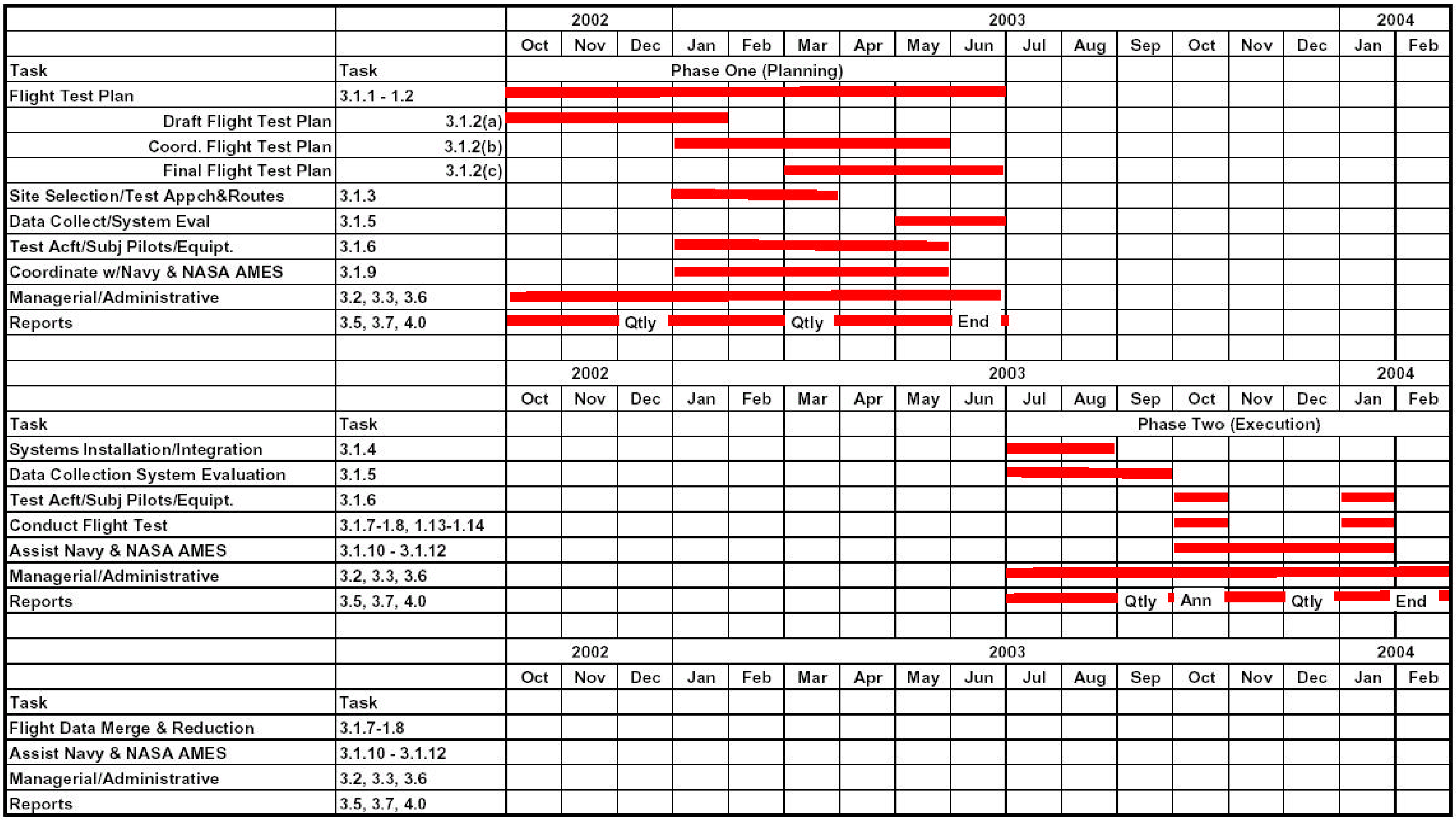


Figure 1 PVFR/SNI Project Flight Test Schedule (page 1 of 2)

Federal Aviation Administration (FAA) Rotorcraft Precision VFR (PVFR) Simultaneous Non-Interfering (SNI) Human Factors Project

		2004										2005						
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Task	Task																	
Flight Test Plan	3.1.1 - 1.2																	
Draft Flight Test Plan	3.1.2(a)																	
Coord. Flight Test Plan	3.1.2(b)																	
Final Flight Test Plan	3.1.2(c)																	
Site Selection/Test Appch&Routes	3.1.3																	
Data Collect/System Eval	3.1.5																	
Test Acft/Subj Pilots/Equipt.	3.1.6																	
Coordinate w/Navy & NASA AMES	3.1.9																	
Managerial/Administrative	3.2, 3.3, 3.6																	
Reports	3.5, 3.7, 4.0																	
		2004										2005						
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Task	Task																	
Systems Installation/Integration	3.1.4																	
Data Collection System Evaluation	3.1.5																	
Test Acft/Subj Pilots/Equipt.	3.1.6																	
Conduct Flight Test	3.1.7-1.8, 1.13-1.14																	
Assist Navy & NASA AMES	3.1.10 - 3.1.12																	
Managerial/Administrative	3.2, 3.3, 3.6																	
Reports	3.5, 3.7, 4.0																	
		2004										2005						
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Task	Task	Phase Three (Data Processing/Final Report)																
Flight Data Merge & Reduction	3.1.7-1.8																	
Assist Navy & NASA AMES	3.1.10 - 3.1.12																	
Managerial/Administrative	3.2, 3.3, 3.6																	
Reports	3.5, 3.7, 4.0	Qtly			Qtly			Qtly	Ann		End							

Figure 1 PVFR/SNI Project Flight Test Schedule (page 2 of 2)

APPENDIX A

DESCRIPTION OF THE PVFR TEST HELICOPTER (OH-58A+)

The UTSI OH-58 is an A+ model with larger engines than the A model. Specifications for the A+ model will vary accordingly.

