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UNITED STATES COAST GUARD

AIRCRAFT FLIGHT CRITICAL PART VERIFICATION SYSTEM
FINAL REPORT

Contract DTCG38-97-C-300004

June 26, 1998

Boeing North American
Reusable Space Systems
Huntsville Operations

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PREFACE

The United States Coast Guard (USCG) Aircraft Repair Supply Center (ARSC) in Elizabeth City, North Carolina is part of a larger initiative being conducted by an interagency task force known as the Flight Safety Critical Aircraft Parts Process Action Team (FSCAP-PAT) to aid in the elimination of unapproved and counterfeit parts. As stated by Mr. Terry Boyce, USCG Quality Assurance Specialist, Unapproved Parts Investigator, "It's important to find a solution to this problem. A price cannot be placed on a human life." The USCG is responsible for demonstrating the feasibility of using two-dimensional (2D) matrix symbols for marking and tracking USCG flight critical components. 2D symbology is a key technology for fighting the problem of unapproved/counterfeit parts in aviation.

Boeing North American (BNA), Reusable Space Systems, in Huntsville, Alabama houses the 2D Symbology Center and is an industry leader and innovator in the field of 2D symbology marking, reading, data transmission and automated parts identification (API) system integration. BNA was awarded contract DTCG38-97-C-300004 on June 25, 1997, for implementing a 2D symbology-based API system pilot project.

USCG and BNA personnel worked together throughout the duration of the project. Most of the pilot activities took place outside the BNA facility, requiring USCG personnel to be trained and take an active role in the project.

This document provides, in detail, the processes for implementing an Aircraft Flight Critical Part Verification (AFCPV) system, including, but not limited to, label printing; system hardware configurations; data transmission; material testing; and system adjustments made for the USCG during the course of the project.

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1. INTRODUCTION

This final report, jointly written by USCG and BNA personnel, documents the actions taken by the USCG and BNA for the AFCPV System Pilot Project contract. The contract was extended by the USCG for six months, beyond the original performance period of six months, to allow the flight critical components enough flight time for an accurate evaluation. Period of performance was from July 1997 to June 1998. (Reference Appendix A, USCG Pilot Project Schedule.) BNA completed its contractual commitments by successfully demonstrating the feasibility of using 2D matrix symbols to identify and track USCG flight critical components.

The objectives of the AFCPV system are to reduce the threat or use of counterfeit or unauthorized parts; improve inventory/logistics management and parts tracability; reduce technical risks involved in marking, tracking, replacing and storing flight critical parts; improve flight and aviation maintenance environment safety; and improve operations efficiency, all of which will increase the efficiency and reduce the cost of part tracking processes.

Pre-selected flight critical components on HH-65A and HH-60J helicopters were marked with a label or permanent laser etched mark using a unique tracking number,. (Reference Appendix B.) These unique numbers were compatible with the USCG Aviation Maintenance Management Information System (AMMIS), Aviation Computerized Maintenance System (ACMS), and the future Aviation Logistics Management Information System (ALMIS) databases.

During the course of the pilot project, actual flight critical components were marked, using both labels and direct laser etched markings; a portable computer was connected in wireless mode to the AMMIS tracking database; marked components were tracked for label performance; and system demonstrations were performed. USCG ARSC engineering developed a project support plan to document the logistics support and planning for the AFCPV system. (Reference Appendix C, Two-Dimensional Data Matrix Code Pilot Project Support Plan.)

This project received significant attention, not only from the USCG, but also from the Airline Transport Association (ATA), Department of Transportation (DoT), Federal Aviation Administration (FAA), airline manufacturing and transportation companies, and others interested in reducing the threat of unauthorized/counterfeit parts. All aircraft and high dollar manned vehicles are susceptible to part identification and tracking errors and counterfeiters. The AFCPV system, as demonstrated during this pilot project, can provide improved part accountability and increased efficiency and reliability of parts tracking.

2. 2D SYMBOLOGY BACKGROUND

2D matrix symbols have been in use by various industries since the mid 1980's. The technology, like its 1950's predecessor, bar code, was slow to develop in its early stages. The challenges of the 1980's were improved redundancy capability, direct part marking, portable hand-held readers, and decoding from shiny surfaces. Significant advances were made on all of these challenges throughout the 1990's, making 2D symbology a highly effective component of advanced API systems.

2.1. Advantages

The advantages of 2D symbols over bar codes and/or human readable are:

- **Scalability.** Depending on the marking method, 2D symbols can be scaled down to minute sizes. Bar codes can only be shortened in height, not width. Bar code and human readable data cannot be placed on small components.

