LUCIA PP-9803

CLEARANCE REQUEST FOR PUBLIC RELEASE OF DEPARTMENT OF DEFENSE INFORMATION

(See Instructions on back.)

(This form is to be used in requesting review and clearance of DoD information proposed for public release in accordance with DoDD 5230.9.)

TO: Director, Freedom of Information & Security Review, Rm. 2C757, Pentagon

1. DOCUMENT DESCRIPTION

a. TYPE Cost and Performance	b. TITLE Tri-Serv Dem/Val of FLASHJET Process - Rotary Wing Evaluation
c. PAGE COUNT 23	d. SUBJECT AREA Environmental Security Technology Certification Test

2. AUTHOR/SPEAKER

a. NAME *(Last, First, Middle Initial)* Hutchin, Dean; Stemniski, Peter	b. RANK	c. TITLE
d. OFFICE		e. AGENCY US Army Environmental Center

3. PRESENTATION/PUBLICATION DATA *(Date, Place, Event)*

Report for Public Clearance.

4. POINT OF CONTACT

a. NAME *(Last, First, Middle Initial)* Marqusee, Jeffrey (or Kelly, Amy 696-2124)	b. TELEPHONE NO. *(Include Area Code)* (703) 696-2120

5. PRIOR COORDINATION

a. NAME *(Last, First, Middle Initial)*	b. OFFICE/AGENCY	c. TELEPHONE NO. *(Include Area Code)*
Robert Boyd	ODDR&E (BioSystems)	(703) 588-7401

6. REMARKS

THE INFORMATION CONTAINED IN THIS REPORT FALLS UNDER THE PURVIEW OF THIS OFFICE.

WHEN CLEARED, PLEASE FAX DD-1910 TO 703-696-2114.

CLEARED
FOR OPEN PUBLICATION

NOV 04 2002 11

DIRECTORATE FOR FREEDOM OF INFORMATION
AND SECURITY REVIEW
DEPARTMENT OF DEFENSE

7. RECOMMENDATION OF SUBMITTING OFFICE/AGENCY

a. THE ATTACHED MATERIAL HAS DEPARTMENT/OFFICE/AGENCY APPROVAL FOR PUBLIC RELEASE *(qualifications, if any, are indicated in Remarks section)* AND CLEARANCE FOR OPEN PUBLICATION IS RECOMMENDED UNDER PROVISIONS OF DODD 5320.9. I AM AUTHORIZED TO MAKE THIS RECOMMENDATION FOR RELEASE ON BEHALF OF:

Environmental Security Technology Certification Program

b. CLEARANCE IS REQUESTED BY 20021108 *(YYYYMMDD)*.

c. NAME *(Last, First, Middle Initial)* Marqusee, Jeffrey	d. TITLE Director, Environmental Security Technology Certification Prog
e. OFFICE OUSD(I&E)	f. AGENCY OUSD(A&T)
g. SIGNATURE	h. DATE SIGNED *(YYYYMMDD)* 20021031

03-S-0166

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JAN 2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2003 to 00-00-2003**
4. TITLE AND SUBTITLE **Tri-Service Dem/Val of the Pulsed Optical Energy Decoating (FLASHJET) Process for Military Applications - Rotary Wing Evaluation**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Environmental Security Technology Certification Program (ESTCP),4800 Mark Center Drive, Suite 17D08,Alexandria,VA,22350-3605**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**32**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ESTCP
Cost and Performance Report

(PP-9803)

Tri-Service Dem/Val of the Pulsed Optical Energy Decoating (FLASHJET®) Process for Military Applications – Rotary Wing Evaluation

January 2003

ESTCP
ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

COST & PERFORMANCE REPORT
ESTCP Project: PP-9803 (AVI)

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
DoD	Department of Defense
ECAM	Environmental Cost Analysis Methodology
ESTCP	Environmental Security Technology Certification Program
HAP	Hazardous Air Pollutant
HEPA	High Efficiency Particulate Air
JTP	Joint Test Protocol
NESHAP	National Emission Standard for Hazardous Air Pollutant
SERDP	Strategic Environmental Research and Development Program
TRI	Toxic Release Inventory

ACKNOWLEDGMENTS

We wish to acknowledge the invaluable technical, business, and programmatic contributions provided by the following organizations involved in the creation of this document:

- U.S. Army Environmental Center - Aberdeen Proving Ground, MD
- U.S. Army Aberdeen Test Center - Aberdeen Proving Ground, MD
- U.S. Army Cost and Economic Analysis Center - Arlington, VA
- Naval Air Systems Command - Patuxent River Naval Air Station, MD
- Warner-Robins Air Logistics Center - Robins, GA
- Corpus Christi Army Depot - Corpus Christi, TX
- U.S. Pacific Fleet Helicopter Anti-Submarine Light Wing - San Diego, CA
- Davis-Monthan Air Force Base - Tucson, AZ
- National Defense Center for Environmental Excellence - Johnstown, PA
- The Boeing Company - St. Louis, MO
- Platinum International, Inc. - Alexandria, VA

Technical material contained in this report has been approved for public release.

1.0 EXECUTIVE SUMMARY

A major waste stream associated with Department of Defense (DoD) industrial maintenance facilities is toxic chemical and media blast materials associated with coating removal operations. From the 1994 Toxic Release Inventory (TRI) data for all DoD operations, coating removal operations accounted for approximately 20% of all waste (2.5 million pounds annually from a total of 11.3 million pounds total DoD waste). Chemical coating removers often contain methylene chloride, phenols, and toluene, which are classified as hazardous air pollutants (HAPs). To replace chemical coating removal processes, many facilities switched to the more environmentally preferred method of media blasting. However, media blasting increases the tonnage of coating removal hazardous waste leaving the facility. These conventional coating removal operations have additional safety and health concerns for workers. Due to these undesirable attributes, military maintenance operations are compelled to re-evaluate current coating removal methods and search for alternatives. DoD facilities are also faced with Executive Order 13148, formerly Executive Order 12856, where installations must decrease all waste disposal volumes by 50%. Additionally, DoD facilities are faced with complying with National Emission Standard for Hazardous Air Pollutant (NESHAP) regulations such as the Aerospace NESHAP. In 2004 the Miscellaneous Metal Parts and Products NESHAP regulation that will be final and a section of this regulation will deal with the controlling of HAPs during coating removal activities. This will greatly impact coating removal operations involving ground and fighting vehicles.