Specifications

Specification information was obtained from the website of the Quonset Air Museum, Kingstown, Rhode Island. The website is:

http://users.ids.net/~qam/AircraftPages/oh58akowa.htm

Description

Manufacturer: Bell Helicopter Company (now Bell Helicopter Textron Inc.)
Designation: OH-58
Version: A
Name: Kiowa
Type: Utility/general purpose/gun ship
Cabin: Plot and optional co-pilot/observer side-by-side, and up to three passengers or 1,534 lbs. of freight crammed in the rear of the cabin.

Dimensions

Fuselage Length: 32 ft 3.5 in
Height: 9 ft 6.5 in
Rotor Diameter: 33 ft 4 in

Weights

Empty Weight: 1,585 lb.
Max. Weight: 3,200 lb. (maximum take-off)

Propulsion

Power plant: One Allison T63-A-700 turboshaft rated at 317 shp
Fuel capacity: Internal fuel 73 US gal (60.7 Imp gal; 276.3 liters); external fuel none; no provision for in-flight refueling

Performance

Range: 380 miles
Cruising Speed (Sea Level): 121 mph
Max. Speed (level): 138 mph
Ceiling: 18,500 ft

Electronic & operational equipment

Standard communication and navigation equipment

APPENDIX B

DESCRIPTION OF BASIC GPS RECEIVER

(MEETS TSO C129 CLASS A1 CRITERIA)

(Characteristics of Bendix/King KLN89B are assumed)

Information regarding the Bendix/King KLN 89B was obtained for the following website:

http://www.bendixking.com/static/brochures/pdf/kln89_89b.pdf

KLN 89B/KLN 89 GPS Receiver

General Description

The KLN 89 is a panel-mounted, 8-channel, GPS-based navigation system with a pilot-updatable database. The KLN 89B adds IFR-certifiable en route, terminal and approach capability. A basic installation of either consists of the panel-mounted unit, an altitude input and a KA 92 antenna. Among the additional components which may be added to increase the KLN 89B or KLN 89 capabilities are: an external course deviation indicator (CDI) or horizontal situation indicator (HSI); a remote magnetic indicator (RMI); some Shadin or ARNAV fuel management systems; several external moving map displays; and certain Shadin air data systems.

KA 92 Antenna

The KA 92 antenna is a compact, aerodynamically-styled "patch" antenna that mounts on top of the aircraft.

KLN 89B/KLN 89 Specifications

Receiver Dimensions

Width:	6.31 inches (16.03 cm)
Height:	2.00 inches (5.08 cm)
Length:	10.72 inches (27.23 cm)
Weight:	2.55 pounds (1.16 kg)

Receiver Operational Characteristics

Temperature Range:	-40o C. to +55o C.
Altitude Range:	Up to 35,000 feet
Power Inputs:	11 – 33 Volts DC at 2.5 Amperes maximum
TSO (KLN 89B only):	C129 Class A1
GPS Engine:	Eight-channel parallel GPS XPRESS™ receiver

KA 92 Antenna

Width:	2.70 inches (6.86 cm)
Height:	0.70 inches (1.78 cm)
Length:	4.30 inches (10.92 cm)
Weight:	0.30 pounds (0.14 kg)
Airspeed Rating:	600 knots true airspeed

Available Accessories

MSG/Waypoint annunciator (required for IFR)
GPS Approach: Arm/Active annunciator (required for IFR)
NAV/GPS annunciator
Computer Requirement for Database Updates:

> Most IBM-compatible personal computers containing a 3.5-inch floppy disk drive capable of reading 1.44-megabyte diskettes and having an RS-232 serial port; updates are also available via the Internet at www.alliedsignal.com/aerospace.

Sheet Number ___________

APPENDIX C

HELICOPTER PVFR/SNI FLIGHT TEST PROJECT

FLIGHT LOG

DATE _______________ SUBJECT PILOT # ______________________ Flight # ______________________

SAFETY PILOT ___________________________TEST ENGINEER/OBSERVER __________________________

No.	Flight Number	Start Time	Stop Time	Altimeter/ Wx/Temp	Comments

APPENDIX D
SUBJECT PILOT INITIAL BRIEFING

(Provided Separately: See PowerPoint Briefing “PVFR Initial Pilot Briefing.PPT”)

PVFR/SNI Project

Initial Briefing for Subject Pilots

Background – What are PVFR and SNI?

- **PVFR stands for Precision Visual Flight Rules**
  - **PVFR is an method of flying using VFR with approved GPS navigation equipment to gain improved access to the Air Traffic Control (ATC) system**
- **SNI means Simultaneous, Non-Interfering operations**
  - **SNI operations allow properly equipped aircraft to operate in congested airspace with increased efficiency and reduced delays**

Background – Where will PVFR and SNI be used?

