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I am submitting herewith a thesis written by Steven R. Girard entitled “Modernization of the United States Naval Test Pilot School's Helicopter Fleet - Replacement of the TH-6B and the OH-58C with the Bell 407 Helicopter.” I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Aviation Systems.

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**MODERNIZATION OF THE UNITED STATES NAVAL TEST
PILOT SCHOOL'S HELICOPTER FLEET - REPLACEMENT OF
THE TH-6B AND THE OH-58C WITH THE BELL 407
HELICOPTER**

A Thesis

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Master of Science

Degree

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DEDICATION

This thesis is dedicated to my wife, Robin, and son, Rick, who have shouldered the weight of many nights without my help. Additionally, this thesis is dedicated to my parents, Richard and Cecile Girard, who have always encouraged me to strive to excel and better myself so that I may better provide for my family.

ACKNOWLEDGMENTS

I wish to thank all those who have helped me in completing this thesis. I would also like to thank the staff of the United States Naval Test Pilot School for all of their help in collecting the information on the history of their current fleet of helicopters and for providing insight on the required characteristics of their replacement helicopter.

Lastly, I want to thank my family and friends, whose suggestions and encouragement made this work possible.

ABSTRACT

The United States Naval Test Pilot School (USNTPS) experienced a helicopter mishap on 05 August 2001. The USNTPS Commanding Officer believed that this mishap occurred in large part due to the extremely high workload being placed onto both the school's students and instructors. As a result of this belief, the USNTPS Commanding Officer ordered his staff to implement the following three orders:

1. Immediately reduce syllabus exercises by 10%.
2. Begin to revamp each syllabus in order to reduce the student workload by 25%.
3. Review syllabus aircraft requirements and recommend one aircraft that can be eliminated from the syllabus inventory without degradation in the school's ability to accomplish its assigned mission.

The first order was completed promptly. The second order was partially completed as a result of reducing the number of exercises in each syllabus, and by restructuring the requirements of each syllabus; however, the 25% student workload was not fully achieved. In order to achieve the desired 25% student workload reduction sought in the second order, the USNTPS Rotary Wing staff proposed that two of the helicopters currently in use during the USNTPS Rotary Wing syllabus, the TH-6B and the OH-58C, be eliminated and replaced by one helicopter that could accomplish all of the missions of the two eliminated helicopters. This proposal would complete the Commanding Officer's second order by reducing the workload associated with one aircraft and it will also satisfy the last order.

The USNTPS has acted upon the recommendation of the Rotary Wing staff and has decided to replace the TH-6B and the OH-58C, but no definite timetable has been established. A replacement time frame of fiscal year 2006 is desired. The USNTPS has several required characteristics for their replacement helicopter such as: A large flight envelope; a modern, single-piloted helicopter; modern avionics; excellent autorotational characteristics; 2 hours (minimum) endurance with a reserve; and a maximum airspeed of 120 KIAS or greater.

In the author's opinion, the helicopter that can accomplish both the TH-6B's and OH-58C's missions is the Bell 407 helicopter. This statement is based on the author's knowledge of the USNTPS and on a flight evaluation of the Bell 407 helicopter. There are potentially several other helicopters in the world today that could perform the mission required by the USNTPS; however, this thesis will deal with how the Bell 407 helicopter meets the requirements of the USNTPS Rotary Wing syllabus.

The Bell 407 helicopter is a single piloted, seven-seat, single engine, four-bladed main rotor helicopter manufactured by Bell Helicopter Canada. The maximum normal gross weight is 5,000 pounds and 6,000 pounds with an external load. The airspeed range is 0 to 140 KIAS. The Bell 407 helicopter has dual conventional controls with mechanical linkages. The cyclic, collective, and yaw flight controls are assisted by single stage servo actuators utilizing a single 1,000 pounds per square inch (psi) hydraulic system. The Allison model 250-C47B turboshaft engine delivers 674 shaft horsepower at takeoff power and is controlled via a Full Authority Digital Engine Control (FADEC) system. The main transmission is rated for 674 shaft horsepower at takeoff (5 minute limit) and 630 shaft horsepower at maximum continuous power.

Comparing the Bell 407 helicopter's characteristics against the required characteristics sought by the USNTPS, it was determined that the Bell 407 helicopter satisfies all of the required characteristics. As a result of this comparison, it is the author's opinion that the Bell 407 helicopter can successfully replace the TH-6B and the OH-58C helicopters at the USNTPS without any degradation in mission capability.

With this conclusion in mind, it is the author's opinion that the USNTPS should do the following:

1. Complete a flight evaluation, to include a full Report of Test Results, of a Bell 407 helicopter by two USNTPS instructors based on the current Rotary Wing syllabus in order to confirm the suitability of the Bell 407 helicopter's capability to perform the syllabus.
2. Based on a successful flight evaluation, select the Bell 407 helicopter as the replacement helicopter for the TH-6B and the OH-58C.
3. Using a Cost/Benefit analysis system, the USNTPS needs to determine which manufacturer supplied and commercially available accessories for the Bell 407 helicopter are required to meet the Rotary Wing syllabus exercise requirements.
4. Enter into contract negotiations with Bell Helicopter in order to purchase six Bell 407 helicopters with all applicable accessories included for use in the USNTPS Rotary Wing syllabus.

PREFACE

A portion of the information contained within this thesis was obtained during a United States Naval Test Pilot School sponsored qualitative evaluation during the keystone syllabus exercise, Development Test IIA (DT-IIA). The author's hands-on Bell 407 helicopter flight experience was gained during this exercise. The research, results and discussion, and conclusions and recommendations presented are the opinion of the author and should not be construed as an official position of the United States Department of Defense, The United States Marine Corps, The United States Navy, the Naval Air Systems Command, or the Bell Helicopter Textron Corporation.

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LIST OF ABBREVIATIONS

AD	Airworthiness Directives
AFCS	Automatic Flight Control System
AVDLR	Aviation Depot Level Repairable
DT-IIA	Developmental Test IIA
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FAR	Federal Aviation Regulations
FLIR	Forward Looking Infrared
FMC	Full Mission Capable
FY	Fiscal Year
gpm	Gallons per minute
GPS	Global Positioning System
ICS	Intercommunication System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
JP-5	Jet Propellant 5
KIAS	Knots Indicated Airspeed
LED	Light Emitting Diode
MHz	Mega Hertz
N _G	Engine Gas Generator Speed
N _P	Engine Power Turbine Speed
N _R	Rotor rpm
NATOPS	Naval Air Training and Operating Procedures
psi	Pounds per square inch
rpm	Revolutions per minute
RTR	Report of Test Results
SAS	Stability Augmentation System

SAVITAD	System for Attenuating Vibration Independent of Tuning and Dampening
SOP	Standing Operating Procedure
STC	Supplemental Type Certificate
TD	Technical Director
UHF	Ultra High Frequency
USNTPS	United States Naval Test Pilot School
USMC	United States Marine Corps
VHF	Very High Frequency

CHAPTER 1: INTRODUCTION

BACKGROUND

On 05 August 2001, the United States Naval Test Pilot School (USNTPS) suffered an aviation mishap involving an OH-58C helicopter. The USNTPS Commanding Officer believed that this mishap occurred in a large part due to the extremely high workload being placed onto both the school's students and instructors. As a result of this belief, the USNTPS Commanding Officer ordered his staff to implement the following three orders:

1. Immediately reduce syllabus exercises by 10%.
2. Begin to revamp each syllabus in order to reduce the student workload by 25%.
3. Review syllabus aircraft requirements and recommend one aircraft that can be eliminated from the syllabus inventory without degradation in the school's ability to accomplish its assigned mission.

The first order of reducing the current number of syllabus exercises by 10% was completed rather quickly and was implemented right away. As a result of this reduction and some schedule rearranging, the length of the courses at the USNTPS have been reduced from 48 weeks to the current 43 week course. The second order of reducing the student workload by 25% was partially addressed by altering the reporting requirements that the students had to complete for each exercise. Additionally, this reduction had an

added benefit of reducing the instructor workload due to the fact that the instructors would not have to grade as many reports as they had previously done prior to the mishap.

The third order of recommending one aircraft for elimination was an extremely difficult task. A unique recommendation from the Rotary Wing staff was presented to the USNTPS Commanding Officer. The recommendation was to eliminate two principal helicopters from the USNTPS Rotary Wing syllabus and replace them with one helicopter that could accomplish all of the missions presently assigned to those two principal helicopters.

STATEMENT OF THE PROBLEM

The decision to eliminate the two helicopters from the Rotary Wing syllabus has been made; however, the replacement helicopter has not been selected as of yet. The decision was to replace the TH-6B and the OH-58C helicopters with a single helicopter that can accomplish all of the current missions of these two helicopters without any degradation in mission accomplishment. It is the author's belief that the Bell 407 helicopter will be more than capable of successfully accomplishing both the TH-6B's mission as one of the two group helicopters used at the USNTPS and the OH-58C's mission as the helicopter of choice to complete high-risk instructional test techniques associated with the autorotational characteristics segment of the Rotary Wing syllabus.

DESCRIPTION OF THE UNITED STATES NAVAL TEST PILOT SCHOOL

In order to comprehend the ramifications of the Commanding Officer's orders, an understanding of the USNTPS mission and how it accomplishes that mission is required. The USNTPS mission, reference 1, is to provide "instruction to experienced pilots, flight officers, and engineers in the processes and techniques of aircraft and systems test and evaluation. The school investigates and develops new flight test techniques, publishes manuals for use of the aviation test community for standardization of flight test techniques and project reporting, and conducts special projects. USNTPS maintains its staff as a focal point of expertise providing the aviation test community with engineering and training consultation." The USNTPS accomplishes this mission essentially via three conduits: an academic, flight, and report curriculum. Each curriculum is further broken down into three syllabi: Fixed Wing, Rotary Wing, and Airborne Systems. Two classes are formed each year, one in February and one in August. Each class has a maximum of 36 students with approximately 12 Rotary Wing students, 16 Fixed Wing students, and 8 Airborne Systems students. This thesis will focus on the Rotary Wing syllabus.

The Rotary Wing academic syllabus, presented in table B-1, covers a wide spectrum of topics, which range from mathematics to report writing and everything in between. The Rotary Wing academic syllabus consists of 523 hours of classroom instruction, 24 examinations, and nine laboratory events during the 43 week long course.

The Rotary Wing flight and report syllabus, presented in table B-2, essentially divides the 43 week course into four segments: Performance, handling qualities, autorotational characteristics, and system evaluations. The Rotary Wing flight syllabus consists of 74 flights for pilots and 38 flights for engineers. The number of flights

presented are those merely needed to accomplish the required syllabus, and do not include the flights required for pilots to maintain currency in the aircraft, proficiency in the syllabus's maneuvers, or those required to meet United States Naval flight minimums such as instrument or night proficiency.

Three main types of helicopters are used to complete the Rotary Wing flight syllabus: H-6, H-58, and H-60. Of these three main types of helicopters used, they can be further broken down into five models of helicopters: TH-6, OH-58, UH-60, SH-60, and NSH-60. In reality though, the Rotary Wing flight syllabus requires six series of helicopters to complete its mission: TH-6B, OH-58C, UH-60A, UH-60L, SH-60B, and SNH-60B. Additionally, the Rotary Wing syllabus pilots are also qualified in the C-12 aircraft, which is a twin-engine turboprop aircraft. The two main type/model/series helicopters used in the core of the USNTPS Rotary Wing syllabus are the TH-6B and the UH-60A/L helicopters, which are referred to as the "group" helicopters. The group helicopters are able to conduct flights in both the performance and handling qualities segments; however, neither is used for the flights in the autorotational characteristics segment. The only helicopter used for the flights in the autorotational characteristics segment is the OH-58C. The students are not required to maintain a current Naval Air Training and Operating Procedures (NATOPS) qualification in the OH-58C, but they are required to know the helicopter's systems, limitations, normal and emergency procedures, and the specific standing operating procedures (SOP) for these flights.