In October 1997, the Environmental Security Technology Certification Program (ESTCP) awarded the U.S. Army Environmental Center funding for a project to demonstrate and validate the Flash Tech, Inc. FLASHJET® Coatings Removal Process on military equipment, specifically on rotary wing and ground/fighting vehicle applications. The process was sold from The Boeing Company to Flash Tech, Inc. in December 2001. These applications followed successful work on fixed wing aircraft sponsored by the Strategic Environmental Research and Development Program (SERDP). The FLASHJET® process, originally patented by the McDonnell Douglas Corporation, combines the xenon-flashlamp and carbon dioxide (dry ice) pellet blasting technologies into an environmentally acceptable coatings removal process.

In this rotary wing part of the demonstration/validation, the FLASHJET® process was evaluated on CH-53 off-aircraft components and one fleet SH-60 Seahawk. The CH-53 off-aircraft components were evaluated at The Boeing Company's FLASHJET® facility in St. Louis, MO in February-March 1999 and the SH-60 Seahawk at The Boeing Company's FLASHJET® facility in Mesa, AZ from October-December 1999.

The main objective of the aviation portion of this demonstration/validation was to determine if the FLASHJET® process could effectively remove a significant amount of the external surface area topcoat on all aviation demonstration equipment, specifically to remove greater than 80% of the external coated surface area. All CH-53 off-aircraft components were stripped down to the primer and had greater than 90% of the surface area topcoat removed. The SH-60 aircraft had greater than 95% of the accessible surface area stripped using the FLASHJET® process. All results from the aviation demonstration can be found in the Joint Test Report in Reference #4.

Economic analyses were conducted to determine which coating removal process is more cost effective for an installation with a large rotary wing aircraft workload. The existing plastic media blasting process was used as the base scenario in the analysis and was compared to the FLASHJET® process. The capital costs for one complete FLASHJET® system is estimated at $3.3M. Even though the capital cost for the FLASHJET® system is higher than other traditional coating removal technologies, the acquisition costs are offset by attractive life cycle costs.

The most attractive features of the FLASHJET® process are the attractive net present value and discounted payback periods. The discounted payback period calculated for an installation considering the FLASHJET® process that is currently using media blasting as the coating removal technology for CH-53 off-aircraft components was 4.22 years assuming a 15 year life cycle and a 3.2% discounted payback period. If this installation were to increase their workload, thus having a continuous coating removal operation, the discounted payback period would decrease significantly. If an installation was considering either the FLASHJET® process or media blasting operations for just CH-53 off-aircraft components, the installation would save approximately $9M over a 15 year period by implementing the FLASHJET® process. For the SH-60 Seahawk, an installation considering either media blasting or the FLASHJET® process would save approximately $7.9M over a 15 year period if the FLASHJET® process was selected. By implementing the FLASHJET® process and having a continuous workload, the FLASHJET® process has the potential for significant cost avoidances at major depainting installations.

2.0 TECHNOLOGY DEVELOPMENT

2.1 DEVELOPMENT HISTORY

The FLASHJET® process evolved through several years of research and development. In 1987 the U.S. Air Force experimented with the xenon-flashlamp technology to remove coatings from aircraft substrates. The technology effectively removed the coating but the ash generated was not properly contained and the temperatures on the substrates were extremely high. In 1990 the U.S. Air Force funded another study to demonstrate the carbon dioxide pellet blasting technology for aircraft coating removal. This technology adequately removed the coating but showed the potential for damage to composite substrates.

In 1991 a team of engineers from the McDonnell Douglas Corporation, Maxwell Laboratories, and Cold Jet, Inc. combined these two previously tested technologies into one process. In 1992 the Warner-Robins Air Logistics Center funded a proof-of-concept study to demonstrate the FLASHJET® process on composite substrates. A small 6" FLASHJET® system was developed and successfully tested on a F-15 boron/epoxy vertical stabilizer.

Interest in the FLASHJET® process evolved within the Department of Defense (DoD) after the success of the F-15 vertical stabilizer demonstration. The U.S. Air Force and U.S. Navy partnered and received funding through the SERDP to further qualify the FLASHJET® process on fixed wing aircraft. In this SERDP project, high cycle fatigue testing programs were conducted on substrates commonly found on fixed wing aircraft. The objective of these testing programs was to determine potential fatigue failures possibly caused by the FLASHJET® process. Results from these testing programs showed that the FLASHJET® process does not cause fatigue failures on fixed wing aircraft. Based on these results, the U.S. Navy approved the use of the FLASHJET® process on metallic fixed wing aircraft in 1997 and composite fixed wing aircraft in 2000. Another product developed under this SERDP project was the FLASHJET® mobile manipulator to facilitate practical application of the technology. This manipulator closely resembles aircraft de-icing mechanisms; the stripping head is attached to a manipulator arm and moved directly up to the equipment for operator controlled coating removal operations. The mobile manipulator was developed for larger type aircraft that cannot fit inside a fixed gantry system stripping bay. This ESTCP project further evaluated applications that were not covered under previous FLASHJET® technology demonstrations including the SERDP project.

2.2 PROCESS DESCRIPTION

The FLASHJET® system consists of six components including the flashlamp and stripping head; the manipulator robotic arm; the computer processing cell controller; the effluent capture system; the carbon dioxide pelletizer; and the power supply for the system. The FLASHJET® process can be operated using either the fixed gantry system or mobile manipulator system. The fixed gantry system was used in the CH-53 off-aircraft component and SH-60 Seahawk demonstrations.