- **Principal Use – Busy Terminal Areas and Airport Control Zones**
- **Other Potential Uses for PVFR routes**
  - **Valleys**
  - **Mountain passes**
  - **Areas that lack features for visual navigation**
    - **Over water**
    - **Featureless terrain**
      - **Desert**
      - **Plains**
      - **Forests**

Background – Why does FAA need a test project to implement PVFR and SNI?

- **Need supporting flight test data to determine PVFR route widths on straight segments and turn points**
  - **FAA has data to support IFR route widths but no data to support VFR route widths**
- **Need to investigate human factors issues of requiring VFR pilots to follow a PVFR route defined by GPS waypoints**
- **Need to determine if there are unidentified issues associated with PVFR routes and SNI operations**

PVFR Flight Test – Points of Contact

- **Flight Test Project – STI (FAA Contractor)**
  - **Project Director – Steve Hickok**
  - **Technical Director/Administrative Support – Ed McConkey**
  - **UTSI Support**
    - **UTSI Project Manager – Dr. Ralph Kimberlin**
    - **PIC/Safety Pilots**
    - **Aircraft Support – Mike Leigh**
    - **Technical Support -**
- **Head and Eye Tracker (NASA Ames)**
  - **Jeff Mulligan**
- **PVFR Simulation Project – Naval Postgraduate School (NPS)**
  - **Rudy Darken**
  - **Cdr. Joe Sullivan**
- **FAA Management and Oversight**
  - **Kip Krebs (FAA - HQ)**
  - **Ken Knopp (FAA – Technical Center)**
  - **FAA Sponsoring Offices (Flight Standards and Air Traffic Control)**

Flight Test – Subject Pilot's Schedule

- Travel to Tullahoma, TN
- Initial Briefing for Subject Pilots
- Subject Pilot Background Questionnaire
- Test Aircraft Orientation
- Familiarization Flight
- Data Collection Flight(s)
- Subject Pilot Debriefing/Questionnaire
- Travel to Home Base

Subject Pilot Background Questionnaire

- **Name, Address, Phone Numbers, E-Mail Address**
- **Flight Experience**
- **Hours in Aircraft (Fixed-Wing & Helicopters)**
  - **Total**
  - **Last 6 Months**
- **Ratings**
- **Aircraft Types**
- **Familiarity with GPS (Receiver Make & Model)**

Test Aircraft Orientation

- Test Aircraft
  - Bell OH-58A+ (US Army Surplus Operated by UTSI)
  - Similar to Bell 206 and US Navy TH-57
  - Basic Aircraft Systems plus Bendix-King KLN 89B GPS Receiver
- Test Instrumentation
  - TSPI
  - Head and Eye Tracker
  - Laptop Computer

Test Aircraft – OH-58A+

Test Aircraft Instrument Panel

Test Aircraft – Bendix/King KLN 89B GPS Receiver

Test Instrumentation - TSPI

- TSPI – Time & Space Position Indication System (Highly Accurate GPS Tracking System)
- TSPI will track aircraft on all flight segments
- TSPI will be used to calculate pilot's adherence to the PVFR route (cross track deviation) on straight segments and during turns
- TSPI is operated by flight test engineer – no pilot involvement

Test Instrumentation – Head and Eye Tracker

- **Head & Eye Tracker (H&ET) will be worn by subject pilot during all flight operations**
- **H&ET tracks position of pilots head and eye during flight**
- **Analysis will determine where pilot is looking (outside/inside aircraft and what instruments are being viewed)**

(Note: Need picture of H&ET as worn by pilot)

Flight Crew

- **UTSI PIC (safety pilot) will be responsible for safe operation of aircraft**
- **Subject Pilot**
  - **Will be responsible for operating aircraft during familiarization and data collection flights**
  - **Will fly all segments unless PIC determines that he needs to take control of aircraft**
- **Flight Test Engineer will operate test equipment during all flight segments**
- **Observers from FAA or Industry may or may not be present on some flights**

PVFR Flight Rules

- **Flight is to be conducted in accordance with VFR**
- **Subject Pilot is responsible for maintaining separation from other aircraft and terrain**
- **Adherence to PVFR route is important, but safe VFR operation is overriding requirement**
- **Notify PIC (as you would notify ATC) if you must deviate from PVFR route for traffic, weather, or any other reason**