- **Redundancy.** 2D symbols can contain from 0 to 50% redundancy, allowing the given percentage of the symbol to be destroyed and still capable of being decoded.

- **Permanent Etching.** 2D symbols are the only part identification symbology capable of being etched directly onto the surface of a component and successfully decoded without degrading the properties of the material. For flight and other critical components, materials testing is necessary to ensure the marking does not adversely affect materials properties. Bar code companies are pursuing bar code etching; however, the etching depth required for readers to decode the bar codes is not acceptable for critical components.

- **Abundant Data.** 2D symbols contain a minimum of 30 times more information than a bar code, in a given space.

- **No Misreads.** A characteristic of 2D symbology is that the reader cannot produce inaccurate data. The user receives a good read or a NO READ . Barcodes can be manipulated by adding lines/bars. Damaged or altered bar codes can result in inaccurate data.

- **Tamper-resistance.** 2D symbols are practically impossible to alter once they have been applied. If someone does attempt to change a 2D symbol, the most likely result will be a NO READ, as described in the previous bullet. Bar codes are easily altered by adding a line, with an ink pen, for example, resulting in incorrect data.

2.2. USCG Symbology Choice

Data Matrix™ 2D symbology was chosen by the USCG for label and direct part marking. Data Matrix™ was chosen because of the symbol's robust ability to be decoded on surfaces ranging from paper labels to shiny metallic surfaces. The symbology is in the public domain, and most current hand-held 2D readers contain the Data Matrix decoding software. The symbol provides a wide range of redundancy levels (0 to 50%), and is expected to be released as an American National Standards Institute (ANSI) standard in 1998.

3. SYSTEM DESIGN AND COMPONENTS

The USCG pilot AFCPV system provides users with the ability to capture and decode unique machine readable symbols applied to labels or directly onto components. The system also provides for the transmission of decoded information directly to the users' host database computer. This unique number is linked to information for the given component, including on-line management comparisons; inventory management, warehousing, shipping and receiving; historical and air station supply data; and operational statistics. The pilot system is paperless, and is designed to reduce computer input errors, perform on-line hardware status checks, and update information management systems on a real-time basis. It provides the capability to electronically retrieve work authorization documents for on-screen processing, inventory modifications, and related drawings, specifications, and other documentation required by the user to accomplish work tasks.

The following commercial off-the-shelf components were integrated to create the pilot system:

1. **Desktop PC.** The Gateway computer provides capabilities such as label creation, inventory control, host access and reading/decoding symbols.

2. **Desktop Label Printer.** The Eltron thermal transfer printer accepts labels four inches wide, and can print bar code and 2D symbols on a variety of materials. This printer uses an ink ribbon instead of heat to apply the information onto the label.

3. **Hand-held portable computer.** This Texas Micro computer, called a Hardbody, is a rugged, 486 full screen touch computer equipped with radio frequency (RF) capabilities and two serial ports. The unit's small size and light weight makes it an effective in-the-field part tracking tool. (Reference, Appendix D, tab 7.)

4. **Hand-held / Portable Readers.**

   - **Metanetics® IR-2000** - A small hand-held reader capable of decoding all bar codes, stacked bar codes, some 2D matrix symbols (Data Matrix™ and Vericode®) and taking a bitmap image (photograph). Can read symbols from paper, composites and some metals with symbol sizes 1/8 to 1 1/4 inches.

- **Welch Allyn® Imageteam™ 4400 Series** - A small hand-held reader capable of decoding all bar codes , stacked bar codes, some 2D matrix symbols (Data Matrix™ and Aztec Code), and taking a bitmap image (photograph). Can read symbols from paper, composites and some metals with symbol sizes from 1/4 to 1 1/4 inches.

5. **Radio Frequency (RF) Card.** A Proxim PCMCIA card provides RF capability through an access point across approximately 750 feet (line of site). This technology enables personnel to remotely send and retrieve information.

6. **Label Software.** Label Matrix by Strandware provides a complete software package for creating and printing labels from a standard PC. Label Matrix integrates bar codes, stacked bar codes, 2D symbologies, text and graphics into a single package. The label printer drivers are included.

7. **Label Materials.** Tests were conducted to determine the labels (including inks, stocks, adhesives and protective over-laminate) that would provide optimum label performance. Computype, a label manufacturer, provides first-class label material and requires the materials and inks to be tested before shipping. Polyester label TS532P was chosen for this project because of its resistance to water, mild acids, salt and alkalis, most petroleum based greases, and lower aliphatic solvents. The adhesive backing offers high temperature performance, and good resistance to cold and moisture while the peel adhesion is high and increases over time. Reference Appendix D for the specifications of this material.