The FLASHJET® process combines the xenon-flashlamp and carbon dioxide (dry ice) pellet blasting technologies into one process. The xenon-flashlamp is the primary coatings removal mechanism. The xenon-flashlamp emits low-pressure xenon gas and creates a high intensity flash that is directly reflected to the coating causing the coating to be ablated from the surface. Pulsed light energy generated from the xenon-flashlamp pulses 4 to 6 times per second. The amount of coating ablated is directly proportional to the amount of energy programmed into the system. The FLASHJET® process can be controlled to remove as little as 0.001" or as much as 0.004" of coating during each pass. This control factor can be an asset if only topcoat removal is required.

The carbon dioxide pellet blasting portion of the process is not a direct form of coating removal. A continuous stream of carbon dioxide pellets cools and cleans the substrate, assisting in keeping the substrate at an acceptable temperature while the xenon-flashlamp ablates the coating. Additionally, the pellet stream keeps the flashlamp clear by pushing away all coating towards the effluent capture system intake. All carbon dioxide used during the FLASHJET® process is captured from other industrial sources, converted into liquid carbon dioxide, shipped to the liquid carbon dioxide holding tank at the FLASHJET® facility, and converted into dry ice pellets.

The effluent capture system collects all the effluent ash and organic vapors generated during the ablation process. Effluent ash is vacuumed into the effluent capture system, separated by size in a particle separator, and then captured in a series of high efficiency particulate air (HEPA) filters. Organic vapors are captured and processed through an activated charcoal tank and emitted into the atmosphere with less than 5 parts per million light hydrocarbon emission.

Operator involvement is limited compared to other traditional coating removal processes. Operating the FLASHJET® process requires only two operators. During the scan path programming process, both operators program scan paths into the computer processing cell controller. Manual override of the pre-programmed scan paths is possible if a section of the equipment needs additional attention. During the stripping operation, two operators are required due to the Occupational Safety and Health Administration requirements for operating robotic processes.

Figure 1 provides a general overview of the FLASHJET® process. The yellow light details the pulsed light energy generated from the xenon-flashlamp. The light is reflected down to the substrate via a polished reflector located directly behind the flashlamp. The blue stream coming from the rear of the stripping head shows the recycled carbon dioxide pellet stream that cools and cleans the substrate along with sweeping away any of the ablated coating. The green stream details all of the ablated coating and organic vapors generated during the ablation process. This stream is vacuumed into the effluent capture system. Please note that this picture does not fully represent the operation of the FLASHJET® process. The optimal stand-off distance is 2.19" from the surface of the substrate. Please note that this picture was developed for information purposes only. The standoff distance in this picture is not the actual standoff distance during operation of the system.

2.3 TECHNICAL ADVANTAGES

The FLASHJET® process has several advantages over other traditional coating removal technologies. One advantage is that the process generates minimal quantities of waste. Other traditional coating removal processes not only generate paint waste but also media waste including chemical and media blasting waste. The effluent ash captured on the HEPA filters is the only waste generated in this process. The HEPA filters are tested for hazardous waste characteristics and then disposed of accordingly. Only disposing of the spent HEPA filters significantly reduces the amount of waste and costs associated with disposing waste.

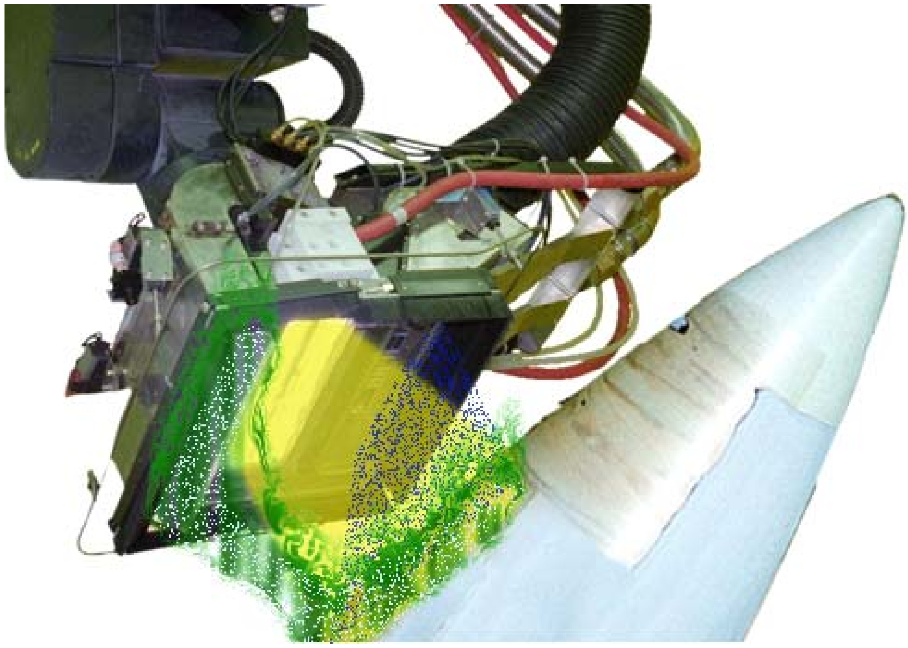

Figure 1. The FLASHJET Process.

Another advantage that the FLASHJET® process has over other traditional coating removal processes is the short discounted payback period. With minimal operator involvement and waste to be disposed, the cost to operate the FLASHJET® process is significantly less than other traditional coating removal processes.

The FLASHJET® process also offers numerous health and safety advantages. One advantage is that operators are not directly involved in the process. In other traditional coating removal processes, several operators are involved and are suited up in personal protective equipment. Workers operating the FLASHJET® process are located in a central control room shielded away from the high intensity light, noise, and effluent ash generated during the ablation process.