Familiarization Flight

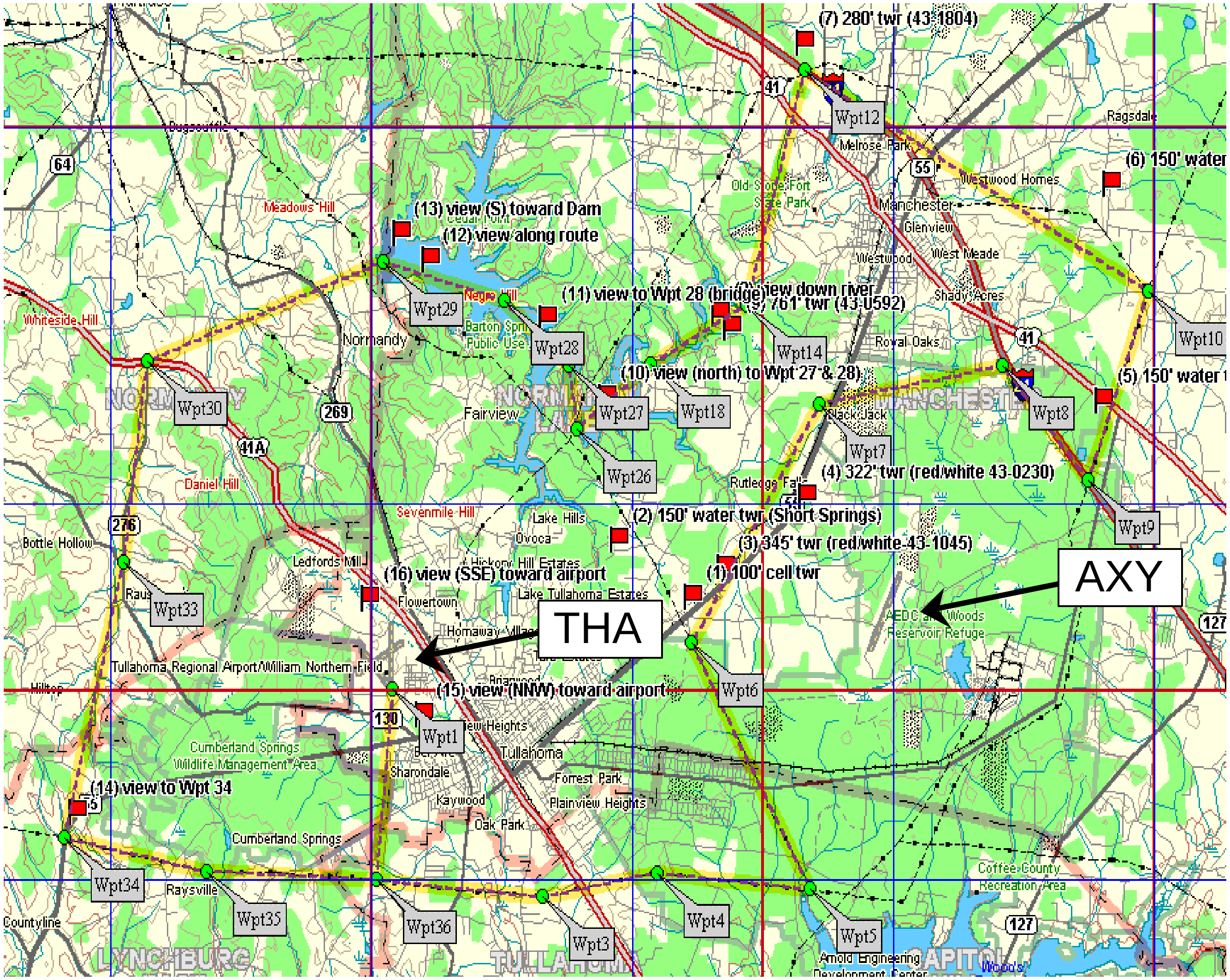
- **Purpose is to acquaint subject pilot with aircraft, aircraft systems, GPS, and PVFR routes**
- **Approximately 30 minutes of flight time**
- **Instruction by PIC in aircraft systems and operation of GPS receiver**
- **PVFR familiarization route with visual features and GPS waypoints that are similar to PVFR test route**
- **Ask as many questions as necessary to become comfortable with aircraft, systems, GPS and PVFR routes**

Data Collection Flight

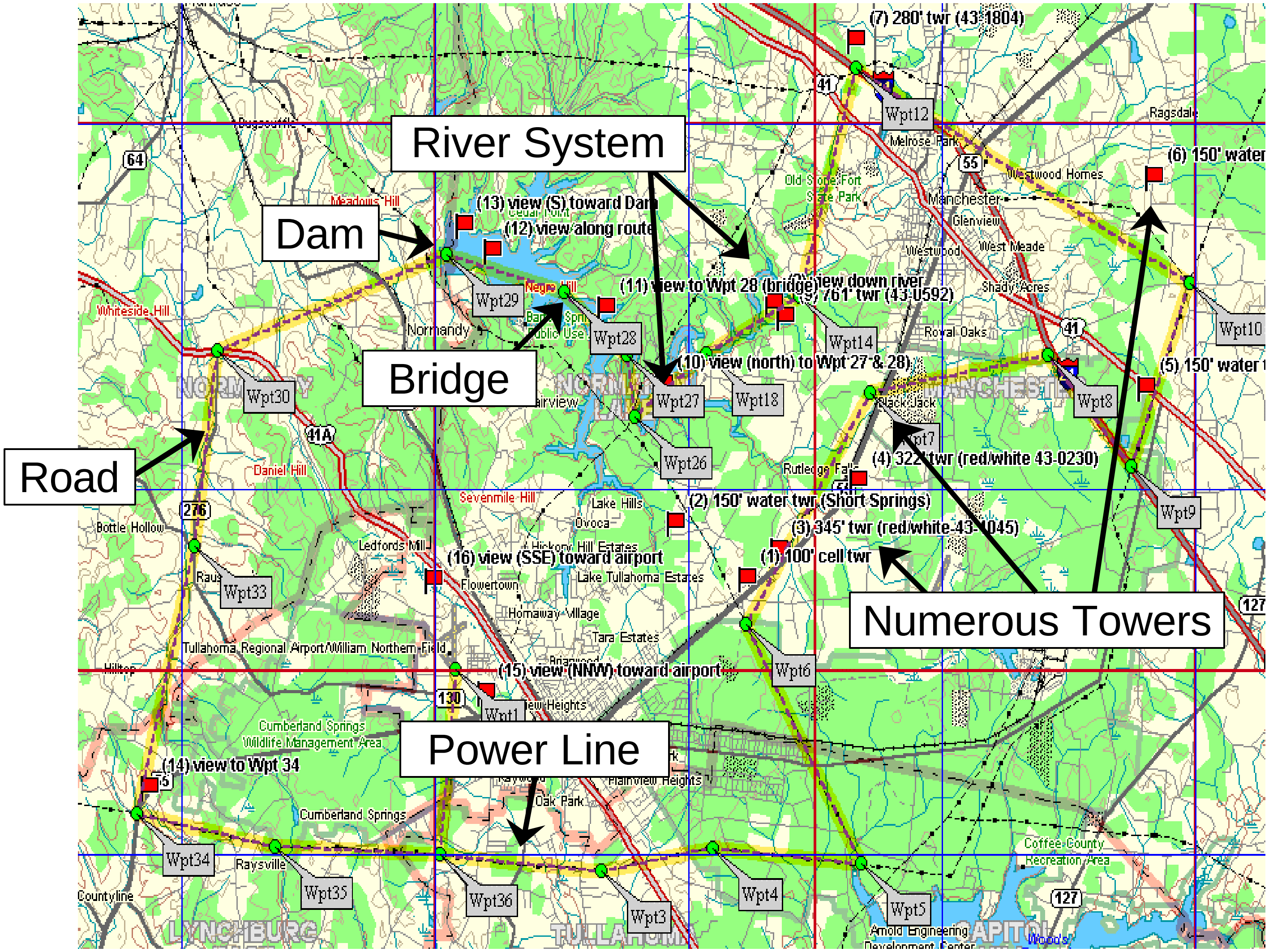
- **Depart THA according to prevailing traffic* (or PIC) and join PVFR route**
- **Fly the PVFR route as directed by PIC**
- **PIC may give Subject Pilot simulated ATC instructions during flight (e.g., hold at XYZ waypoint for traffic departing/arriving THA, turn to avoid traffic at XX o'clock, at ABC waypoint proceed direct to DEF waypoint, etc.)**
- **At end of PVFR route proceed to THA as directed by tower (or PIC)**