The OH-58C may be utilized as a substitute helicopter in the performance or handling qualities segments in the event of a serious helicopter availability shortage. However, the OH-58C has a potentially deadly characteristic that requires an operating

restriction during the handling qualities segment. The potentially deadly characteristic is the OH-58C's teetering rotor system and the operating restriction is that no helicopter with a teetering rotor system shall conduct any open loop testing at the USNTPS. A teetering rotor system is defined in reference 2 as a rotor in which "The blade axes remain fixed relative to one another. The entire rotor tilts relative to the shaft." Open loop testing, as defined in the USNTPS Flight Test Manual 107, Rotary Wing Stability and Control, reference 3, is "testing that is conducted without the pilot actively managing the flight controls. The objective of open loop testing is to determine and quantify the stability and control characteristics of the aircraft. In open loop testing, the pilot makes one input into the aircraft through the flight controls and the response is observed." This operating restriction was unfortunately learned the hard way at the USNTPS. A series of three mishaps occurred several years ago during open loop testing conducted in the AH-1G/S model helicopter, which has a teetering rotor system, and resulted in three deaths at the school. From that time forward, the USNTPS has restricted open loop testing on helicopters with teetering rotor systems, which essentially all but restricts this type of helicopter from performing the maneuvers necessary to successfully instruct the handling qualities segment of the Rotary Wing flight syllabus.

The Rotary Wing report syllabus consists of 29 reports during the 43 week course. The 29 reports are comprised of a mixture of test plans, Report of Test Results (RTR), partial RTRs, Dailies, Yellow sheets, and oral briefs.

DESCRIPTION OF THE USNTPS FOUR CORE ROTARY WING SYLLABUS SEGMENTS

General

The USNTPS Rotary Wing syllabus is essentially divided into four segments: Performance, handling qualities, autorotational characteristics, and system evaluations. The performance and handling qualities segments are completed using either of the group helicopters (TH-6B and UH-60A/L), the autorotational characteristics segment is completed using the OH-58C, and the system evaluations segment is completed using the SH-60B helicopter and the P-3 Orion aircraft.

Performance Segment

The performance segment of the USNTPS Rotary Wing syllabus is usually conducted using the TH-6B and the UH-60A/L. The initial performance demonstration flight is normally completed using the opposite group helicopter than the student will use for the remainder of the performance segment. This is done in order to expose the students to both group helicopters early on in the course. The remaining performance flights, which include engine assessment, hover/vertical climb performance, level flight performance, and forward flight climb and descent performance are completed using the group helicopter. The final performance progress check, which is an all-encompassing check ride from preflight brief to a post-flight analysis of test day data, is completed

using the group helicopter. As previously stated, the OH-58C may be substituted for a group helicopter in the performance segment of the flight syllabus during times of serious group helicopter availability issues. The actual performance capabilities of the group helicopters are not the overall issue during this segment of training. The important issue is the test techniques themselves; however, conducting performance testing on a modern helicopter would be beneficial.

Handling Qualities Segment

The handling qualities segment of the USNTPS Rotary Wing syllabus is conducted with the group helicopter and focuses on the forward flight longitudinal and lateral-directional handling qualities test techniques as well as the low airspeed handling qualities test techniques. The OH-58C is not used for any open loop testing during this segment due to the restriction placed on it because of its teetering rotor system. If the OH-58C is used during the handling qualities segment of the USNTPS Rotary Wing syllabus, major restrictions are put into place that severely limit the school's ability to accomplish its mission during this segment of training. Additional helicopters and airplanes are utilized at the school to round out the flying qualities segment. For example, the NSH-60B, which is a variable stability helicopter, is used during low airspeed handling qualities test technique instruction to demonstrate real time how the change of stability derivatives influences the helicopter's handling qualities. Another example is the variable stability Learjet, which is used to demonstrate how different types

of controls, control laws, and stability derivatives influence the handling qualities of an airplane.

Autorotational Characteristics Segment

The autorotational characteristics segment of the USNTPS Rotary Wing syllabus is conducted using only the OH-58C helicopter. Although the OH-58C and its teetering rotor system has a major drawback during open loop testing known as mast bumping, the OH-58C is a remarkably well-behaved helicopter in the realm of autorotations, as evidenced by its use as a primary trainer for both the United States Army and United States Navy. The OH-58C helicopter is not without other drawbacks though. The OH-58C is susceptible to a phenomenon known as “spike knock”, which occurs when the helicopter lands incorrectly and the spike mounted to the bottom of the helicopter’s main transmission comes into contact with the surrounding structure. This “spike knock” is audible to the aircrew and, if heard, requires that the helicopter remain on the ground, terminating the flight, and receive a visual inspection by qualified maintenance personnel prior to the next flight. The visual inspection results can range from no further maintenance action required on one end of the spectrum to a replacement of the drive train on the other end. The autorotational characteristics segment consists of only three flights: a warm-up flight, an Autorotational Landing Assessment flight, and a Height-Velocity Diagram flight. Although only three flights, this segment of the USNTPS Rotary Wing syllabus is extremely important due to its introduction of high-risk test methodology. As a result of this type of training, the requirement exists to have a

helicopter that will allow a student to be able to intentionally deviate from the operating manual's recommended autorotational procedures and still be able to safely execute an autorotation to the ground.

System Evaluations Segment

The system evaluations segment of the USNTPS Rotary Wing syllabus is conducted without using the group helicopters, but instead using the SH-60B's radar and a nose mounted Forward Looking Infrared (FLIR) system on the USNTPS's specially configured P-3 Orion airplane. The TH-6B has a FLIR system that can be mounted to the right side of the helicopter; however, due to the FLIR being an obsolete first generation FLIR system and the limitations of the mounting system, the current TH-6B/FLIR combination is not satisfactory for meeting the school's system evaluations segment. As a result, the USNTPS Rotary Wing syllabus must now depend on the school's single, highly tasked P-3 Orion to complete its system evaluations segment.

HELICOPTERS TO BE REPLACED AT THE USNTPS

Description of the TH-6B

The TH-6B helicopter is a four-place, single engine observation helicopter manufactured by McDonnell Douglas Helicopter Systems (formerly Hughes Aircraft).

The principal dimensions of the TH-6B are presented in figure A-1. The maximum gross weight of the TH-6B is 2,550 pounds. The airspeed range is 0 to 120 KIAS.

The flight control system consists of dual conventional controls, which are reversible, unaugmented and unboosted. The flight control system is not designed to eliminate inherent control coupling or to provide any automatic stabilization. The cyclic pitch control system is fully mechanical incorporating a one-way hydraulic lock assembly that is designed to shunt aft feedback forces from the main rotor to preclude aft movement of the cyclic. The pilot's cyclic control incorporates manual friction controls in the longitudinal and lateral axes. The cyclic grip incorporates an electrically operated trim system that is designed to reduce stick forces at an established trim position. A four-position switch located on the top of the cyclic activates the trim system. The dual cyclic sticks are linked by push-pull rods to the cyclic longitudinal and lateral control mixers, which are connected to the main rotor swashplate. The pilot's collective pitch stick incorporates a friction control grip that is designed for adjustment to prevent stick creep and to increase forces opposing motion. The collective control system also includes a bungee type overcenter spring that is designed to maintain a fairly constant collective stick load throughout the full range of travel. The two collective pitch sticks are mechanically interconnected and linked to the main rotor swashplate to control the main rotor blade pitch. Helicopter directional control is achieved through either the pilot or copilot's tail rotor pedals. The tail rotor control system provides heading and anti-torque by controlling pitch of the tail rotor blades. The pedals are adjustable fore and aft approximately five inches via one of three predetermined pinned positions to accommodate varying pilot leg length.

The helicopter has three fixed airfoils on the tailboom: an upper vertical stabilizer, a lower vertical stabilizer, and a horizontal stabilizer mounted at a 25 degree angle upward from the horizontal. The horizontal tail is designed to increase longitudinal stability and to help maintain a level attitude in forward flight. The upper vertical fin has a 5 degree offset and is designed to improve the tail rotor neutral position in flight. The vertical stabilizers are designed to increase lateral stability and to minimize yaw during forward flight.

The TH-6B has a T63-A-720 turboshaft engine mounted in the aft fuselage section directly behind the cabin and the engine is rated at 420 shaft horsepower (installed) at sea level, standard day conditions. The main transmission has a two-stage reduction unit that limits the maximum power applied to 278 shaft horsepower. The main rotor system consists of four rotor blades with a diameter of 26.4 feet, and the main rotor blades are attached to a fully articulated rotor hub with approximately 3 degrees of offset. The tail rotor assembly consists of a highly cambered, two-bladed, semi-rigid, delta hinged, teetering rotor system mounted on the left side of the tailboom. The helicopter uses an oleo damped, skid-type landing gear. A more detailed description of the TH-6B is contained in the Hughes 500 Model 369HE Owner's Manual, reference 4 and the TH-6B Pilot's Flight Manual Supplement, reference 5.

Positive Characteristics of the TH-6B

The TH-6B has served the USNTPS Rotary Wing syllabus well over the last 12 years. Its side-by-side layout offers a good instructional environment. The TH-6B has

also been a stable group helicopter capable of supporting two of the four segments of the syllabus (performance and handling qualities) and at one time, three of the four segments of the syllabus (performance, handling qualities, and system evaluations). The TH-6B has less than desirable handling qualities; however, this characteristic actually makes the TH-6B a very good teaching tool. The poor handling qualities are readily apparent to the students, which allows the students to quickly absorb the learning objectives of the handling qualities segment of the Rotary Wing syllabus.

Negative Characteristics of the TH-6B

Although the TH-6B has served the USNTPS Rotary Wing's syllabus well over the last 12 years, it was never meant to. The TH-6B was only intended to be a stopgap helicopter after the USNTPS was forced to return its HH-65 Dauphins to the United States Coast Guard. A negative characteristic of the TH-6B is that it is an old commercial helicopter, which has extremely limited support from the manufacturer due to the helicopter's age and its relatively small numbers left in use today. Another negative characteristic of the TH-6B is that the main rotor is easily oversped and it tends to enter into blade stall during maneuvering flight. The helicopter has an extremely large friction band, which severely restricts its ability to repeat precise data points required by the syllabus. The light gross weight of the TH-6B restricts the cargo capability and with a fully instrumented helicopter needed for the core segments of the syllabus, the TH-6B can only hold a maximum of 50 pounds of cargo. The TH-6B also has a center of gravity problem. The TH-6B is very nose heavy, which reduces some capability during

performance and handling qualities instruction and has a major impact during the system evaluations segment. Instead of mounting the FLIR system under the nose of the helicopter, the FLIR system has to be mounted on the right side of the helicopter abeam the main transmission, which restricts the field of view of the FLIR. Spare parts availability and cost have become major factors in the last few years as well. Full mission capable (FMC) rates, defined at the USNTPS as a helicopter with or without maintenance pending able to complete the assigned instructional syllabus mission, has been abysmal over the last three fiscal years (01 Oct to 30 Sep). FMC rates for the last three complete fiscal years (FY) for the six TH-6Bs at the USNTPS are listed below:

FY00:	59.1%
FY01:	56.0%
FY02:	74.6%

The FMC rates of the TH-6B listed above are based on a statistically significant number of flight hours.

FY00:	1086.1 hours
FY01:	971.7 hours
FY02:	1155.4 hours

As such, they give an accurate depiction of the reliability, or the lack thereof, of the TH-6B over the last three fiscal years. The abysmal FMC rates also confirm that of the six TH-6Bs at the USNTPS, typically only four are ready for flight, while the other two TH-6Bs are being used as parts helicopters in order to keep the rest of the fleet in the air.

Another indication that the TH-6B is aging is seen in its rising average operating cost per flight hour. The average cost per flight hour, which includes direct and indirect

maintenance, fuel, oil, fuel delivery contract costs, labor, consumables, parts, and aviation depot level repairable (AVDLR) costs for the last three complete fiscal years are listed below:

FY00:	\$1,220/flight hour
FY01:	\$1,422/flight hour
FY02:	\$1,725/flight hour

The cost to operate all six of the USNTPS's TH-6Bs in FY02 was an amazing two million dollars. A complete breakdown of the TH-6B's costs, as reported by the USNTPS, is presented in table B-3.

Description of the OH-58C

The OH-58C helicopter is a multi-place, single engine observation helicopter manufactured by Bell Helicopter. The principal dimensions of the OH-58C are presented in figure A-2. The maximum gross weight of the OH-58C is 3,200 pounds. The airspeed range is 0 to 120 KIAS.

The flight controls are a positive mechanical type system activated by dual conventional controls. The cyclic stick includes an electronically operated cyclic force trim that is designed to prevent cyclic movement from the selected trim position. A transmission mounted hydraulic pump powers the hydraulic servo cylinders that are connected to the control system's mechanical linkage and are designed to reduce cyclic control forces to almost zero.