2.4 TECHNICAL LIMITATIONS

With the numerous advantages the FLASHJET® process has to offer, there are some limitations. One limitation is the high acquisition cost for installing a FLASHJET® system. The current capital cost for one FLASHJET® system is approximately $3.2M. This cost is significantly higher than other traditional coating removal processes. However if the installation has a continuous workload, the system will pay for itself in a relatively short time period.

Another limitation deals with the size of the stripping head. The stripping head is 12" wide and has problems negotiating around tight corners. A secondary coating removal process, such as a portable laser coating removal system, may be required. In many cases minimal hand sanding may adequately meet the need for simple spot coating removal. The ESTCP is currently exploring the potential of a hand held laser coating removal technology (PP-200027).

This page left blank intentionally.

3.0 DEMONSTRATION DESIGN

3.1 DEMONSTRATION OBJECTIVES

There were four objectives of this demonstration/validation. The first objective was to successfully demonstrate the FLASHJET® process on various rotary wing and ground/fighting vehicle equipment. The FLASHJET® process has been tested extensively on control panels during early research but this effort demonstrated the process on fully assembled applications. The second objective was to successfully validate the FLASHJET® process on rotary wing applications via a high cycle fatigue testing program. The third objective was to calculate an estimated life cycle cost per square foot for the FLASHJET® process for the test equipment. The fourth and final objective was to gather valuable information during the demonstration and transfer lessons learned to DoD installations that are planning to implement the FLASHJET® process.

3.2 MEASUREMENT OF PERFORMANCE

A joint group consisting of technical representatives from the affected DoD Program Managers, government engineering technical representatives, and original equipment manufacturers identified engineering, performance, and operational impact requirements for depainting processes. The group then reached a consensus on tests to qualify potential alternatives against these technical requirements, including procedures, methodologies, and acceptable criteria as applicable.

Performance testing was divided into two categories. Effectiveness tests evaluated the ability of the FLASHJET® process to remove coating without damage to the underlying substrate, to selectively remove topcoat layers only, and to reach intricate areas of the test specimen. The FLASHJET® Qualification Testing Program was developed to evaluate the potential fatigue effects of the FLASHJET® process on rotary wing aircraft. Results from both testing programs can be found in the aviation Joint Test Report found in Reference #4.

Table 1 is an excerpt from the Joint Test Protocol (JTP) developed for qualifying the process on selected equipment for this demonstration/validation. The JTP maybe found as Appendix A of the ESTCP Demonstration Plan and Joint Test Protocol in Reference #3.

Table 1. JTP Performance and Test Requirements.

Test Category	Test Name	JTP Section	Acceptance Criteria	Reference
Effectiveness Testing	Coatings Removal	3.1.1	Coating material removed completely, no damage to the underlying substrate	None
	Selective Coatings Removal	3.1.2	Topcoat layer removed, no damage to underlying primer layer	None
	Strippable Area Assessment	3.1.3	At least 80% of the surface area stripped	None
FLASHJET® Qualification Testing Program	High Cycle Fatigue Test	3.2	Varies by test	ASTM E466-96

3.3 SITE/FACILITY CHARACTERISTICS

Because of the high cost for procuring and installing a FLASHJET® system, the demonstration was held at original equipment manufacturer facilities that are currently using the FLASHJET® process on other applications. Two sites hosted the aviation portion of this demonstration: The Boeing Company's FLASHJET® Paint Stripping Cell in St. Louis, MO and The Boeing Company's AH-64A FLASHJET® Paint Stripping Facility in Mesa, AZ. Both of these systems were the only operational systems at the start of this demonstration/validation.

The Boeing Company's FLASHJET® Paint Stripping Cell in St. Louis, MO hosted the CH-53 off-aircraft component testing. This FLASHJET® Paint Stripping Cell is capable of handling small components but not for handling assembled aircraft. The CH-53 components stripped in this evaluation included the auxiliary pylon; auxiliary fuel tank; main rotor blade; cargo ramp; cargo door - upper; personnel door - upper; and personnel door - lower. Component testing occurred between February and March 1999.

The Boeing Company's AH-64A Apache FLASHJET® Paint Stripping Facility in Mesa, AZ hosted the SH-60 Seahawk demonstration from October to December 1999. This facility is capable of handling any type of aircraft up to the dimensions of a CH-46 with the rotors removed. After arrival, parts of the SH-60 were removed to maximize the stripping area for the demonstration. To minimize the impact on the Apache AH-64A FLASHJET® production schedule, the SH-60 was stripped during open segments of the Apache FLASHJET® schedule.

4.0 PERFORMANCE ASSESSMENT

4.1 CH-53 OFF-AIRCRAFT COMPONENTS

The CH-53 off-aircraft components were evaluated under parameters set forth in the JTP as mentioned in Section 3.2 of this report. Before the off-aircraft components were stripped, coating thickness measurements were taken on all metallic components. These thickness measurements gave the operator some idea of how many passes would be needed to strip a given section.

Specific components evaluated in this demonstration included the main rotor blade, personnel door-upper, personnel door-lower, cargo ramp, auxiliary pylon, and auxiliary fuel tank. The results from the testing are highlighted in the following sections.

All of the results from these tests can be found in the ESTCP Final Report and Joint Test Report in Reference #4.

4.1.1 Main Rotor Blade

The main rotor blade was approximately 31' long and 2' wide and composed of Titanium. Three scan/strip zones were used when stripping the rotor blade. The average coating thickness of the blade was 0.0042". The topcoat was removed and the primer was clearly visible. This component passed the test requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the main rotor blade was 91%.

4.1.2 Cargo Door

Eight scan/strip zones were used when stripping the cargo door. The average coating thickness of the cargo door was 0.0043". The topcoat was removed and the primer was clearly visible. This component passed the test requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the cargo door was 98%.