*** Note: THA has no control tower**

PVFR Route - Overview



PVFR Route – Visual Features



Typical Visual Features

Short Springs Water Tower

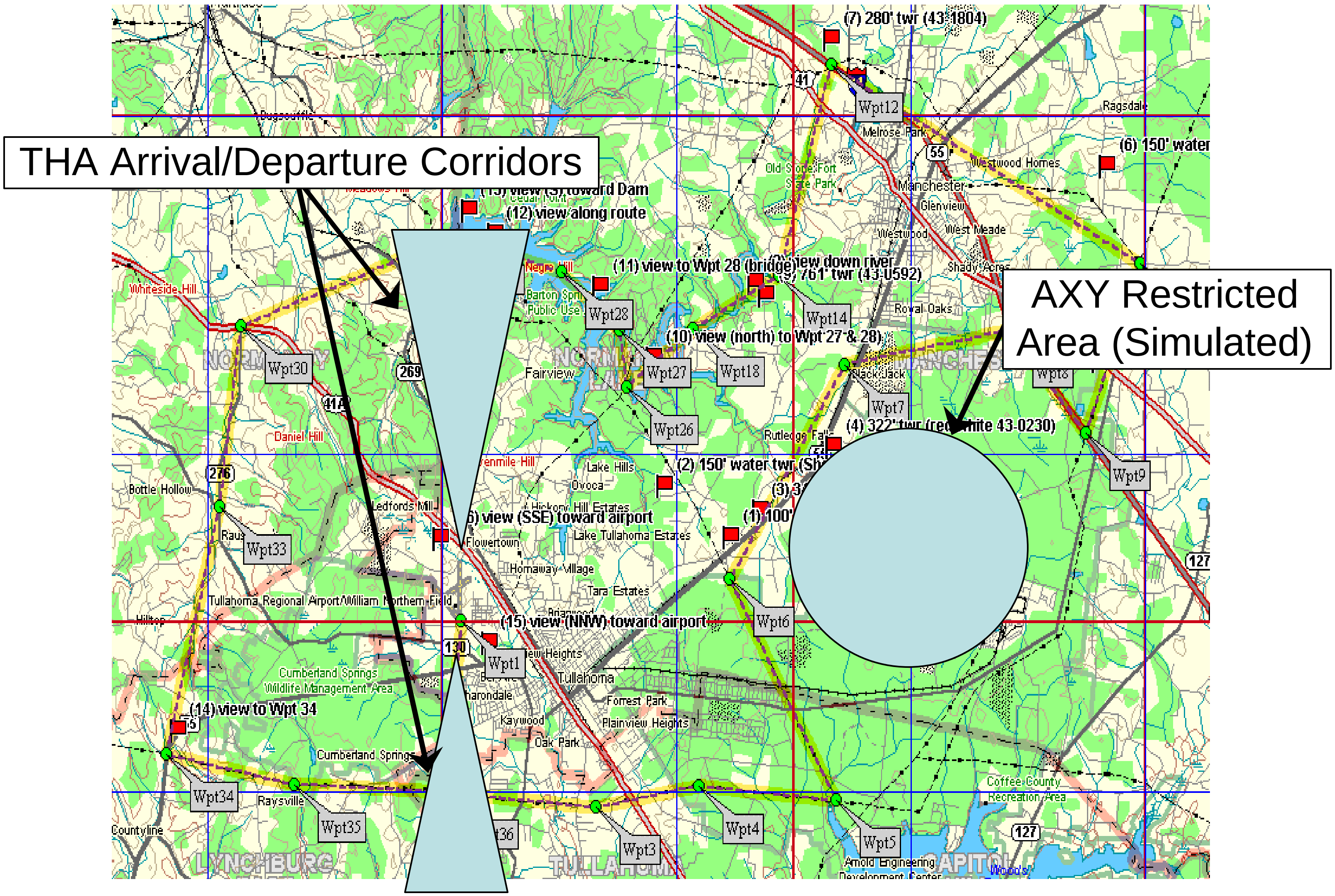
Bridge over Normandy Lake

Hillsville Water Tower

Tower near Highway

Dam at Western End of Normandy Lake

PVFR Route – ATC Features (Simulated)