The fuselage is a semi-monocoque design that consists of the forward section, intermediate (transition) section, and the aft (tailboom) section. The forward section consists of the cabin compartment, fuel cell enclosure, and pylon support structure. The intermediate section supports the engine and includes the equipment and electronic compartments. The aft (tailboom) section is an aluminum monocoque design that supports the tail rotor, tail rotor drive train, and the vertical and horizontal stabilizers. The vertical stabilizer has a steel tube attached on the bottom that provides protection for the tailboom from ground contact.

The OH-58C has an Allison T63-A-720 turboshaft engine rated at 420 shaft horsepower (installed) and transmits power to the transmission main driveshaft and tail rotor through a freewheeling unit. The transmission is mounted on the cabin roof deck, forward of the engine and transfers engine power to the main rotor through the mast assembly. The transmission pylon support structure is designed to focus the transmission loads at the airframe center of gravity, reduce vertical vibration, and eliminate transmission induced rolling moments. The isolation mount is designed to dampen transmission-to-fuselage vibrations and limit pylon rock. Movement of the transmission and isolation mount is limited by the drag pin (spike), which extends down into the transmission mount support mounted on the deck. Contact between the drag pin (spike) and the transmission mount is designed to produce a noise known as “spike knock”. The main rotor system is a two bladed, semi-rigid, seesaw type rotor with an under-slung feathering axis hub that rotates at 354 rpm. A more complete description of the OH-58C helicopter can be found in the OH-58C Operator's Manual, reference 6.

Positive Characteristics of the OH-58C

The OH-58C helicopter is a very good autorotational helicopter, which only fulfills a unique requirement at the USNTPS. The OH-58C is able to enter autorotations from a wide range of airspeeds and altitudes and safely complete an autorotation to the ground. A few other positive characteristics of the OH-58C with regards to its autorotational characteristics are the helicopter's low gross weight, low rate of descent, high inertia rotor system, and its relatively easy to fly autorotational profile. Additionally, the OH-58C affords the instructor a wide margin of safety during the high-risk autorotational characteristics segment of the USNTPS Rotary Wing syllabus, which facilitates the educational opportunities of this particular segment of the syllabus.

Negative Characteristics of the OH-58C

The OH-58C helicopter is not without flaws. As previously stated, the OH-58C is prohibited from conducting open loop testing at the USNTPS. This prohibition reduces the OH-58C's role at the USNTPS. Additionally, during the autorotational characteristics segment of the USNTPS Rotary Wing syllabus, the OH-58C typically suffers either a transmission overtorque or a "spike knock" during each class. Even with these negative characteristics taken into account, the OH-58C is still a very good helicopter for use during the autorotational characteristics segment; however, it is only useful during this one particular segment of the syllabus. As a result of its use for only one of the four segments of the USNTPS Rotary Wing syllabus, the OH-58C is actually only used for three flights during the 74 flight Rotary Wing syllabus. Three out of 74 flights or 4%

planned usage. A 4% planned usage rate does not justify a helicopter with an average cost per flight hour of \$1,457 for FY02. A complete breakdown of the OH-58C's costs, as reported by the USNTPS, is presented in table B-4.

REQUIRED CHARACTERISTICS OF THE REPLACEMENT HELICOPTER

In order to accurately determine what the USNTPS requires for its replacement helicopter, the USNTPS Technical Director (TD), Mr. L. Scott, reference 7, was asked to define the required characteristics that the USNTPS wanted for their replacement helicopter. During this interview, the USNTPS TD stated that the decision to go forward with a replacement helicopter has already been made and no definite timetable has been established; however, a FY06 helicopter purchase date is highly conceivable. Using a FY06 purchase date, it is realistic to say that only currently fielded helicopters will be viable for the replacement helicopter. The USNTPS TD also provided a list of the required characteristics of a potential replacement helicopter:

1. Large flight envelope (0 to 2.0 load factor)
2. Maximum airspeed of 120 KIAS or greater
3. 1,000 pounds (minimum) of cargo capacity
4. External hook capability
5. Excellent autorotational characteristics
6. Single pilot capability
7. Modern aircraft
8. Force trim system*
9. Automatic Flight Control System (AFCS)*
10. Minimum 2 hours of endurance with a reserve
11. Cabin
12. Intercommunication System (ICS) in the cabin
13. Instrument Flight Rules (IFR) capable
14. 2 radios (1 UHF/1VHF)
15. An IFR certified Global Positioning System (GPS)

16. Transponder with Mode C
17. Capability to mount a Forward Looking InfraRed (FLIR) system
18. An established flight school

*Desired characteristic, but not a required characteristic.

This list of requirements provides both broad and specific requirements, and some requirements are even implied. The broad requirements are included to allow for a wide range of competitors. It is important to note that the number of engines required or a definite gross weight is not specifically defined; yet these characteristics are constrained by the requirement to have excellent autorotational characteristics.

Two implied requirements are cost and maintainability/supportability. No broad or specific requirement was given for cost of the replacement helicopter or average cost per flight hour; however, the purchase price of the replacement helicopter must be within reason and the average cost per flight hour should be realistic as well. For a realistic average cost per flight hour estimate, a weighted average based on the TH-6B and the OH-58C usage rates will be used. The USNTPS FY02 average cost per flight hour rates were \$1,725 for the TH-6B and \$1,457 for the OH-58C. Using two-thirds of the TH-6B's and one-third of the OH-58C's average cost per flight hour rates results in an average cost per flight hour of \$1,635. In the author's opinion, this estimate is an economically feasible figure. The replacement helicopter's average cost per flight hour should not be any higher than this amount and preferably lower. Maintainability/Supportability are implied through the requirement for a modern helicopter. Parts availability should not be an issue as it currently is for the TH-6B, and FMC rates, although not stated, should be at least 85% as a threshold and 95% as an objective.

The most important characteristic to remember when the time comes to select the replacement helicopter for the USNTPS Rotary Wing syllabus is the mission that the helicopter will perform. The replacement helicopter must be able to efficiently and safely conduct the entire spectrum of performance, handling qualities (to include open loop testing), autorotational characteristics, and system evaluations instruction.

CHAPTER 2: REVIEW OF THE LITERATURE

The only known aviation system requirements comparison of the Bell 407 helicopter for fulfilling the role as a primary helicopter in the USNTPS Rotary Wing syllabus was compiled by Major T. S. Caudill, United States Marine Corps (USMC), who was an instructor at the USNTPS. Major Caudill wrote a point paper entitled “Replacement of the OH-58C and TH-6B with a Single Type Model”, appendix C. This point paper compiles a brief history of the move to reduce the type/model/series of aircraft at the USNTPS. The point paper also affords a quick, first look at the capabilities of the Bell 407 helicopter and how it would fit into the USNTPS Rotary Wing syllabus.

The flight manuals for the TH-6B, OH-58C, and the Bell 407 helicopter were used in building the helicopter descriptions. The Bell 407 helicopter also has a Product Data manual and a Product Specifications manual that aided in the description of the Bell 407 helicopter.

The Internet was used extensively for information about the Bell 407 helicopter’s Type Certificate, Supplemental Type Certificates, and Airworthiness Directives.

Additionally, an article appeared in Business & Commercial Aviation, Feb 2001 issue that summarized a survey of Bell 407 helicopter operators.

CHAPTER 3: METHODOLOGY

This section will discuss the author's methodology used to evaluate the Bell 407 helicopter as a replacement for the TH-6B and the OH-58C helicopters at the USNTPS. Before going over the author's methodology, it is important to note that the author did not consider any other helicopters for the replacement helicopter besides the Bell 407. This is due to the fact that the author was able to fly the Bell 407 helicopter during a USNTPS sanctioned syllabus event in 2001. This flight in the Bell 407 helicopter along with many discussions with Major Caudill and other pilots who have flown the Bell 407 helicopter, led the author to write this thesis. When the time comes for the USNTPS to purchase a replacement helicopter, the approved United States Navy acquisition strategy will have to be followed, which should include proposals from several competitors. It is the author's belief that the Bell 407 helicopter will be among these competitors. With that being said, the following list was the thought process used by the author in completing this thesis:

1. Provide the background that has lead the USNTPS to come to the realization that it is time to find a single replacement helicopter that can fulfill not only the TH-6B's and OH-58C's missions, but also fill the current gap in helicopter system evaluations instruction.
2. Describe the USNTPS mission, how the school accomplishes its mission, and the aircraft used to accomplish the mission.
3. Describe the helicopter characteristics required by the USNTPS in order to accomplish its mission.

4. Describe the Bell 407 helicopter.
5. Discuss how the Bell 407 helicopter meets the USNTPS's required helicopter characteristics.
6. Provide conclusions and recommendations concerning the use of the Bell 407 helicopter in the USNTPS Rotary Wing syllabus.

In order to complete the actions listed above, several research methods were utilized such as personal interviews, phone interviews, and personal flight experience in the discussed helicopters. An item that unfortunately does not appear in this thesis is actual Bell 407 helicopter test data. The author attempted to get handling qualities and autorotational data plots from Bell Helicopter Canada for approximately 18 months with no success. These data plots contained propriety information, which was not releasable by Bell Helicopter Canada and not permitted for use within this thesis. Several attempts were made to generalize the data plots, but a successful resolution was not found. It is important to note that a potential buyer of the Bell 407 helicopter will have access to these data plots. These data plots would be extremely useful for the USNTPS because the data plots will tell, in engineering terms, how the helicopter performs. To the average corporate buyer, engineering data plots probably do not mean much, but to the staff at the USNTPS, these engineering data plots are a staple of how they accomplish their mission and will be a great aid in determining the suitability of the Bell 407 helicopter for the USNTPS Rotary Wing syllabus.

CHAPTER 4: RESULTS AND DISCUSSION

DESCRIPTION OF THE BELL 407 HELICOPTER

The Bell 407 helicopter is a single piloted, single engine, turbine powered helicopter manufactured by Bell Helicopter Canada, a division of Textron Canada Ltd. The principal dimensions of the Bell 407 helicopter are presented in figure A-3. The maximum standard gross weight of the helicopter is 5,000 pounds and 6,000 pounds with an external load. The airspeed range is 0 to 140 KIAS.

The flight control system consists of dual conventional controls with mechanical linkages using push-pull control tubes and bellcranks. The cyclic controls consist of two control sticks, torque tubes, two hydraulic servo actuators, control tubes, and bellcranks. Servo actuators are incorporated to minimize the effort required to move the controls and to reduce main rotor feedback forces. The cyclic fore and aft movement is fed through a cam assembly that automatically adds an amount of lateral cyclic input that is a percentage of the fore and aft cyclic movement. A spring canister is provided in line with the cam input to permit cyclic movement in the event that the cam assembly becomes jammed. A balance spring is used within the cyclic system to minimize the cyclic stick mass imbalance forces in the longitudinal and lateral control system. A cyclic friction adjustment wheel is located at the base of the pilot's control stick. The collective pitch controls consist of two collective sticks, jackshaft, control tubes, bellcranks, and a hydraulic servo actuator. An adjustable friction bearing is incorporated into the collective pitch control system that allows the pilot to adjust the friction to his own

requirements. A minimum friction adjustment clamp ensures that the collective stick will always have a preset minimum friction. The collective controls are tied to the mixing lever of the cyclic controls via a collective trunnion and lever installed between the collective jackshaft and control tube. The directional flight control system is a conventional push-pull type system that incorporates a hydraulic servo. A pedal adjuster is included in the system and allows for up to four and one half inches of longitudinal travel. The main rotor cyclic, collective, and yaw flight controls are assisted by single-stage servo actuators utilizing a single hydraulic system. The hydraulic system delivers a maximum volume flow of 2.85 gallons per minute (gpm) at an operating pressure of 1,000 psi with a rotor rpm (N_R) of 100%. The hydraulic system is electrically held off so that in the event of a complete electrical failure, the hydraulic system will fail to the ON position, creating a fail-safe mode.

The tailboom supports the tail rotor drive shaft, tail rotor gearbox, vertical fin, and horizontal stabilizer. The horizontal stabilizer is a non-moveable elevator set to give an aerodynamic down force at normal cruise airspeed. The horizontal stabilizer has leading edge slats that are designed to improve the airflow conditions at high angles of attack and slow airspeeds. Auxiliary fins are installed on the outboard edges of the horizontal stabilizer to help the helicopter stay stable in flight. Both auxiliary fins are angled 5 degrees leading edge outboard. The vertical fin contains mounting provisions for the anticollision light and the tailskid. The vertical fin is mounted 9 degrees leading edge outboard (right) and is designed to relieve the tail rotor in forward flight and to prevent flapping.