4.1.3 Personnel Door - Lower

This purpose of stripping the lower personnel door was to determine if the FLASHJET® process would have any damaging effect on plexi glass. One strip path with two passes was executed to determine if the FLASHJET® process would break the plexi glass. The FLASHJET® process had no effect on the plexi glass after two passes at maximum power.

4.1.4 Personnel Door - Upper

Four scan/strip zones were used when stripping the upper personnel door. The average coating thickness of the upper personnel door was 0.0053". The topcoat was removed and the primer was clearly visible. This component passed the test requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the upper personnel door was 95%.

4.1.5 Cargo Ramp

Nine scan/strip zones were used when stripping the cargo ramp. The average coating thickness of the cargo ramp was 0.0033”. The topcoat was removed and the primer was clearly visible. This component passed the test requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the cargo ramp was 98%.

4.1.6 Auxiliary Pylon

Three sections were designated for stripping the auxiliary pylon. The average coating thickness of Section 1 was 0.0022”. The average coating thickness of Section 2 was 0.0017”. The average coating thickness of Section 3 was 0.0011”. All three sections passed the test requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the pylon was 90%.

4.1.7 Auxiliary Fuel Tank

Due to the length and circular nature of the fuel tank, three sections were designated for stripping the auxiliary fuel tank. No coating thickness measurements were taken due to the fiberglass substrate. All three sections passed the requirements for sections 3.1.1; 3.1.2; and 3.1.3 of the JTP. The visual strip result for the entire auxiliary fuel tank was 98%.

4.2 SH-60 SEAHAWK

The SH-60 Seahawk was stripped using the FLASHJET® process over a two month period during breaks in the Apache FLASHJET® paint stripping program. A total of fifty-three scan/ strip paths were used to strip the aircraft. Only the light gray topcoat was removed leaving the underlying primer. All stripped sections of the aircraft were evaluated under sections 3.1.1; 3.1.2; and 3.1.3 of the JTP.

The SH-60 Seahawk used in this demonstration was provided by the U.S. Navy Pacific Fleet Helicopter Anti-Submarine Light Wing, San Diego, CA. Before this fleet aircraft was given approval for a one-time strip, two high cycle fatigue testing programs were initiated. The first fatigue testing program evaluated 7075-T6 Aluminum 0.016” specimens and the results were unfavorable. These unfavorable results were believed to have been caused by a scratch that was originally on an Aluminum panel. Further testing was conducted on 7075-T6 Aluminum 0.025” specimens and results were favorable. Based on these results, the one time FLASHJET® strip was approved. However, the Naval Air Systems Command imposed some stripping limitations during this demonstration. These limitations included restricting the maximum input voltage to 2050 volts (maximum FLASHJET® capability is 2300 volts), limiting the stripping to only metallic substrates with thicknesses greater than 0.025”, and restricting the stripping of composite substrates. With the metallic thickness limitation and ban on composite substrate stripping, only 60% of the aircraft surface area was stripped using the FLASHJET® process. The remaining 40% surface area had to be hand sanded, which increased the stripping time. The technical stakeholders agreed that for this portion of the demonstration/validation that the 80% coating removal acceptance criteria would be evaluated on the allowable 60% surface area of the SH-60 Seahawk. Visual strip results for the 60% aircraft surface area stripped exceeded 95%. This met the requirements in Section 3.1.3 of the Joint Test Protocol.

All of the results from these tests can be found in the ESTCP Final Report and Joint Test Report in Reference #4.

4.3 TECHNOLOGY COMPARISON

The FLASHJET® process was compared to other traditional coating removal technologies currently operated at DoD installations. For the rotary wing applications, the FLASHJET® process was compared to media blasting.

The significant advantages of using the FLASHJET® process over other traditional coating removal technologies include a faster coating removal strip rate, decreased operator requirements, and the limited quantity of hazardous waste generated in the process. Other traditional coating removal technologies typically only remove approximately 1 ft2 per minute while the FLASHJET® process can remove up to 4 ft2 per minute. The FLASHJET® process allows for minimal operator involvement as the process is fully robotic. Other traditional coating removal processes require a number of operators to complete the process. Finally the FLASHJET® process only generates effluent ash during coating removal while other coating removal processes accumulate not only coating waste but also media waste which is used to remove the coating. All of these factors significantly reduce the total cost for coating removal operations.

This page left blank intentionally.

5.0 COST ASSESSMENT

5.1 COST REPORTING

During the demonstration, significant cost data were captured for conducting an economic analysis to determine if the FLASHJET® process will reduce future spending on depainting activities within the DoD. Cost data from other traditional coating removal processes were also captured for comparing the current technology to the FLASHJET® process. The Environmental Cost Analysis Methodology (ECAM) cost tool was used to determine the discounted payback period, net present value, and internal rate of return in this demonstration/validation. Reference #2 contains the ECAM results.

Upon completion of the CH-53 off-aircraft component testing, economic analyses were conducted using the ECAM cost estimating tool. These analyses incorporated actual data taken from the CH-53 off-aircraft component demonstration, technical information from depainting experts, or from best engineering judgment. Analyses were conducted with the assumption that only a total of 120 CH-53 aircraft would be stripped at the installation. Recall that there were six off-aircraft components per CH-53 aircraft.

Upon completion of the SH-60 demonstration, economic analyses were conducted using the ECAM cost estimating tool. These analyses incorporated actual data taken from either the SH-60 demonstration, technical information from depainting experts, or from best engineering judgment. Analyses were conducted with the assumption that only 120 SH-60 aircraft would be stripped at the installation each year.

5.2 COST ANALYSIS

5.2.1 CH-53 Off-Aircraft Components

Two analyses were conducted to calculate the economic analysis for the CH-53 off-aircraft components. The first analysis, Scenario 1, was based on the assumption that a depainting installation was currently using plastic media blasting (baseline) and was considering implementing the FLASHJET® process to replace plastic media blasting. The second analysis, Scenario 2, was based on the assumption that an installation was considering implementing either the FLASHJET® process or plastic media blasting.