Factors that May Affect Data Collection Flight

- **Adverse weather conditions**
- **Traffic or other safe operating factors**
- **Difficulty with aircraft operation, aircraft systems or data collection system**
- **Difficulty with head and eye tracker**
- **Disorientation or loss of situational awareness by the subject pilot**
- **PIC determines that flight must be interrupted**
- **Advise PIC immediately if any of these factors occur**

Subject Pilot Debriefing

- **Subject Pilots will be debriefed after data collection flight**
- **Purpose of debriefing**
  - **Identify difficulties in flying on PVFR route**
  - **Discuss problems that may have occurred during data collection**
  - **Identify pilot workload issues regarding flying on PVFR routes**
    - **Difficulty in carrying out VFR tasks**
    - **Use GPS guidance**
    - **Operation of GPS receiver**
  - **Discuss ability to follow GPS guidance during PVFR operations**
  - **Discuss issues in following ATC requests during PVFR operations**
  - **Pilot opinions**
    - **Operating on PVFR routes**
    - **Benefits of PVFR routes**
    - **Negative aspects of PVFR routes**

Privacy Policy

- Privacy of Subject Pilots will be strictly observed
- Performance of individual pilots will be known only to STI personnel
- Performance on specific flights by individual pilots will not be released to FAA
- Reports and other documentation resulting from the PVFR/SNI project will not identify any pilots by name or any other traceable method of identification

Administrative Details

- **Subject Pilots will be reimbursed by STI for lodging, meals, and other incidental expenses and travel to/from Tullahoma to home base**
- **Lodging will be at STI approved hotels or motels (number of night's lodging must be pre-approved by STI)**
- **Meals and other incidental expenses will be reimbursed at Federal Government rates**
- **Travel expenses (air or surface) must be pre-approved by STI**
- **Subject Pilots must fill out and sign a STI expense report to obtain reimbursement**
- **Questions regarding expense reimbursement should be addressed to Ed McConkey**

APPENDIX E

PVFR/SNI SUBJECT PILOT - PRE-TEST QUESTIONNAIRE

The purpose of this questionnaire is to collect information concerning your aeronautical experience. This information will be used only for test purposes. Information for all subject pilots will be reported in summary form only. No information that identifies specific pilots will be released to the FAA.

Personal Information: (Subject pilot No. ____________)

Name: ____

Daytime phone: ____________________ E-Mail ______________________________________

Mailing Address: ____

____

City, State, Zip ____

Ratings: ____

____

Current in what aircraft (fixed-wing and helicopters)? ____________________________________

____

Approximate Flight Hours by Helicopter Type:

Helicopter Make/Model[2]	Approximate Flight Hours

[2] Group similar models into a single category

Flight experience (helicopter and fixed-wing aircraft):

		Flight Hours	
All	Total	Helicopter:	Airplane:
	Last 6 Mo	Helicopter:	Airplane:
VFR	Total	Helicopter:	Airplane:
	Last 6 Mo	Helicopter:	Airplane:
IFR (if IFR-Rated)	Total	Helicopter:	Airplane:
	Last 6 Mo	Helicopter:	Airplane:
With Autopilot	Last 6 Mo	NA	NA
Without Autopilot	Last 6 Mo	NA	NA

What aircraft do you usually fly? If it has a GPS system, please identify the make and model of the GPS next to the aircraft make and model.

Aircraft Make and Model	GPS Installed? Yes/No	GPS Make and Model

APPENDIX F

SUBJECT PILOT POST-TEST QUESTIONNAIRE

Notes:

1. Both the Initial Pilot Briefing and this Post-Test Questionnaire will be tested, evaluated, and modified as necessary throughout the integration and preliminary testing period to incorporate valid comments.

2. For the Post-Test Questionnaire, the Subject Pilot will be provided with three sectional charts (Chart A, Chart B, and Chart C) depicting the PVFR Route. Each chart will have the following information:

> Sectional Chart A shows the waypoints and turn magnitudes on the PVFR Route. The turn magnitudes are identified with colored stick pins placed at each waypoint. The color of the pin represents the condition of the turn (for example, 0-30 degrees - yellow pin; 30-60 degrees - blue pin; 60-95 degrees - white pin; > 95 degrees - clear pin).
>
> Sectional Chart B shows the PVFR Route divided into 12 sections. Each section has distinct visual or functional characteristics. Each section of the route is identified by a different color of stick pin. The purpose of this chart is to determine whether subject pilots experience different levels of difficulty in flying on each of the sections. This chart is also used to determine whether subject pilots who flew at night experience different levels of visibility in flying on each of the sections.
>
> Sectional Chart C shows prominent visual features at various points along the PVFR Route. This chart is used to aid the subject pilots in selecting prominent visual features that should be included in the simulation phase of the PVFR Project.