The Bell 407 helicopter has an Allison model 250-C47B turboshaft engine. The engine has a single-stage centrifugal flow compressor, a single combustion chamber, a two-stage gas producer turbine, and a two-stage power turbine. The Allison model 250-C47B turboshaft engine delivers 674 shaft horsepower during takeoff and 630 shaft horsepower at maximum continuous power. The engine has a Full Authority Digital Engine Control (FADEC) system. The FADEC system provides several features to aid in starting, normal operations, and maintainability such as gas generator (N_G) governing, power turbine (N_P) governing, exceedence limiting, surge detection and recovery, autorelight, automatic start, system built in test, power up functional check, continuous functional check, overspeed functional test, failure enunciation, engine condition monitoring, and N_G and N_P overspeed protection. The engine is horizontally installed aft of the transmission above the fuselage. The engine is connected to the transmission by a freewheeling unit and a main driveshaft.

The main transmission is rated for 674 shaft horsepower at takeoff (5 minute limit) and 630 shaft horsepower at maximum continuous power. The main transmission is mounted on a soft mounted System for Attenuating Vibration Independent of Tuning and Dampening (SAVITAD) pylon assembly. The SAVITAD pylon assembly is used to decrease the vibration transfer from the main rotor to the helicopter structure. The standard usable fuel capacity is 127.8 US gallons. The landing gear consists of two skids attached to two arched cross tubes. The landing gear comes in either low skid (16 inches of ground clearance) or high skid (24-3/4 inches of ground clearance). A more detailed description of the Bell 407 helicopter is contained in the Bell 407 Product Data Manual, reference 8, and the Bell 407 Rotorcraft Flight Manual, reference 9.

COMPARISON OF THE BELL 407 WITH THE USNTPS'S REQUIRED CHARACTERISTICS

General

Now that a description of the Bell 407 helicopter has been presented, a comparison with the USNTPS's required characteristics for their replacement helicopter will be presented. Each required characteristic will be addressed individually so that a direct comparison with the Bell 407 helicopter can be made. Some comparisons will not require any elaboration while others will require a great deal of elaboration due to their opinionated view. All of the Bell 407 helicopter information is based on material provided by Bell Helicopter Textron or its employees unless otherwise specified. All cost comparisons are based on 2002 figures unless otherwise noted.

Large Flight Envelope (Load factor of 0 to 2.0)

The Bell 407 helicopter's flight envelope is cleared for a load factor of 0 to 2.0, which meets the USNTPS's required performance.

Maximum Airspeed of 120 KIAS or Greater

The Bell 407 helicopter's maximum airspeed is 140 KIAS, which meets the USNTPS's required performance.

1,000 Pounds (minimum) of Cargo Capacity

The Bell 407 helicopter's empty gross weight in the standard configuration is 2,653 pounds. The standard configuration is defined as the 7-place upholstered interior with individual seat belts, carpeting, and soundproofing material. Ballast is not included in the standard configuration since it is a function of the installed optional equipment. Additionally, 13 pounds of oil is included in the standard configuration weight. The standard usable fuel capacity is 127.8 US gallons. Using JP-5 fuel at 6.8 pounds/gallon, the standard usable fuel weight is 869 pounds. The typical flight at the USNTPS consists of two individuals, which are assumed to weigh 200 pounds each with standard summer flight gear. Using the Bell 407 helicopter's standard maximum gross takeoff weight of 5,000 pounds, the basic cargo capacity is 1,078 pounds, table 1. The USNTPS will most likely incorporate several optional accessories into their helicopters to meet the requirements of the Rotary Wing syllabus. These optional accessories come at a price, helicopter weight and cost. In the author's opinion, the optional accessories with their respective weights, listed in table 2, should be added to the basic Bell 407 helicopter.

Table 1
Basic Cargo Capacity of the Bell 407 Helicopter

Item	Weight (pounds)
Standard maximum gross takeoff weight	5,000
Standard configuration weight	- 2,653
Standard usable fuel capacity weight	- 869
Standard crew weight (2 at 200 pounds each)	- 400
Bell 407 helicopter cargo capacity (basic)	1,078

Table 2
Bell 407 Helicopter Optional Accessories and Their Weights

Item	Weight (pounds)
High skid gear with flight steps	32.1
Dual controls	12.3
Aft audio ICS – 3 station with 3 headsets and drop cords	8.6
Transponder provisions (KT-76A) Mode C	0.9
Transponder equipment (KT-76A) Mode C	2.5
Encoding altimeter w/avionics master switch	2.3
Particle separator with bleed air network	17.0
Engine fire detection	2.0
Cargo hook provisions	4.2
Cargo hook equipment	16.7
Rotor brake	5.5
Cargo restraint internal provisions	1.9
28 Amp Hour battery	24.9
Windows (2), sliding passenger	2.5
Bleed air heater w/ chin bubble defroster	22.6
Paravon blade folding kit w/2 expandable bolts	1.8
Wire strike kit	12.1
Avionics weight (1 VHF/1 UHF/1 GPS) (approximate)	50.0
Utility seating and interior trim	- 41.4
Total Additional Weight of Optional Accessories	178.5

Subtracting the optional accessories listed above from the 1,078 pound basic cargo capacity gives a total cargo capacity of 900 pounds. Bell Helicopter does offer an optional accessory that increases the helicopter gross weight to 5,250 pounds. The 5,250 pound gross weight option has no weight penalty associated with it. If this optional accessory is purchased, the cargo capacity would be 1,150 pounds (900 + 250). The USNTPS will add an instrumentation package to their replacement helicopter in order to meet the needs of the Rotary Wing syllabus. Currently, the instrumentation package in the TH-6B weighs approximately 150 pounds. The exact weight of the replacement helicopter's instrumentation package can only be approximated at this point, but 150

pounds is a very realistic figure to use. Taking into account the instrumentation package weight into both the cargo capacity of the 5,000 and 5,250 pound maximum gross takeoff weights, the Bell 407 helicopter's cargo capacity is approximately 750 pounds (900 – 150) and 1,000 pounds (1,150 – 150) respectively. With the incorporation of the 5,250 pound gross weight option, the Bell 407 helicopter meets the USNTPS required characteristic. Without the 5,250 pound gross weight option, the Bell 407 helicopter does not meet the USNTPS required cargo capacity characteristic. However, in the author's opinion, a 750 pound cargo capacity after a planned 150 pound instrumentation package has been included is sufficient to satisfy the USNTPS Rotary Wing syllabus requirements. To put this issue into perspective, the TH-6B currently has a 50 pound cargo capacity with the instrumentation installed. The cargo is used to vary the helicopter gross weight in order to achieve a data spread in certain performance exercises. To say that the current 50 pounds of cargo in the TH-6B is sufficient to achieve an adequate data spread caused by gross weight is not realistic. Even though the Bell 407 helicopter, without the 5,250 pound gross weight option, falls short of the desired 1,000 pounds of cargo by 250 pounds, the 750 pounds of cargo will be more than adequate to achieve a substantial gross weight spread for the appropriate performance exercises.

External Hook Capability

The Bell 407 helicopter has an external hook capability. The external hook is a Bell Helicopter optional accessory that must be purchased. The external hook has a rated capacity of 2,646 pounds and is mounted beneath the helicopter, near the center of

gravity. The external hook incorporates an electrical release located on the pilot's cyclic stick and a mechanical release located between the pilot and copilot seats.

Excellent Autorotational Characteristics

Of all of the USNTPS's required characteristics, the requirement to have excellent autorotational characteristics is the most important and unfortunately the hardest to quantify without actual data plots. The Bell 407 helicopter has excellent autorotational characteristics. This statement is an opinionated statement based on the author's flight experience in the Bell 407 helicopter, on the opinion of Mr. R. Viola, who is the lead Bell 407 helicopter instructor at the Bell Helicopter Training Academy, reference 10, and on the opinion of several other pilots, references 11 and 12, who have flown the Bell 407 helicopter specifically to evaluate the helicopter for its autorotational characteristics. The author believes that it is important to emphasize this fact by providing the answer Major Caudill, reference 13, gave to the question of whether the Bell 407 helicopter is able to successfully complete the USNTPS autorotational characteristics segment of the Rotary Wing syllabus. Major Caudill's answer to the question posed was "The Bell 407 helicopter will be able to be successfully integrated into the autorotational characteristics segment of the Rotary Wing syllabus." At the time of the interview, Major Caudill was the USNTPS instructor responsible for the instruction of the autorotational characteristics segment. Additionally, Major Caudill had the responsibility of certifying the instructors as qualified to instruct the autorotational characteristics flights.

The Bell 407 helicopter will also provide the USNTPS a few additional benefits compared to the OH-58C such as better waveoff capability through the FADEC system and reduced maintenance requirements due to the elimination of the “spike knock” phenomenon. The Bell 407 helicopter is able to enter autorotations safely throughout its entire airspeed range and throughout the takeoff, enroute, and landing phases of flight. The Bell 407 helicopter will provide the instructor pilot a sufficient safety margin in order to safely recover from a non-optimal flight profile. Mr. Moran, reference 12, expressed some concern about the Bell 407 helicopter’s performance during the final portion of an autorotation. The concern was that the Bell 407 helicopter will not be as forgiving as the OH-58C during the landing phase of touchdown autorotations. Mr. Moran’s concern is a valid concern based on the fact that the Bell 407 helicopter bleeds off rotor rpm at the bottom of an autorotation faster than the OH-58C. This faster rotor rpm bleed off will not allow as much room for error as the OH-58C provides, but as noted by Mr. Viola, the Bell 407 helicopter flies practically the same during low rotor rpm conditions as it does at its designed rotor rpm.

The autorotational characteristics segment of the USNTPS Rotary Wing syllabus is the most demanding of the segments from a pilotage standpoint for the student pilots and some student pilots have problems. A risk mitigation factor presented to Mr. Moran was the fact that if the Bell 407 helicopter were selected as the replacement helicopter for the USNTPS, the Bell 407 helicopter would be a group helicopter. The implication of this fact is that the student pilots will be very proficient at flying the helicopter as compared to flying the OH-58C. Typically, the student pilots have only 3 flights in the OH-58C! The first flight is a refresher flight where the student pilots literally do nothing

but autorotations for two hours. The second and third flights are autorotational characteristic instructional flights. With the Bell 407 helicopter being a group helicopter, the student pilots will fly the helicopter several times each week thereby increasing their overall proficiency in the helicopter. Additionally, the students will have also gone through an established flight school and received primary flight training in the Bell 407 helicopter prior to arriving at the USNTPS.

Considering all of these factors, it is the author's opinion that the Bell 407 helicopter has excellent autorotational characteristics and will definitely meet the requirements of the Rotary Wing syllabus.

Single Pilot Capability

The Bell 407 helicopter is single pilot capable from the right seat. The single pilot capability will allow for Rotary Wing student pilots to fly exercise events with non-pilot Rotary Wing student engineers.

Modern Aircraft

The Bell 407 helicopter was certified in 1996 under Federal Aviation Regulations (FAR) Part 27 and 36, Appendix J and was approved under Canadian Airworthiness Manual Chapter 516. This in itself does not make it a modern aircraft. The Bell 407 helicopter is the latest variant in the 206 series and incorporates the rotor system of the US Army's OH-58D armed scout helicopter. The Bell 407 helicopter uses a FADEC system to control and monitor the engine where many US military helicopters do not use

this advanced technology yet. The Bell 407 is a helicopter with an open production line. An open production line implies that the world's helicopter community is purchasing the helicopter. It stands to reason that a helicopter being actively produced and purchased will have ample product support and spare parts availability. According to a survey of 40 current Bell 407 helicopter operators published in February 2001, reference 14, Bell Helicopter's product support and parts support are an industry leader and have been the deciding factor to purchase the Bell 407 helicopter over other similar class helicopters in several operators' opinions.