Tables 2-5 show the approximate costs for startup and operation and maintenance costs for both Scenario 1 and Scenario 2. Note the significant hazardous waste management costs avoided by using the FLASHJET® process over media blasting.

Table 2. Scenario 1, CH-53 Components, Media Blasting.

Direct Process Costs - CH-53, Media Blasting (Scenario 1)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$0	**Labor**	$407.2K
Training	$0	Waste Management	$138.5K
Permitting	$40K	Utilities	$6.0K
		Direct Materials	$688.9K
		Health and Safety	$2.0K

Table 3. Scenario 1, CH-53 Components, FLASHJET®.

Direct Process Costs - CH-53, FLASHJET® (Scenario 1)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$3.2M	**Labor**	$272.8K
Training	$22.1K	Waste Management	$3.5K
Permitting	$11K	Utilities	$27.6K
1X Program	$3.8K	Direct Materials	$95.6K
		Health and Safety	$1.3K

Table 4. Scenario 2, CH-53 Components, Media Blasting.

Direct Process Costs - CH-53, Media Blasting (Scenario 2)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$2.5M	**Labor**	$407.2K
Training	$8.7K	Waste Management	$138.5K
Permitting	$20K	Utilities	$6.0K
		Direct Materials	$688.9K
		Health and Safety	$2.0K

Table 5. Scenario 2, CH-53 Components, FLASHJET®.

Direct Process Costs - CH-53, FLASHJET® (Scenario 2)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$3.2M	**Labor**	$272.8K
Training	$22.1K	Waste Management	$3.5K
Permitting	$11K	Utilities	$27.6K
1X Program	$3.8K	Direct Materials	$95.6K
		Health and Safety	$1.3K

Tables 6-7 show the calculated 15 year internal rate of return, net present value, and discounted payback for Scenario 1 and net present value for Scenario 2 for both the FLASHJET® process and media blasting. No data is provided for Media Blasting as it is the base scenario and existing technology.

Table 6. Scenario 1, FLASHJET® Economic Results.

Technology	NVP at 15 Years	IRR at 15 Years	Discounted Payback Period
FLASHJET®	$6,662,217	24.8%	4.22 years

Table 7. Scenario 2, CH-53 Off-Aircraft Component, Technology Economic Comparison.

Technology	NPV at 15 Years
FLASHJET®	-$7,988,498
Media Blasting	-$17,178,463

The FLASHJET® process has a more attractive net present value due to the lower waste management, operational labor, and the direct material costs.

Table 8 provides a summary of the estimate life cycle cost per square foot for the CH-53 off-aircraft components for both scenarios.

Table 8. CH-53 Off-Aircraft Component Life Cycle Cost Analysis.

Scenario	Technology	Installation Cost	Annual Costs	~Area (ft^2)	Total Depainted Each Year	LCC/ft^2
Scenario 1	Media Blasting	$40,000	$1,242,610	435	120	$23.86
	FLASHJET®	$3,281,904	$400,761	435	120	$11.87
Scenario 2	Media Blasting	$2,558,680	$1,242,610	435	120	$27.07
	FLASHJET®	$3,279,904	$400,761	435	120	$11.87

If the installation implemented the FLASHJET® process and expanded its equipment stripping capacity, the life cycle cost per square foot figures calculated above would lower depending on the amount of additional workload at the installation. The complete ECAM results for the CH-53 off-aircraft components can be found in Appendix D of the ESTCP Final Report and Joint Test Report in Reference #4.

5.2.2 SH-60 Seahawk

Two analyses were conducted to calculate the economic analysis for the SH-60 Seahawk. Both analyses assumed that the installation was considering implementing either the FLASHJET® process or media blasting as their primary coating removal process. For media blasting, it was assumed that no secondary coating removal process was required. The first analysis, Scenario 1, computed a discounted payback period using actual data from the demonstration figuring that 60% of the aircraft surface area was stripped using the FLASHJET® process and the remaining 40% stripped via hand sanding. The second analysis, Scenario 2, computed a discounted payback period assuming that 95% of the aircraft surface area (including composite substrates) was stripped using the FLASHJET® process.

Tables 9-12 show the approximate costs for startup and operation and maintenance costs for both Scenarios 1 and 2.

Table 9. Scenario 1, SH-60 Seahawk, Media Blasting.

Direct Process Costs - SH-60, Media Blasting (Scenario 1)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$2.0M	**Labor**	$525.6K
Training	$8K	Waste Management	$256.4K
Permitting	$5K	Utilities	$13K
		Direct Materials	$133.7K
		Health and Safety	$18K

Table 10. Scenario 1, SH-60 Seahawk, FLASHJET®.

Direct Process Costs - SH-60, FLASHJET® (Scenario 1)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$3.3M	**Labor**	$358.5K
Training	$1.9K	Waste Management	$2.8K
Permitting	$5K	Utilities	$17K
1X Program	$3.2K	Direct Materials	$18.6K
		Health and Safety	$3.4K

Table 11. Scenario 2, SH-60 Seahawk, Media Blasting.

Direct Process Costs - SH-60, Media Blasting (Scenario 2)			
Startup Costs		**Operation and Maintenance**	
Procure Equipment	$2.0M	**Labor**	$525.6K
Training	$8K	Waste Management	$256.4K
Permitting	$5K	Utilities	$13K
		Direct Materials	$133.7K
		Health and Safety	$18K

Table 12. Scenario 2, SH-60 Seahawk, FLASHJET®.

Direct Process Costs - SH-60, FLASHJET® (Scenario 2)			
Startup Costs		Operation and Maintenance	
Procure Equipment	$3.3M	**Labor**	$115.5K
Training	$1.9K	Waste Management	$2.7K
Permitting	$5K	Utilities	$25K
1X Program	$4K	Direct Materials	$27.9K
		Health and Safety	$3.4K

Tables 13-14 show the calculated net present value after a 15 year period for both the FLASHJET® process and media blasting broken out by scenario.