PVFR Post-Test Questionnaire

Pilot No. _____________

To: Subject Pilots

This questionnaire is intended to record your thoughts and impressions of the PVFR flight test project and the PVFR/SNI concept. The questionnaire offers the subject pilot the opportunity to rate various aspects of the flight test project and to provide additional comments as appropriate.

Subject Pilot Name: _______________________________________ Date: ________________

Sortie Number: ___________________________ Date Flown: ___________________________

Pre-Test Preparation

1A. The Initial Subject Pilot Briefing provided me with a thorough understanding of the subject pilot's role in the PVFR flight test project.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

1B. The Initial Subject Pilot Briefing could be improved in the following areas: ____________

____

____

2A. The Aircraft Orientation Briefing provided me with a thorough understanding of the helicopter systems, the avionics, and the necessary introductions to the Bendix/King KLN89 GPS receiver.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

2B. The Aircraft Orientation Briefing could be improved in the following areas: ____________

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

3A. The PVFR Familiarization Flight provided me with enough training: 1) in the operation of the aircraft, 2) in using the GPS receiver for navigation, and 3) to fly with confidence on the PVFR route structure.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

3B. The PVFR Familiarization Flight could have offered additional training in the following areas: ____

____

____

4A. The Pre-Test Preparation Activities prepared me to perform as a Subject Pilot in the PVFR Flight Test Project.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

4B. The PVFR Familiarization Flight could have offered additional training in the following areas: ____

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

PVFR Flight Test Activities

5A. Compare the PVFR Route used in the Flight Test with VFR Routes that you typically fly.

PVFR Route is much more difficult to fly
PVFR Route is somewhat more difficult to fly
PVFR Route has the same level of difficulty as routes I typically fly
PVFR Route is somewhat easier to fly
PVFR Route is much easier to fly

5B. Describe in what ways the PVFR Route is more difficult to fly (or easier to fly) than VFR Routes that you typically fly: ____

____

____

6A. Compare the workload needed to fly the PVFR Route with workload needed to fly VFR Routes you typically use.

PVFR Route requires much greater workload
PVFR Route requires somewhat greater workload
PVFR Route requires the same level of workload
PVFR Route requires somewhat less workload
PVFR Route requires much less workload

6B. Describe differences in the workload needed to fly the PVFR route with workload needed to fly VFR Routes you typically use: ____

____

____

7A. Compare the amount of time with your head inside the cockpit during the PVFR flight with the amount of time with your head inside the cockpit during your typical VFR flights.

PVFR Route requires much more time inside the cockpit
PVFR Route requires somewhat more time inside the cockpit
PVFR Route requires the same amount of time inside the cockpit
PVFR Route requires somewhat less time inside the cockpit
PVFR Route requires much less time inside the cockpit

PVFR Post-Test Questionnaire

Pilot No. _____________

7B. Describe why flying the PVFR Route requires you to look inside the cockpit more (or less) than flying your typical VFR routes: ____

____

____

8A. On the PVFR Route, some of the route segments were intentionally designed to overlay visual features (VFR waypoints like power lines, roads, highways, rivers, towers, dams, etc.), some were designed to be near visual features, others were designed where there were no obvious visual features.

Indicate your agreement/disagreement with the following statement, "I was never confused by the placement of the GPS routes segments with regard to visual features located in the flight test area."

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

8B. Describe any problems you encountered in confusing GPS route segments and visual features in the flight test area : ____

____

____

9A. The navigation information from the Bendix/King KLN89B GPS Receiver was easy to interpret.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

9B. Describe any problems you encountered in using the GPS Receiver for navigation : ______

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

10A. The course deviation indicator (CDI) display on the GPS Receiver was easy to interpret.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

10B. Describe any problems you encountered in viewing or interpreting the course deviation indicator on the GPS Receiver: ____

____

____

11A. For this question, please refer to Sectional Chart A showing the waypoints and turn magnitudes on the PVFR Route. The turn magnitudes are identified with colored stick pins placed at each waypoint. The color of the pin represents the condition of the turn (0-30 degrees - yellow pin; 30-60 degrees - blue pin; 60-95 degrees - white pin; > 95 degrees - clear pin).

Indicate your agreement with the following statement for each of the four turn conditions:

The turn anticipation function of the GPS Receiver allowed me to smoothly transition from one route segment to the next at each GPS waypoint.

<u>11A1. Turns less than 30º</u>
Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

<u>11A2. Turns between 30º and 60º</u>
Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

<u>11A3. Turns between 60º and 95º</u>
Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

<u>11A4. Turns greater than 95º</u>
Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

11B. Describe any problems you encountered in using the turn anticipation function of the GPS Receiver to transition from one route segment to the next: ______________________________

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

12. For pilots that flew both day and night flights, this question applies to the daytime flight only. All subject pilots should answer this question.

For this question, please refer to Sectional Chart B showing the PVFR Route divided into 12 sections. Each section of the route is identified by a different color of stick pin. (Note that colors are repeated.) Please rate the difficulty of flying the aircraft on each of the 12 sections of the route. Note that some pilots may have flown the route in the reverse direction. Please indicate if you flew the route in the forward or reverse direction.