Cost to operate the helicopter is also an indicator of a modern helicopter. According to Bell Helicopter, the cost to operate a Federal Aviation Administration (FAA) registered Bell 407 helicopter is \$361.14 per flight hour in 2002 dollars. This calculation is based on the parameters listed in table 3, which were obtained from the Bell 407 Product Specifications, reference 15. Even if these rates are based on optimistic figures, such as 46 gallons per hour of fuel consumption and one takeoff – cruise flight – one landing flights, the Bell 407 helicopter's cost per flight hour is impressively low. Remember, the FY02 TH-6B average cost per flight hour was \$1,725 and the OH-58C average cost per flight hour was \$1,457. If the Bell 407 helicopter replaces these two helicopters at the USNTPS, the author fully expects the average cost per flight hour to be greater than that proclaimed by Bell Helicopter due to the unique flight environment experienced by the helicopters at the USNTPS and the overhead costs that are built into the military average cost per flight hour figures. The author would fully expect to see the average cost per flight hour to realistically triple due to the overhead costs and the usage environment of the USNTPS, but that still would mean an average cost per flight hour

Table 3
Direct Cost of Operations of the Bell 407 Helicopter

Items	Bell Helicopter's Projected Costs
Fuel, Lubricants	
Fuel (46 gallons per hour at \$1.50 gallon)	69.00
Lubricants (3% of the fuel cost)	2.07
Airframe Direct Maintenance	
Labor (\$50.00 labor rate)	
Inspection	18.73
Overhaul	5.10
Unscheduled and On-Condition	37.65
Parts	
Inspection	2.00
Overhaul	29.73
Retirement	53.92
Unscheduled and On-Condition	75.94
Powerplant Direct Maintenance	
Overhaul (Including accessories and unscheduled maintenance)	64.00
Line Maintenance (Labor)	3.00
Bell Helicopter's Projected 2002 Cost to Operate the Bell 407 Helicopter:	\$361.14

rate of approximately \$1,100 in 2002 dollars. This would be a substantial savings over what the USNTPS currently spends for its fleet of six TH-6Bs and four OH-58Cs.

Force Trim System

The Bell 407 helicopter does not come equipped with a force trim system from the manufacturer. Aeronautical Accessories, Inc., reference 16, has a cyclic force trim system available for purchase for the Bell 407 helicopter. Aeronautical Accessories', Inc., 2003 product catalog list price for the dual control force trim system is \$39,500. This cyclic force trim system is designed to control both the pitch and roll axes of the flight controls. The cyclic force trim release switch is located on the cyclic. The cyclic force trim system uses magnetic brakes to hold the cyclic in position when the force trim system is on. An artificial force feel is provided when the pilot or copilot manually overrides the magnetic brakes by pushing the cyclic in any direction without depressing the cyclic force trim switch.

Automatic Flight Control System (AFCS)

The Bell 407 helicopter does not currently have an AFCS available from the manufacturer; however Aeronautical Accessories, Inc., reference 16, has been issued a Supplemental Type Certificate (STC), STC number SR00790NY, from the FAA, reference 17, for the installation of a SFIM, Inc. automatic flight control system. According to Mr. Hart, reference 18, a non-IFR certified AFCS is available for the Bell

407 helicopter from SFIM, Inc. The AFCS is a two axes autopilot with a yaw stability augmentation system (SAS). The AFCS also incorporates a cyclic force trim system. SFIM, Inc. provides the system components and engineering required for installation of the system, but they do not install the system. Mr. Hart stated that the approximate cost of the components is \$225,000 and it takes approximately 250 man-hours to install the system, which will add \$12,000 (based on a \$50.00/hour labor rate), to the price bringing the AFCS system to a total cost of approximately \$237,000. It is important to note here that an AFCS is actually only desired by the USNTPS and it is considered more of a “good to have” characteristic rather than a required characteristic. The reason for including an AFCS in the required characteristics list was to help define the replacement helicopter playing field in that if two potential replacement helicopters were equally qualified and one had an AFCS and the other did not, then the helicopter with the AFCS would have the advantage assuming it was not a cost prohibitive accessory. The USNTPS desires the AFCS characteristic to help in the handling qualities segment of instruction. If the replacement helicopter has an AFCS, it must be capable of being flown with and without the AFCS operating. By being able to fly with or without the AFCS on, the USNTPS will be able to demonstrate to the Rotary Wing students two different sets of handling qualities for one helicopter, e.g., the helicopter’s pure handling qualities (AFCS off) and the helicopter’s augmented handling qualities (AFCS on). All of this being said, the fact remains that the Bell 407 helicopter has a commercially available AFCS.

Minimum 2 Hours of Endurance with a Reserve

The Bell 407 helicopter's usable fuel capacity is 127.8 US gallons. Using JP-5 fuel at 6.8 pounds/gallon, the standard usable fuel weight is 869 pounds. The fuel flow of the Bell 407 helicopter at 5,000 pounds, sea level, OAT of +15 degrees Celsius, at long range cruise conditions is calculated to be 325 pounds/hour or 47.8 gallons/hour, reference 9. Using a conservative minimum on-deck fuel of 100 pounds (14.7 gallons), an endurance of 2.3 hours (769/325) is calculated. This endurance value does not take into account the reserve, which is typically 20 minutes at the conditions listed above. A 20 minute reserve at the above conditions results in 108 pounds of additional fuel required. Including the conservative 100 pound on-deck fuel requirement and the 108 pound reserve requirement, the Bell 407 helicopter has an endurance of 2.0 hours at 5,000 pounds, sea level, OAT of +15 degrees Celsius, at long range cruise conditions, which meets the USNTPS's required characteristic.

Cabin

The Bell 407 helicopter has a cabin that seats five. The cabin can be configured in different levels of trim; however, in the author's opinion, the utility trim level is satisfactory for the USNTPS.

ICS in the Cabin

The Bell 407 helicopter can be equipped with either a 3-station or 5-station cabin ICS kit. Both cabin ICS kits are Bell Helicopter optional accessories. In the author's opinion, the 3-station cabin ICS kit is satisfactory.

IFR Capable

The Bell 407 helicopter is certified for land operation under day or night VFR non-icing conditions. The FAA has issued an STC, SR09244RC, to Heritage Aviation Ltd, which allows for the installation of a single pilot IFR configuration on Bell 407 helicopter serial numbers 53019 and 53358. According to Mr. Shimp, reference 11, only one Bell 407 helicopter has been known to be outfitted with this single pilot modification. One of the reasons stated by Mr. Shimp that only one Bell 407 helicopter was modified to this configuration was due to the high cost of the modification. In the author's opinion, whether the Bell 407 helicopter is or is not certified for IFR operations is not the issue. The issue is, is the Bell 407 helicopter capable of conducting operations under instrument flight rules, not instrument meteorological conditions (IMC)? It is the author's opinion that the Bell 407 helicopter is capable of conducting operations under instrument flight rules and therefore meets the intent of the "IFR Capable" required characteristic.

According to the Office of the Chief of Naval Operations (OPNAV) Instruction 3710.7S, reference 19, the following aircraft equipment is required for instrument flight: airspeed indicator; altimeter; turn-and-slip indicator; a clock displaying hours, minutes, and seconds with a sweep-second pointer or digital readout; attitude indicator; magnetic

compass with current calibration card; heading indicator or gyrostabilized magnetic compass; and vertical speed indicator. Additionally, two-way radio communication equipment, navigation equipment, and navigation lights are required. The Bell 407 helicopter has all of these items, although the attitude indicator and the heading indicator or gyrostabilized magnetic compass are optional accessories. In order to successfully integrate the Bell 407 helicopter into the USNTPS Rotary Wing syllabus, both an attitude indicator and a heading indicator or gyrostabilized magnetic compass will be required; therefore, the Bell 407 helicopter will meet the US Navy aircraft requirements for IFR flight. Therefore, the Bell 407 helicopter meets the USNTPS desired characteristic of IFR Capable.

2 Radios (1 UHF / 1 VHF)

The Bell 407 helicopter's standard configuration, defined here as the items included in the list price, does not include a radio. Provisions are included in the Bell 407 helicopter for two VHF radios. Aeronautical Associates, Inc., reference 16, has certified modifications of the avionics console to expand the avionics capabilities of the Bell 407 helicopter. This console assembly modification costs \$2,410 according to Aeronautical Accessories' 2003 catalog. The USNTPS would have to select commercial avionics equipment to match their requirements and have the equipment installed into their helicopters.

An IFR Certified GPS

The Bell 407 helicopter does not currently come with an IFR certified GPS from the manufacturer. As stated in the “2 Radios (1 UHF / 1 VHF)” required characteristic discussed in the above paragraph, the ability to expand the avionics capability of the Bell 407 helicopter exists today. Commercial IFR certified GPS units are available and could be incorporated into the Bell 407 helicopter.

Transponder with Mode C

The Bell 407 helicopter can be equipped from the manufacturer with two different transponders, both of which have Mode C. Both transponders are Bell Helicopter optional accessories and both provide essentially the same capabilities. Both transponders are Class I radio transmitter/receivers that operate on radar frequencies, receive ground radar interrogations at 1030 MegaHertz (MHz), and respond with radar pulses at 1090 MHz. The main difference between the two transponders is that the KT-76A has a mechanical display and the KT-70 has an Light Emitting Diode (LED) display.

Capability to Mount a FLIR System

The Bell 407 helicopter has the capability to mount a FLIR system. Aeronautical Accessories, Inc., reference 16, has two quick-mount kits currently available for purchase. The quick-mount kits are for the WESCAM Model 12 Dual Sensor System (IR/Camera) and the FLIR Systems, Inc. Model U6000 and U7000 Thermal Imagers. The quick-mount kits cost \$2,620 for either kit according to Aeronautical Accessories’

2003 product catalog. Both of these quick-mount kits provide for installation of a FLIR system onto the lower fuselage immediately aft of the lower window assemblies. In order to allow for proper ground clearance with either of these quick-mount kits, the high skid gear optional accessory is required.

An Established Flight School

The Bell 407 helicopter has an established pilot and maintenance training facility known as the Bell Helicopter Training Academy. Located in Hurst, TX, the Bell Helicopter Training Academy has preplanned training classes that provide for ground school instruction, flight training device instruction, and flight instruction. The USNTPS requires an established flight school in order to get the Rotary Wing pilots flight time in the helicopter. The reason behind this requirement is to relieve the USNTPS instructors of the duty of initial familiarization training flights in the helicopter. This is an instructor workload driven requirement. Prior to the recent mishaps at the USNTPS, student pilots received two familiarization flights in an aircraft and then completed a check ride in that aircraft. Following a successful check ride, the student pilots were considered qualified to act as pilot in command of that aircraft. The current, i.e., post mishap flight syllabus, requires that each student pilot must have a minimum of 10 hours first pilot time in model prior to acting as the pilot in command. As a result of this requirement, the burden of getting the 10 hours of first pilot time has fallen on the instructors. To redirect this burden, the USNTPS has instituted the policy of sending the student pilots to either

military or commercial training centers to receive pilot training prior to beginning their instruction at the USNTPS.

Based on the Bell Helicopter Training Academy 2002 Course Catalog, reference 20, the Bell Helicopter Training Academy charged \$1,250 per flight hour for the Bell 407 helicopter. Several scheduled one week courses were available that included ground school instruction, flight training device instruction, and flight training. The USNTPS wants the student pilots to arrive with approximately five hours of first pilot time in the TH-6B (group helicopter). Based on the reported Bell Helicopter Training Academy 2002 flight hour costs for the Bell 407 helicopter, five hours of flight training would cost \$6,250 per student pilot.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

In the author's opinion, the Bell 407 helicopter can successfully fulfill the requirements of the USNTPS Rotary Wing syllabus and provide the USNTPS with a helicopter that is modern, cost effective, logistically supportable, and accomplishes the mission.

As a first measure of whether or not the Bell 407 helicopter can fulfill all of the defined requirements of the USNTPS Rotary Wing syllabus, the comparisons need to be examined. Many of the characteristics are "cut and dry", e.g. either they meet the desired characteristic or they do not. The "cut and dry" characteristics are the large flight envelope, maximum airspeed of 120 KIAS or greater, external hook capability, single pilot capability, force trim system, cabin, ICS in the cabin, transponder with mode C, capability to mount a FLIR system, and an established flight school. The Bell 407 helicopter has all of these characteristics.

The remaining characteristics require a bit more thought than a simple 'yes' or 'no' answer. First, the 1,000 pounds (minimum) of cargo capacity. An operational cargo capacity of 750 pounds, based on a 5,000 pound standard maximum gross takeoff weight, is 25% under the minimum desired, but this takes into account 150 pounds of instrumentation gear already added into the weight of the Bell 407 helicopter and a full load of fuel (869 pounds of JP-5 at 6.8 pounds per gallon). Next is the excellent autorotational characteristics requirement. The answer from Major Caudill, a subject

matter expert in this area, eliminates any doubt that the Bell 407 helicopter will be able to successfully accomplish the USNTPS's Rotary Wing autorotational characteristic flight segment. The additional benefit of the student pilots being proficient in the helicopter completing the autorotational characteristic flights will only add to the safety of these flights. The next characteristic requiring more than a 'yes' or 'no' answer is the question of "Is the Bell 407 helicopter a modern helicopter?". The answer is yes due to the fact that the Bell 407 helicopter was certified in 1996, it uses a FADEC system, it has an open production line, it is logistically supportable, and the Bell 407 helicopter is cost effective to operate.