Table 13. Scenario 1, SH-60 Seahawk, Technology Economic Comparison.

Technology	NPV at 15 Years
FLASHJET®	-$7,968,275
Media Blasting	-$13,175,554

Table 14. Scenario 2, SH-60 Seahawk, Technology Economic Comparison.

Technology	NPV at 15 Years
FLASHJET®	-$5,312,485
Media Blasting	-$13,175,554

The significant cost avoidance factors for the FLASHJET® process include reduced operational labor costs, waste management disposal costs, and direct material costs.

Table 15 provides a summary of the estimate life cycle cost per square foot for the SH-60 Seahawk aircraft for both scenarios.

Table 15. SH-60 Life Cycle Cost Analysis.

Scenario	Technology	Installation Cost	Annual Costs	~Area (ft^2)	Total Depainted Each Year	LCC/ft^2
Scenario 1	Media Blasting	$2,048,150	$946,700	1500	120	$6.02
	FLASHJET®	$3,278,120	$400,315	1500	120	$3.44
Scenario 2	Media Blasting	$2,048,150	$946,700	1500	120	$6.02
	FLASHJET®	$3,278,920	$174,550	1500	120	$2.18

As with the CH-53 off-aircraft components, if the installation implemented the FLASHJET® process and expanded its equipment stripping capacity, the life cycle cost per square foot figures calculated above would lower depending on the additional workload at the installation. The complete ECAM results for the SH-60 Seahawk can be found in Appendix E of the ESTCP Final Report and Joint Test Report in Reference #4.

6.0 IMPLEMENTATION ISSUES

6.1 COST OBSERVATIONS

A limiting factor for many installations is the high acquisition cost for implementing the FLASHJET® process. Currently the implementation cost for one FLASHJET® system is $3.3M. This figure is significantly higher than other traditional coating removal processes. For smaller installations that do not have a large paint/depaint workload, it is not cost effective to implement the FLASHJET® process. Installations that have a continuous workload are at a greater advantage and will experience significant cost avoidances if the FLASHJET® process is implemented.

Installations that do implement the FLASHJET® process will also decrease costs related to manpower, health and safety, and waste disposal. Traditional coating removal processes require a significant number of operators. Also traditional coating removal processes require operators to wear personal protective equipment during the depainting operation. Hazardous waste quantities are also significantly higher. These factors increase the total cost of depainting. The FLASHJET® process only requires two operators present during operation, requires minimal personal protective equipment, and generates minimal waste which depending on its characteristics can be disposed of in a solid waste landfill.

Results of the ECAM analysis show that the FLASHJET® process has the potential to significantly reduce costs associated with depainting. Installations that implement the FLASHJET® process and operate at greater than 50% of the time can reduce the costs associated with depainting.

6.2 PERFORMANCE OBSERVATIONS

The FLASHJET® process was closely monitored to determine if the process would meet the depainting requirements specified in the JTP. Specifically, the evaluation team was concerned about how the FLASHJET® process would selectively remove the topcoat while leaving the underlying primer. Throughout the demonstrations, the team evaluated the ability of the FLASHJET® process to leave the primer and no significant problems were noted.

Another observation noted during the demonstration was that the light gray color coating found on the SH-60 was much harder to strip than originally anticipated, especially at an input voltage 2050 volts. The pulsed light was reflecting off of the light color topcoat making it much harder to strip. With the requirements set forth by the Naval Air Systems Command for the demonstration, stripping an aircraft at 2050 volts takes much longer than stripping at 2300 volts. It was suggested that for equipment with light color paint, the maximum voltage be used during the first few passes to enhance the stripping efficiency.

Periodic maintenance checks are also required to ensure maximum stripping performance. During the first few strip paths of the SH-60 demonstration, the system was not stripping at the maximum stripping index of 11" but at approximately 6". It was determined that a dirty reflector inside the FLASHJET® stripping head caused this problem. The reflector was replaced and stripping indexes returned to 11".

6.3 SCALE-UP

The current configuration of the FLASHJET® process will meet the requirements of any installation that has a significant paint/depaint workload. For rotary wing applications, the fixed gantry FLASHJET® system should be used to minimize operator involvement and maximize depainting time.

6.4 OTHER SIGNIFICANT OBSERVATIONS

The time to program scan paths into the central computer for the SH-60 Seahawk was approximately 80 hours. This programming requirement should only be a one-time occurrence if programmed correctly. To make this a one-time occurrence, it is essential that each piece of equipment being stripped be placed in the same position inside the stripping bay each time. In the Apache FLASHJET® stripping program, each Apache is rolled onto pre-positioned jack stands and set in the same position each time. Pre-programmed scan paths stored in the central cell computer allow the operators to strip an Apache in less than eight hours.

6.5 LESSONS LEARNED

Valuable information was noted during both demonstrations. Lessons learned which will help the installations implementing the FLASHJET® processes are listed below:

- During the CH-53 off-aircraft component demonstration, tables were used to hold the components during testing. The equipment needed to be clamped down to the table to hold the piece in place. It is suggested that if depainting installations are to strip off-aircraft components, or any type of component, that the installation build custom made fixtures to make the stripping process easier. Having custom made fixtures will also reduce the amount of programming time for the components. When the component is positioned in the same place each time, the operator can use the preprogrammed strip paths already stored in the central computer. This factor will increase equipment throughput time.

- A routine maintenance program should be established to ensure optimal performance. The maintenance program should include periodic checks ensuring that all components of the FLASHJET® system are functioning properly and that the FLASHJET® stripping head is clean. It is also necessary to have an adequate number of backup supplies including fuses, xenon-flashlamps, reflectors, etc. on site in case of an unexpected failure.