Direction Flown: Forward (Section 1 through Section 12)
Reverse (Sections 12 through Section 1)

Rating Scale	Flying Difficulty
1	Very Easy
2	Easy
3	Neutral
4	Difficult
5	Very Difficult

Section Number	Stick Pin Color	Description	Rating (1-5)
1	Clear	Transition Segment from THA to PVFR Route	
2	Blue	Flight along Power Line	
3	Yellow	Segments to Avoid Simulated Restricted Area Near AEDC	
4	White	Direct Route Near But Not Directly Over State Highway 55	
5	Green	Direct Route Near But Not Directly Over I-24 Highway	
6	Red	Direct Route Generally Following the Duck River	
7	Clear	Direct Route Over Normandy Lake	
8	Blue	Direct Route with Few Visual Features for VFR Navigation	
9	Yellow	Direct Route Near But Not Directly Over Highway 276	
10	White	Direct Route with Few Visual Features for VFR Navigation	
11	Green	Flight along Power Line	
12	Red	Transition Segment from PVFR Route to THA	

PVFR Post-Test Questionnaire

Pilot No. _____________

Night Flights
(If you did not fly any night flights, please skip to Question 16A on the next page.)

13A. The PVFR Route was more difficult to fly at night than during the day.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

13B. The differences between flying the PVFR route at night and during the day are: ________

____

____

14A. Compare the amount of time your head was inside the cockpit during the Night PVFR flight with the amount of time your head was inside the cockpit during the Day PVFR flight.

Night PVFR Route requires much more time inside the cockpit
Night PVFR Route requires somewhat more time inside the cockpit
Night PVFR Route requires the same amount of time inside the cockpit
Night PVFR Route requires somewhat less time inside the cockpit
Night PVFR Route requires much less time inside the cockpit

14B. Describe why flying the Night PVFR Route required you to keep your head inside the cockpit more (or less) than flying the Day VFR Route: _________________________________

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

15. For this question, please again refer to Sectional Chart B showing the PVFR Route divided into 12 sections. This question is similar to question 12 but it applies only to the night flight.

Rating Scale	Flying Difficulty
1	Very Easy
2	Easy
3	Neutral
4	Difficult
5	Very Difficult

Rating Scale	Visibility of Features
6	Clearly Visible
7	Generally Visible
8	Sometimes Visible
9	Occasionally Visible
10	Not Visible

Section Number	Stick Pin Color	Description	Flying Difficulty Rating (1-5)	Visibility Rating (6-10)
1	Clear	Transition Segment from THA to PVFR Route		
2	Blue	Flight along Power Line		
3	Yellow	Segments to Avoid Simulated Restricted Area Near AEDC		
4	White	Direct Route Near But Not Directly Over State Highway 55		
5	Green	Direct Route Near But Not Directly Over I-24 Highway		
6	Red	Direct Route Generally Following the Duck River		
7	Clear	Direct Route Over Normandy Lake		
8	Blue	Direct Route with Few Visual Features for VFR Navigation		
9	Yellow	Direct Route Near But Not Directly Over Highway 276		
10	White	Direct Route with Few Visual Features for VFR Navigation		
11	Green	Flight along Power Line		
12	Red	Transition Segment from PVFR Route to THA		

Note: End of Night Flight Questions

PVFR Post-Test Questionnaire

Pilot No. _____________

Flight Test Environment

16A. Wearing the head and eye tracking system did not affect my operation of the aircraft or systems during the PVFR flight test.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

16B. Wearing the head and eye tracking system caused the following problems or distractions during the PVFR flight: ____

____

____

17A. The PVFR flight test environment is a realistic representation of VFR operations.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

17B. The following parts of the PVFR route could be changed to improve realism: ___________

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

Operational Opinions

18A. Most VFR helicopter pilots could operate safely in a PVFR route structure environment.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

18B. I have the following concerns about PVFR operations for the general helicopter pilot population: ____

____

____

19A. A PVFR route structure would benefit my flight operations.

Strongly Agree
Generally Agree
Neutral
Generally Disagree
Strongly Disagree

19B. A PVFR route structure in my local operational area would provide the following benefits:

____

____

____

PVFR Post-Test Questionnaire

Pilot No. _____________

20. Referring to Sectional Chart C, please identify prominent visual features of the PVFR test area that we should include in the simulation part of the PVFR evaluation. Please identify all features that you feel are important to having a realistic simulation capability. For visual features that are shown on Sectional Chart C, you may enter the number of the feature. If the visual feature is not highlighted in Sectional Chart C, please describe the feature and indicate its approximate location with respect to waypoints or another visual feature.

Thank you for participating in the PVFRSNI Flight Test Project!!

Steve Hickok	Ed McConkey	Kip Krebs (AAR-100)
STI Project Manager	STI Technical Director	FAA PVFR Project Manager

APPENDIX G

FAA ACCEPTANCE OF PVFR/SNI TEST PLAN

The flight tests and analyses identified in this test plan are designed to assess the flight technical error (FTE), navigation system error (NSE), total system error (TSE), and human factors associated with operating GPS-equipped helicopters during PVFR/SNI operations. These system error and human factors assessments address the issues that the FAA needs to resolve in order to develop policy, criteria and guidance to implement PVFR/SNI operations for helicopters.

We hereby indicate our concurrence that successful execution of this test plan should provide the necessary test results for the development of criteria and policy for the implementation of PVFR/SNI operations by helicopters in the NAS.

AFS-410 ____ Date ___________________

AFS-420 ____ Date ___________________

AAR-100 ____ Date ___________________

AAR-432 ____ Date ___________________