The next requirement/desire of an AFCS would seem to be a "cut and dry" answer, but this characteristic will require significant discussion as to whether or not it should be purchased. The reason for the discussion is due to the cost versus benefit of the AFCS. This single characteristic will add nearly one quarter of a million dollars to the retail list price of the helicopter. The benefits gained will have to be carefully weighed against the cost of the AFCS. The next requirement of a minimum 2 hours of endurance with a reserve was calculated using conservative values and still resulted in 2.0 hours of endurance with a 20 minute reserve and a 100 pound minimum fuel on deck constraint. The last requirement of an IFR capable helicopter is relatively straight forward since the Bell 407 helicopter has the potential to incorporate all of the indicators and avionics equipment required for IFR flight by the US Navy. The choice of avionics equipment selected by the USNTPS will be the key issue here. The manufacturer's selection of avionics equipment is limited; however, the commercially available avionics equipment will be able to easily support all of the USNTPS's requirements to include 2 radios, an

IFR certified GPS, and an IFR capable helicopter assuming the USNTPS is willing to accept the monetary costs associated with this type of equipment.

With all of the 18 comparisons being favorable, the Bell 407 helicopter appears to be a satisfactory replacement helicopter for the USNTPS's TH-6B and OH-58C helicopters. However, the Bell 407 helicopter has had its share of growing problems since being introduced in 1996. Some of these problems have been catastrophic, e.g., tail rotor impacting the tailboom and causing separation of the tail rotor, and some problems have been minor, e.g., door latch assembly breakage. The problems have been addressed via the Airworthiness Directives (AD) channel of the FAA. As a result of the current FAA ADs, no helicopter flight envelope limitations have been reduced; however, maintenance requirements have been imposed which will affect the Bell 407 helicopter.

Other less tangible considerations that need to be taken into account about the Bell 407 helicopter need to be discussed as well. The Bell 407 helicopter published list price for 2002 was \$1,495,000. The USNTPS intends to purchase six of the selected replacement helicopters, which will cost \$8,970,000. This is the base price of the Bell 407 helicopter and does not take into account the optional accessories or avionics systems for the helicopters, which will most likely bring the cost of six Bell 407 helicopters into the \$10,000,000 range. This is a large sum of money, but the potential savings per flight hour is on the order of \$625 per flight hour ($\$1,725[\text{TH-6B}] - \$1,100[\text{Bell 407 approximate}] = \625). Assuming a \$625 per flight hour cost multiplied by 1,000 hours of flight time per year results in \$625,000 saving per year over operating the TH-6B. For the OH-58C, the potential savings per flight hour is on the order of \$357 per flight hour ($\$1,457[\text{OH-58C}] - \$1,100[\text{Bell 407 approximate}] = \357). Assuming a \$357 per

flight hour cost multiplied by 500 hours of flight time per year results in \$178,500 saving per year over operating the OH-58C. Therefore, the total combined potential savings as a result of using the Bell 407 helicopter versus the TH-6B and the OH-58C is approximately \$800,000 per year. Additionally, the Bell 407 helicopter will be under warranty, which will further aid in keeping the maintenance costs down while the warranty is in effect.

Another less tangible consideration is the cost of maintaining the Bell 407 helicopter. The USNTPS uses contract maintenance and the maintenance contract is based on total numbers of aircraft and numbers of each type/model/series aircraft. By replacing two aircraft type/model/series with one aircraft, the USNTPS's maintenance manpower requirements will be reduced. A reduction in maintenance personnel could also allow for a reduction in maintenance administration requirements.

Most importantly though is the impact of a reduction in the number of type/model/series aircraft to the students and instructors of the USNTPS. Will the replacement of the TH-6B and the OH-58C helicopters with the Bell 407 helicopter reduce the workload of the students and instructors and still be able to accomplish the mission of the USNTPS? The answer is "Yes, the Bell 407 helicopter will reduce the student and instructor workload and it will accomplish its assigned missions at the USNTPS."

RECOMMENDATIONS

In the author's opinion, the USNTPS should do the following:

1. Complete a flight evaluation, to include a full Report of Test Results, of a Bell 407 helicopter by two USNTPS instructors based on the current Rotary Wing syllabus in order to confirm the suitability of the Bell 407 helicopter's capability to perform the USNTPS Rotary Wing syllabus.
2. Based on a successful flight evaluation, select the Bell 407 helicopter as the replacement helicopter for the TH-6B and the OH-58C.
3. Using a Cost/Benefit analysis system, the USNTPS needs to determine which manufacturer supplied and commercially available accessories for the Bell 407 helicopter are required to meet the Rotary Wing syllabus exercise requirements.
4. Enter into contract negotiations with Bell Helicopter in order to purchase six Bell 407 helicopters with all applicable accessories included for use in the USNTPS Rotary Wing syllabus.

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REFERENCES

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APPENDICES

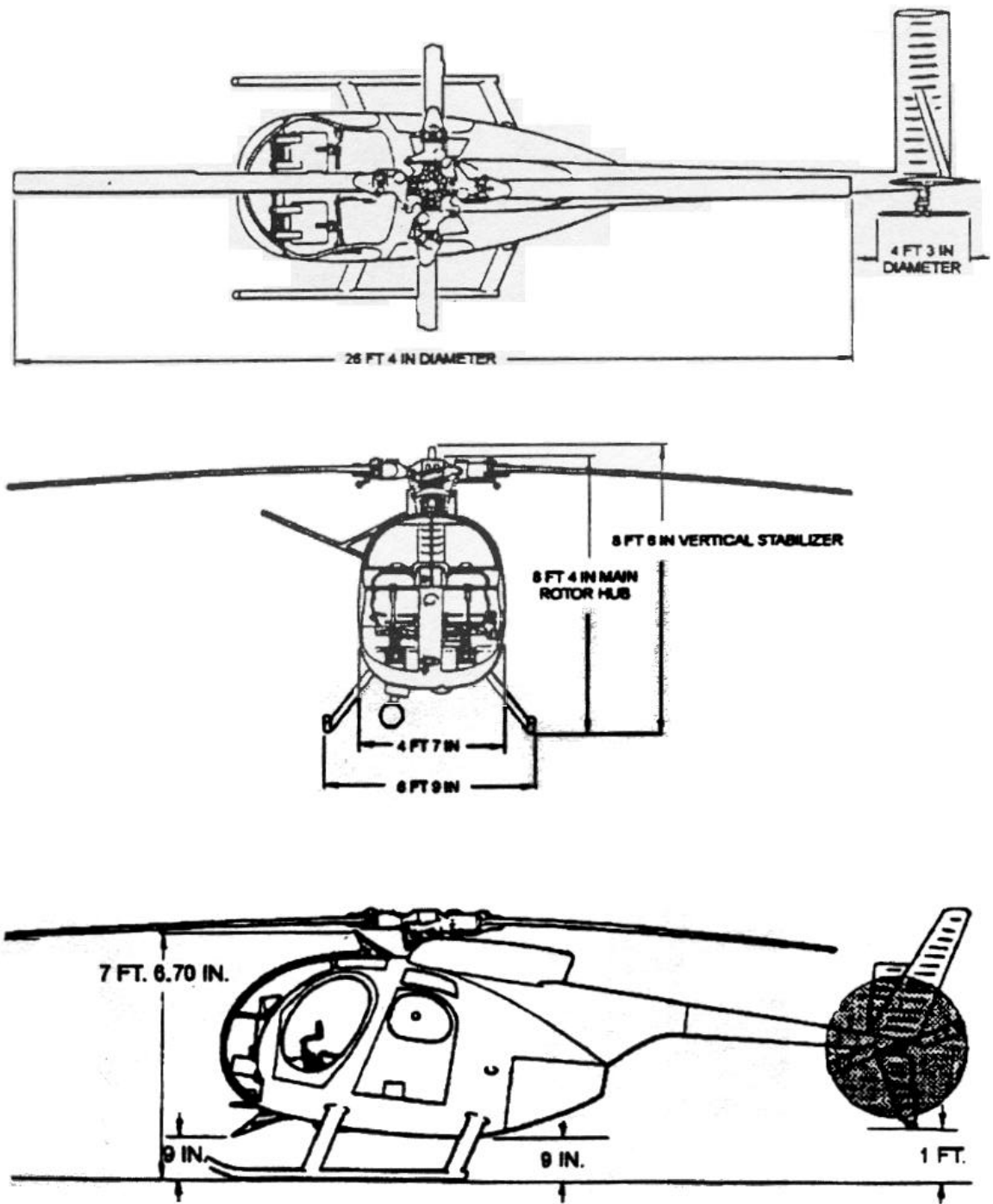


Figure A-1
Principal Dimensions of the TH-6B Helicopter
(TH-6B Pilot's Flight Manual Supplement)

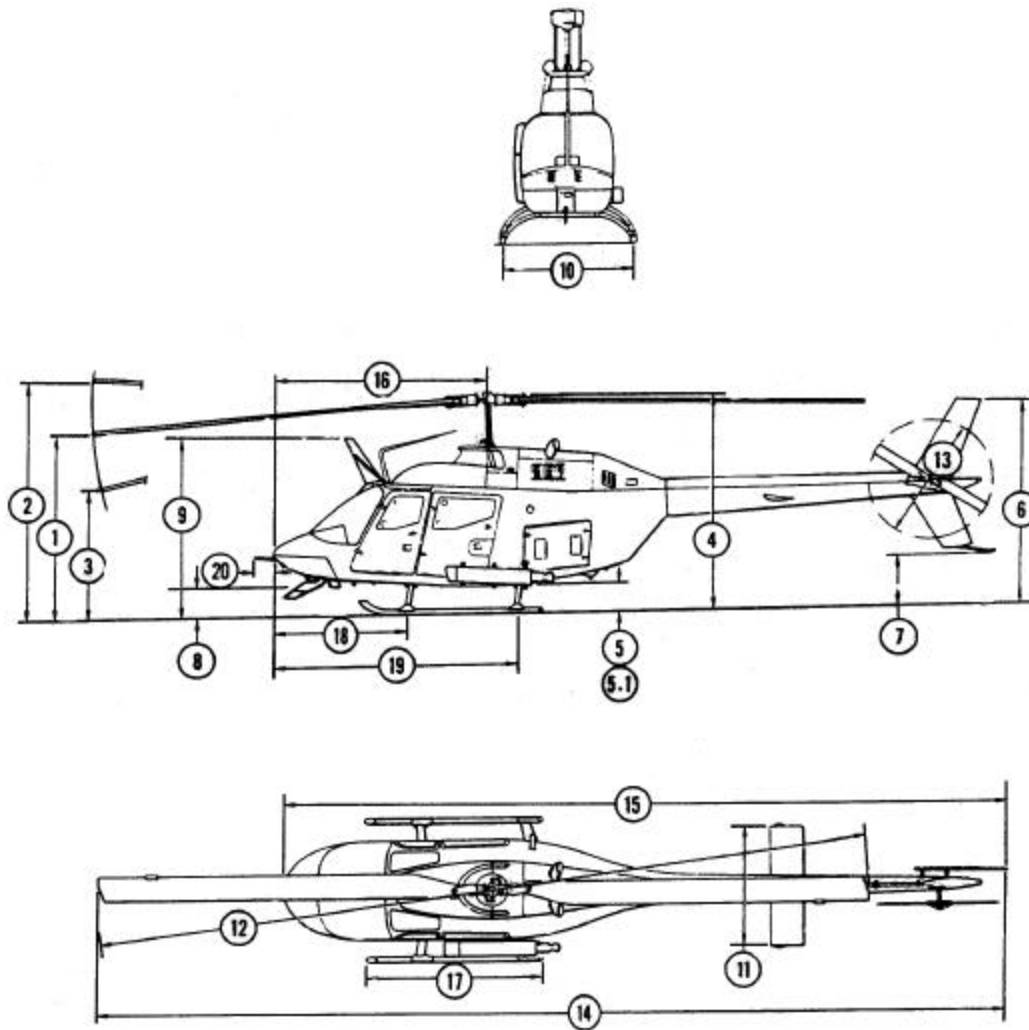


Figure A-2
Principal Dimensions of the OH-58C Helicopter
(Operator's Manual Army Model OH-58A/C Helicopter)