- When stripping an Aluminum substrate with a thickness less than 0.025”, a lower input voltage should be used to minimize the potential of damaging the thin substrate. Thin skin Aluminum substrates with small surface areas cannot dissipate the high temperatures and can possibly damage the substrate. For this reason it is suggested that the input voltage be lowered over thin skin Aluminum sections.

- Approval is required to strip composite sections of the aircraft using the FLASHJET® process. In this demonstration, the Naval Air Systems Command limited the use of the FLASHJET® process on only Aluminum substrates with thicknesses greater than 0.025”. Composite substrates were not allowed to be stripped in this demonstration. It is crucial that the necessary high cycle fatigue testing scenarios for composite substrates be conducted. Permitting the use of the FLASHJET® process on composite substrates will greatly reduce the man-hours required for stripping aircraft and will also reduce the life cycle cost per square foot.

6.6 END-USER/ORIGINAL EQUIPMENT MANUFACTURER (OEM) ISSUES

In the early planning stages for this demonstration, the Program Managers of equipment being evaluated set specific testing requirements needed for full approval of the FLASHJET® process on their equipment. At the conclusion of the demonstration, engineers in the program offices evaluated the data and approved the use of the FLASHJET® process on their equipment. Approval letters from Program Managers are currently being drafted for circulation.

Since the FLASHJET® process is a proprietary technology, the only avenue for implementing the technology is to contract directly with Flash Tech, Inc. The contracting process can take a very long time so it is suggested that installations considering to implement the technology work closely with their local contracting office to determine what requirements are necessary for contracting directly with Flash Tech, Inc. Flash Tech, Inc. has also established a working relationship with the Navy contracts office at Lakehurst. All services can utilize this contract vehicle. The point of contact at the Lakehurst Naval Air Station is Keith Davis at 732-323-2243.

6.7 APPROACH TO REGULATORY COMPLIANCE AND ACCEPTANCE

The FLASHJET® process is a relatively clean coating removal process which has very little impact on environmental compliance. In order to operate a FLASHJET® system, the installation must comply with the Clean Air Act as effluent vapors are released during operation. In many cases the installation's Clean Air Act permit is sufficient.

The only other issue that must be considered is the disposal of the spent HEPA filters if the filters are deemed hazardous. If the filter is deemed hazardous then the installation must comply with the Resource Conservation and Recovery Act following proper disposal procedures.

This page left blank intentionally.

7.0 REFERENCES

1. Breihan, David W. The Boeing Company. *Performance Report - FLASHJET® Paint Stripping Process on CH-53 Helicopter Parts as a part of the Environmental Security Technology Certification Program (ESTCP) - Demonstration and Validation.* Contract No. DACA31-98-R-0047-0001. April 1999.

2. Concurrent Technologies Corporation. *Environmental Cost Analysis Methodology (ECAM) Handbook.* Environmental Security Technology Certification Program (ESTCP) Validation Tasks. Contract No. DAAA21-93-C-0046. Task No. 098. CDRL No. A013. January 1998.

3. Hutchins, Dean W. U.S. Army Environmental Center. *Tri-Service Dem/Val of the Pulsed Optical Energy Decoating (FLASHJET®) Process for Military Applications - Technology Demonstration Plan and Joint Test Protocol.* Version 4. October 27, 2000.

4. Hutchins, Dean W. U.S. Army Environmental Center. *Tri-Service Dem/Val of the Pulsed Optical Energy Decoating (FLASHJET®) Process for Military Application -ESTCP Final Report and Joint Test Report.* March 15, 2002.

5. Pavlik, Milissa B. The National Defense Center for Environmental Excellence (NDCEE) - Concurrent Technologies Corporation. *Tri-Service Demonstration and Validation of the FLASHJET® Process for Military Applications: CH-53 Off-Aircraft Component Economic Analysis.* Contract No. DAAA-21-93-C-0046. Task No. N126. CDRL No. A004. September 1999.

6. Pavlik, Milissa B. The National Defense Center for Environmental Excellence (NDCEE) - Concurrent Technologies Corporation. *Tri-Service Demonstration and Validation of the FLASHJET® Process for Military Applications: CH-53 Off-Aircraft Component Test Report.* Contract No. DAAA-21-93-C-0046. Task No. N126. CDRL No. A003. September 1999.

7. Stemniski, Peter M. Platinum International, Inc. *Environmental Cost Analysis Methodology - FLASHJET® Coating Removal Process on the SH-60 Seahawk Aircraft as a Part of the Environmental Security Technology Certification Program - Demonstration and Validation.* February 2000.

8. Stemniski, Peter M. Platinum International, Inc. *Performance Report - FLASHJET® Coating Removal Process on the SH-60 Seahawk Aircraft as a Part of the Environmental Security Technology Certification Program - Demonstration and Validation.* February 2000.

This page left blank intentionally.

APPENDIX A

POINTS OF CONTACT

Point of Contact (Name)	Organization (Name & Address)	Phone/E-mail	Role in Project
Dean Hutchins	USAEC	410-436-6855 Dean.Hutchins@aec.apgea.army.mil	ESTCP FLASHJET Program Manager
Peter Stemniski, P.E.	USAATC	703-601-4191 Peter.Stemniski@hqda.army.mil	Former ESTCP Program Manager
Steve Hartle	NAVAIR Patuxent River	301-342-8006 HartleSJ@navair.navy.mil	Navy POC
Randy Ivey	WRALC	912-926-4489 Randy.Ivey@robins.af.mil	Air Force POC
Wayne Schmitz	The Boeing Company	314-232-2921 Wayne.M.Schmitz@boeing.com	FLASHJET Program Manager
Dwayne Huffman	The Boeing Company	314-233-4920 Clarence.D.Huffman@boeing.com	FLASHJET Technical POC

ESTCP Program Office

901 North Stuart Street
Suite 303
Arlington, Virginia 22203

(703) 696-2117 (Phone)
(703) 696-2114 (Fax)

e-mail: estcp@estcp.org
www.estcp.org