7. Tail Skid to Ground	1 ft. 4.4 in.	3 ft. 4.4 in.	4 ft. 4.0 in.
8. Lower Cutter to Ground	12.0 in.	2 ft. 2.0 in.	2 ft. 3.0 in.
9. Upper Cutter to Ground	7 ft. 9.5 in.	9 ft. 9.5 in.	9 ft. 10.5 in.
WIDTH			
10. Skid Gear	6 ft. 5.4 in.	7 ft. 3.0 in.	11 ft. 6.1 in.
11. Horizontal Stabilizer	6 ft. 5.2 in.	No Change	No Change
DIAMETERS			
12. Main Rotor	35 ft. 4.0 in.	No Change	No Change
13. Tail Rotor	5 ft. 2.0 in. or 5 ft. 5.0 in. (Improved)	No Change	No Change
LENGTH			
14. Overall (Main Rotor Fore and Aft) to Aft End of Tail Skid	40 ft. 11.8 in.	No Change	No Change
15. Nose of Cabin to Aft End of Tail Skid	32 ft. 2.0 in.	No Change	No Change
16. Nose of Cabin to Center Line of 8 ft. 10.1 Main Rotor	8 ft. 10.1 in.	No Change	No Change
17. Skid Gear	8 ft. 1.3 in.	10 ft. 4.2 in.	19 ft. 5.0 in.
18. Nose of Cabin to Center Line of Forward Cross Tube	6 ft. 0.0 in.	5 ft. 9.4 in.	5 ft. 11.7 in.
19. Nose of Cabin to Center Line of Aft Forward Cross Tube	10 ft. 9.0 in.	10 ft. 6.3 in.	10 ft. 8.7 in.
20. Pitot Tube	6.8 in.	No Change	No Change

* Check antennas that may protrude lower

	HEIGHT	STANDARD SKID GEAR	HIGH SKID GEAR	FLOAT GEAR A
1. Forward Tip of Main Rotor (Static Position to Ground with Droop		9 ft. 6.0 in.	10 ft. 0.0 in.	9 ft. 7.9 in.
2. Forward Tip of Main Rotor to Ground (Tie-Down)		12 ft. 0.0 in.	12 ft. 6.0 in.	12 ft. 1.9 in.
3. Forward Tip of Main Rotor to Ground (Tie Down)		6 ft. 8.0 in.	7 ft. 2.0 in.	6 ft. 10.0 in.
4. Ground to Top of Main Rotor Reservoirs		9 ft. 7.0 in.	10 ft. 9.0 in.	10 ft. 10.0 in.
5. Bottom of Cabin		13.0 in.	27.0 in.	28.0 in.
6. Top of Vertical Stabilizer		8 ft. 1.5 in.	10 ft. 1.5 in.	11 ft. 1.0 in.

Figure A-2 Continued

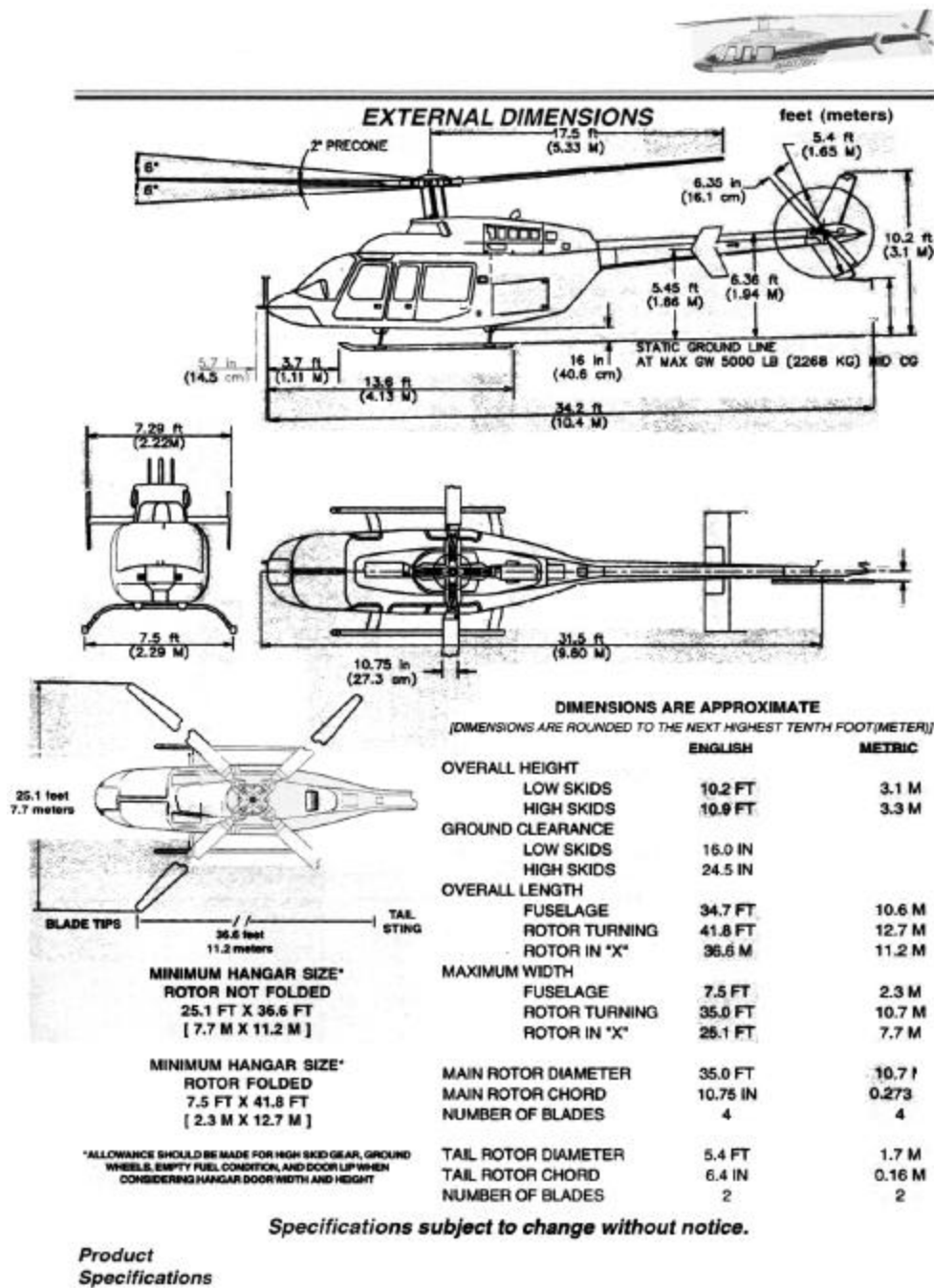


Figure A-3
 Principal Dimensions of the Bell 407 Helicopter
 (Bell 407 Product Specifications)

Table B-1
Academic Syllabus
Rotary Wing (Pilots and Engineers)

Week	Course	Hours	Exams	Labs
1 - 3	Mathematics	2	1	
1 - 4	Pitot Static Systems	19	1	
1 - 5	Calculus	18	1	
1 - 6	Mechanics	15	2	
1 - 7	Introduction to Airborne Systems	30	1	1
2 - 13	Report Writing / Risk Assessment	13		
3 - 3	Crew Station Analysis 1	5		
3 - 13	Helicopter Performance & Aerodynamics	50	1	
6 - 10	Statistics 1	15	1	
7 - 11	Helicopter Rotor Systems	20	1	
8 - 9	Control Systems 1	3		1
10 - 19	Subsonic Aerodynamics	34		
12 - 19	Helicopter Stability and Control	35	2	1
13 - 17	First and Second Order Systems	16	1	
14 - 17	Airborne Radar Systems	15	1	1
17 - 19	Dynamic Systems Analysis Techniques	9	1	
18 - 19	Airborne Electronic Warfare Systems	5	1	
19 - 20	Analysis & Modeling	4		
19 - 26	Airborne Electro-Optical Systems	20	1	1
20 - 20	Program Management 1	3		
21 - 22	BREAK			
23 - 26	Thermodynamics	16	1	
24 - 28	Helicopter Dynamics	22	1	2
25 - 25	Control Systems 2	3		1
25 - 28	Statistics 2	14	1	
28 - 28	Report Writing 2	1		1
28 - 29	Crew Station Analysis 2	5		
28 - 33	Airplane Stability and Control	16	1	
29 - 30	Control Systems 3	4		
29 - 31	Avionics Architecture	10	1	
30 - 33	Integrated Airborne Systems	9		
30 - 35	Propulsion Systems	17	1	
32 - 32	Veridian – AFCS Lectures			
33 - 33	Program Management 2	6		
34 - 34	FIELD TRIP			
35 - 38	Advanced Digital Communications	12	1	
35 - 38	Airplane Performance	12	1	
35 - 40	Special Topics – Flight Mechanics	6		
36 - 36	Loads	4		
37 - 38	Dynamic Interface	3		
37 - 38	Low Observable – EO	4		
39 - 40	Advanced Systems Topics II	8		
40 - 40	Low Observable – RADAR	4		
41 - 41	DT-IIA FLY WEEK			
42 - 43	Program Management 3	6		
42 - 43	V/STOL Aircraft	10		
TOTAL		523	24	9

Table B-2
Flight and Report Syllabus
Rotary Wing (Pilots and Engineers)

Week	Exercise	Aircraft ⁽¹⁾	Briefs ⁽²⁾	Test Plan	Flights ⁽³⁾	Report ⁽⁴⁾
2	Data Card Brief	-	1		-	-
3 - 14	Aircraft Familiarization	TH-6/UH-60/C-12 ⁽⁵⁾	4		11(3)	-
3	Intro to Performance Testing	-	1		-	-
3	Instrumentation	-	2		-	-
3	Jet Orientation	T-2/T-38	1		1	Oral Debrief
3	P-3 Familiarization Brief	-	1		-	-
3 - 6	Radar Simulator Familiarization	TPS Simulator	-		-/1	-
4 - 6	Cockpit Evaluation	TBD	1		-	Partial RTR
4 - 10	Integrated Systems Demo	P-3	1		1	NGD ⁽⁷⁾
4	Risk Assessment	-	1		-	-
5	Intro to FQ Testing	-	3		-	-
5	Intro to Handling Qualities	-	1		-	-
5 - 7	Performance Demo	TH-6/UH-60	2		1	NGD ⁽⁷⁾
5 - 40	Instrument Proficiency ⁽⁸⁾	Any	-		6	-
6 - 8	Handling Qualities I	TH-6/UH-60	2/1	Provided	1	Partial RTR
6 - 9	Engine Assessment	TH-6/UH-60	1	Provided	-	None ⁽⁹⁾
7	Specifications and T&E Master Plans	-	1		-	-
7 - 32	Autorotational F.Q. Series	OH-58	5/1	Self	3(1)	Oral Debrief, NGD
7 - 10	Hover/Vertical Climb Evaluation	TH-6/UH-60	1/1	Group	2/Team	RTR
8 - 14	Performance Practice	TH-6/UH-60	None ⁽¹⁰⁾		6 ⁽¹¹⁾	-
10	Long Weekend Break					
10 - 13	Level Flt/Climb & Descent Performance	TH-6/UH-60	1/1	Team	2/Team	Informal Oral
11 - 14	Mech. Characteristics Evaluation ⁽¹²⁾	TBD	3/1		-	Partial RTR
12	Systems WLR	-	1		-	-
12	Long FQ Intro	-	2		-	-
13 - 17	Long FQ Demo	TH-6/UH-60	1		1	-
15 - 18	Performance Progress Check	TH-6/UH-60	1		1	Oral Debrief
15 - 20	Long FQ Evaluation	TH-6/UH-60	2/1	Team	2/Team	RTR
16 - 18	Long Stab Demo ⁽¹³⁾	Learjet	1		1(0)	-
17 - 20	RW VSS 1	NSH-60	1		1(0)	NGD
17 - 20	RW VSS Demo	NSH-60	1		(0)1	-
17 - 20	FLIR Lab	-	1		-/1	-
18 - 20	Lat-Dir Demo ⁽¹³⁾	Learjet	1		1(0)	-
18 - 32	FQ Practice Flights	TH-6/UH-60	None ⁽¹⁴⁾		6 ⁽¹¹⁾	-
21 - 22	Two Week Break					
23	Jet Orientation 2 ⁽⁶⁾	T-2/T-38	1		1	Oral Debrief
23	Safety Standdown		-		-	-
23	Refresher Familiarization	TH-6/UH-60	-		1(0)	-
23	Lat-Dir FQ Intro	-	3		-	-
23 - 27	RW VSS 2	NSH-60	1		1(0)	NGD
23 - 27	Lat-Dir FQ Demo/Evaluation	TH-6/UH-60	1/1	Team	2	Yellow Sheet
23 - 29	FLIR Evaluation	P-3	1/1	Team	1/1	RTR
25 - 27	Radar Test Tech Simulator	TPS Simulator	1		0/1	-
27 - 44	High Lift/Drag Demo	X-26	2		5(4)	NGD
28 - 32	Radar Demo	SH-60B	1	Provided	1/Team	NGD
28	Low Airspeed FQ Intro	-	2		-	-

Table B-2 Continued

Week	Exercise	Aircraft ⁽¹⁾	Briefs ⁽²⁾	Test Plan	Flights ⁽³⁾	Report ⁽⁴⁾
28 - 31	Low Airspeed 1	TH-6/UH-60	1	Team	1	Daily
28	Advanced FCS Lectures	-	6		-	-
28 - 35	AFCS Demo/Evaluation	UH-60L	1/1	Provided	1	Partial
29 - 31	Adv FCS Intro/Demo Lab	TPS Simulator	1		0/1	-
29 - 32	Adv FCS Design Lab	TPS Simulator	1		0/1	-
29 - 40	Asymmetrical Power Demo/Evaluation	C-12	2		1	NGD
29 - 33	S & C Review ⁽¹³⁾	Learjet	1		1(0)	-
29 - 33	S & C Overview ⁽¹³⁾	Learjet	1		0(1)	-
32 - 35	Low Airspeed 2	TH-6/UH-60	1/1	Provided	1	NGD
32 - 37	Qualities Evaluation 1 (Helicopter)	TBD	1	Self	1	Daily
34	Field Trip					
35 - 40	FW Longitudinal Stability/Performance/Stalls	C-12	2/1		1	Daily
35 - 40	FW Lat-Dir FQ Demo	U-6	1		1	Oral Debrief
35 - 37	FQ Progress Check	TH-6/UH-60	1		1	Oral Debrief
35 - 39	Adv FCS Demo/Evaluation	Learjet	3		1(0)	-
37 - 43	DT-IIA	TBD	1/1	Team / ERB	4/Team	RTR
41 - 42	Qualities Evaluation 2 (Helicopter)	TBD	1	Team ⁽¹⁶⁾	1	NGD
40 - 44	Qualities Evaluation 3 (Fixed Wing)	TBD	1		1	NGD
45 - 47	Qualities Evaluation 4 (Simulator)	TBD	1		-/1	-
45	Graduation					
Total			85/13	10	74(38) ⁽¹⁵⁾	

Notes:

- (1) One aircraft for performance and the other for flying qualities.
- (2) The number of preparatory briefs is listed. If the exercise has a summary debriefing it is listed following a "slash".
- (3) Number of syllabus dedicated flights for engineers is shown in parenthesis when different that for pilots. Simulator events are shown following a "slash".
- (4) Unless noted otherwise reports are an individual effort.
- (5) Flight Test Engineers (FTE) will receive one dual Familiarization flight in each aircraft.
- (6) Pilots and FTEs who have not had an orientation flight in a jet airplane.
- (7) Non-Graded Daily (NGD).
- (8) Twelve hours of instrument proficiency are required for OPNAV minimums. Flights include an instrument check and should be scheduled to maintain currency.
- (9) Results of these tests are used in the Level Flight/Climb & Descent Team Oral.
- (10) Briefed as part of Performance Demonstration (Performance Demo).
- (11) Actual number of practices varies, but two will be with an instructor.

Table B-2 Continued

- (12) Mechanical Characteristics consisting of a 1.0 hour Demonstration, a 3.0 hour ground test period, but no flight is the main part of report with Flight Control Description attached as an appendix.
- (13) Engineers may fly as observers on the Learjet Longitudinal Stability, Lateral-Directional Stability, and Stability & Control (S & C) Overview flight.
- (14) Briefed as part of Longitudinal Stability Demonstration.
- (15) Assumes six teams.
- (16) Three teams from two Rotary Wing groups, where each team is responsible for one of three Qualitative Evaluation test plans after DT-IIA. Each team briefs the other teams on their test plan.

Table B-3
USNTPS Aircraft Management Report for the TH-6B

Operating Expense	FY2002	FY2001	FY2000
Flight Hours	1155.4 hrs	971.7 hrs	1086.1 hrs
Budgeted Flight Hours	833 hrs	1000 hrs	1,000 hrs
Full Mission Capable Rate	74.6%	56.0%	59.1%
Maintenance Man Hours Performed	5,083.1 hrs	5323.9 hrs	6,383.2 hrs
Maintenance Man Hours Per Flight Hour	4.4	5.5	5.9
Direct Maintenance Man Hour Costs	\$850,158	\$758,804	\$831,228
Indirect Maintenance Man Hour Costs	\$139,449	\$123,620	\$72,306
Petroleum, Oil, and Lubricants	\$27,241	\$23,189	\$15,806
Fuel Delivery Contract	\$78,050	\$57,301	\$43,053
Intermediate Maintenance Labor	\$329,928	\$139,874	\$159,928
Intermediate Maintenance Consumables	\$28,927	\$56,242	\$47,191
Aviation Depot Level Repair	\$288,983	\$3,372	\$10,269
Parts	\$169,386	\$159,117	\$88,697
Miscellaneous Items	\$80,726	\$59,896	\$56,336
Total Costs	\$1,992,849	\$1,381,415	\$1,324,814
Average Cost Per Flight Hour	\$1,725	\$1,422	\$1,220

Table B-4
USNTPS Aircraft Management Report for the OH-58C

Operating Item	FY2002	FY2001	FY2000
Flight Hours	370.8 hrs	617.7 hrs	663.7 hrs
Budgeted Flight Hours	500 hrs	600 hrs	600 hrs
Full Mission Capable Rate	60.4%	90.4%	82.1%
Maintenance Man Hours Performed	1,988.3 hrs	3,389.8 hrs	3,182.9 hrs
Maintenance Man Hours Per Flight Hour	5.4	5.5	4.8
Direct Maintenance Man Hour Costs	\$268,063	\$454,927	\$556,244
Indirect Maintenance Man Hour Costs	\$110,792	\$111,898	\$49,945
Petroleum, Oil, and Lubricants Costs	\$8,417	\$17,967	\$9,660
Fuel Delivery Contract	\$25,048	\$36,426	\$26,309
Intermediate Maintenance Costs	-	\$456	-
Aviation Depot Level Repair	\$55,241	-	\$1,506
Parts	\$46,833	\$30,678	\$33,453
Miscellaneous Items	\$25,907	\$38,075	\$34,426
Total Costs	\$540,302	\$690,427	\$711,543
Average Cost Per Flight Hour	\$1,457	\$1,118	\$1,072

November 2001

Memorandum

From: Major Troy S. Caudill

To: Commanding Officer

Via: Executive Officer
Technical Director
Chief Flight Instructor
Senior Rotary Wing Instructor
Chief Academic Instructor

Ref: RW 1542

Subj: REPLACEMENT OF THE OH-58C AND TH-6B WITH A SINGLE TYPE MODEL

1. Due to the continuing logistical issues with the TH-6B and it's decreasing availability rate, along with the recent decision to separate OH-58C and TH-6B aircraft qualifications, I believe it is time to seriously consider replacing both the OH-58 and TH-6 with a single type model that can support the Rotary Wing syllabus. This downward trend in availability of the TH-6 and the marginal suitability of the OH-58 for the handling qualities flight syllabus will hamper the completion of the Rotary Wing course in the near future.

2. The TH-6B has served the USNTPS well over the years. However, the aircraft has been out of production for some time and over the last few years numerous logistical issues have been brought to light. The aircraft is supported by the MD Helicopter's supply system and the few spare parts available are being depleted. The limited number

of civilian models of this type still in service makes it uneconomical for MD Helicopter to continue logistical support for much longer. It is very likely in the coming year that a component on the aircraft that requires replacement will not be available, or if available, the cost would be extremely high. Especially when you consider the aircraft's propensity for main rotor overspeeds and recent issues with the landing gear.

3. Likewise, the OH-58 series has served us well. Although not hampered by the same logistical issues of the TH-6B, it is primarily used for the Auto/HV demo, QE-III, and VTOL demo exercises. The aircraft has been used in the past as a backup for the UH-60 in the execution of the performance syllabus, but is marginally suited for this. Inadequate performance characteristics and ease with which an over torque can occur, limit its usefulness. Use of the OH-58 in the handling qualities syllabus is possible and has been done in the past, but again it is marginally suited for this mainly due to the teetering type rotor system and the issues associated with it. Also, quality of instruction would be limited if used in this role.

4. The current reorganization of the RW 1542 was made in part to reduce the workload of the instructors and students. One assumption that was made during the reorganization was the OH-58C and TH-6B would be treated as one aircraft, as had been done previously. Splitting the qualifications of these aircraft along with the decision not to grant fourth aircraft waivers will impact the completion of the RW syllabus. The reorganized 1542 can be completed with current instructor manning levels, but will not

maintain the desired workload reduction. An increase in the number of instructors or deletion of core exercises will be required to maintain the desired workload.

5. During Class 120's DT-II exercise, I was afforded the opportunity to fly the BHT-407. The 407 is the latest upgrade to the 206 (Jet Ranger) series. The aircraft has a maximum gross weight of 5,000 pounds and a maximum airspeed of 140 kts. I was very impressed with the aircraft's performance and handling qualities. The Rolls Royce 250-C47B engine is an upgrade to the 250-C20 in the OH-58 and TH-6 with the addition of a Full Authority Digital Electronic Control. With a crew of two and nearly full load of fuel, sustained vertical climb rates of over 2,500 fpm and V_h of 140 kts were achievable prior to reaching any engine or transmission limits. Handling qualities were excellent. The soft-in-plane flex beam type hub with four blades and mechanical linkage with hydraulic assist was very responsive and alleviates the concerns of mast bumping. Control forces were light, approximately 1 pound, but initial tendencies are to PIO laterally until a feel of the aircraft is attained. Additionally, maintaining airspeed approximately ± 2 kts requires some attention. My only complaint would be the absence of a trim system. Autorotational characteristics were benign and full autorotations to the deck were possible. There didn't appear to be any issues in the low airspeed environment except for yaw control during air taxi, very similar to the OH-58.

6. Over all, I think the BHT-407 would be an excellent replacement aircraft for the OH-58C and TH-6B. From this limited evaluation, it is my opinion that it could perform all the exercises required in the current RW 1542, including the Auto/HV demo, QE-III, and

VTOL demo's. The 407 performance and handling qualities characteristics are more closely aligned with those of the UH-60 than the OH-58C and TH-6B, and would afford each RW group the exposure to aircraft characteristics they are more likely to be evaluating in the future. In addition, it would support the desire to reduce the number of type, model, and series of aircraft used at the school. As a modern aircraft, I'm sure maintenance costs will be reduced. Some components on this aircraft require very little or no maintenance, the rotor hub as an example. Further cost saving might also be realized as the number of personnel required to maintain the aircraft could be reduced.

7. The BHT-407 may or may not be the aircraft desired for the school. Aircraft qualifications and 1542 issues aside, I think a decision should be made before we are placed in the same situation as last year, when the UH-60's availability was very limited and the OH-58 was used in it's place during the performance flight syllabus. In the case of the TH-6B in the handling quality syllabus, if availability were to be limited, we would not have an aircraft to fall back on.

Very Respectfully,

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VITA

Steven R. Girard was born in Holyoke, Massachusetts and raised in South Hadley, Massachusetts. He graduated from South Hadley High School in 1987. Upon graduating, from Syracuse University with a Bachelor of Science degree in Aerospace Engineering in 1991, he was commissioned a Second Lieutenant in the United States Marine Corps. After attending The Basic School in Quantico, Virginia, he reported to flight training in Pensacola, Florida. He was designated a Naval Aviator on 03 December 1993. After training in the AH-1W SuperCobra helicopter in Camp Pendleton, California, he participated in two Marine Expeditionary Unit (Special Operations Capable) deployments between 1995 and 1998. He then attended the Amphibious Warfare School in Quantico, Virginia where he was selected to attend the United States Naval Test Pilot School in Patuxent River, Maryland. Upon graduating from the United States Naval Test Pilot School in 2000, he reported to the Naval Rotary Wing Aircraft Test Squadron. After six months of duty at the Naval Rotary Wing Aircraft Test Squadron, he was assigned as an instructor at the United States Naval Test Pilot School. After one year of instructing at the United States Naval Test Pilot School, he returned to the Naval Rotary Wing Aircraft Test Squadron, where he is currently working as a test pilot on the H-1 Upgrades program.