8. **Component Tracking Number.** Each label marked component receives a unique tracking number, serving as a "license plate" for each component. Each number consists of 12 numeric characters, all unique to the component. The numbering system started with 000000000001 and went through 000000000500.

4. SYSTEM IMPLEMENTATION

The pilot system hardware was set up and maintained in an environmentally controlled office inside the ARSC warehouse (Building 63). The intent of this system was to provide USCG personnel with the ability to create and print the 2D labels and read/decode the labels for tracking purposes. USCG personnel were trained to operate all system components in October, 1997. (Reference to Appendix E, USCG 2D Pilot Project Instructions and Back-up Information manual.)

4.1. Label Design

The initial label design was to provide, given enough space on the component, a 1 x 2-inch label including a 3 of 9 bar code, human readable data and a Data Matrix symbol containing 12 numeric characters. Currently, bar code 3 of 9 is used at most USCG and other government/military facilities. The 2D symbol was added to the right of the bar code with the intent of phasing out the bar code at a later date. All marks utilized the maximum error detection and correction (EDAC) levels since the components were expected to experience harsh environments. See Figure 1 for the design of the label with a bar code.

FIGURE 1. Label with bar code

Three months into the pilot project, the USCG decided to eliminate the bar code from the label design and create a 3/4 x 3/4-inch label with only the 2D symbol containing 12 numeric characters, and the human readable data. See Figure 2 for the design of the label without a bar code.

FIGURE 2. Label without bar code

4.2. Label Generation and Application

The labels were initially created using the desktop computer, label printer and label software located in the ARSC parts warehouse. Later in the project, pre-printed labels were procured by BNA from Comuptype, and supplied to USCG personnel for installation.

The labels were applied at the ARSC warehouse to flight critical components and their shipping boxes. Each box was removed from the bin, the component removed from the box, the area for the label cleaned with alcohol, and the label applied onto the surface of the component, which was placed back into its original box. A duplicate label was placed onto the box and the box was retaped and placed back into its bin.

As the project progressed, USCG personnel suggested marking aircraft components in Post Depot Maintenance (PDM) at ARSC and traveling to other air stations to apply the labels directly onto the aircraft. This approach allowed for the accumulation of more test data for a more accurate evaluation. USCG and

BNA personnel traveled to New Orleans and Savannah and applied labels to the aircraft components.

In New Orleans, 35 components were marked on each of four aircraft. It is suggested by the label manufacturer that the labels cure onto the surface of the components for 24 hours prior to any strenuous use of the label. One of the helicopters flew within four hours of the label application. After the helicopter returned back to New Orleans, the components were evaluated and all the labels were intact.

In Savannah, 35 components were marked on each of the five aircraft. As in the case at New Orleans, most of the aircraft did not stay grounded for the 24 hour curing period.

4.3. System Connectivity

During October 1997, integration of computer systems was successfully demonstrated to USCG personnel. The Hardbody hand-held computer was connected in wireless mode to the AMMIS host database via an access point. The hand-held reader was attached to the serial port of the hand-held computer. The reader utilized the battery pack option, allowing the unit to be completely portable. USCG personnel walked though the warehouse, sending and receiving part identification information via the hand-held computer to and from AMMIS. The hand-held computer also displayed the same real-time data as shown on a desktop computer attached directly to AMMIS.

The hand-held reader attached to the hand-held computer housed the decoding software. The decoded part identification data was transmitted to the hand-held computer for viewing and transmission purposes. The reader beeped when it decoded the symbol, allowing the user to know that a transaction had taken place. Software to display the decoded data was located in the hand-held computer.

5. DIRECT PART MARKING

The USCG chose two different components to be evaluated for permanent direct part marking: torque transducer and spherical bearing beam attach bolt. Direct part marking consists of using an ABLaser Co. Yag laser to etch 2D symbols into the metal surface to create a permanent mark. The laser is controlled by a computer that inputs the frequency, amps and speed of the laser beam.

The labels used during the pilot project served to demonstrate the feasibility of a 2D symbology-based system. For a full scale API system, direct part marking may be preferable for most components. Advantages of direct part marking include, but are not limited to, permanency, resistance to temperature variants and harsh solvents, and life-long traceability. The following steps were taken to determine the acceptability of direct part marking:

1. The BNA Materials and Processing (M&P) Laboratory, Downey, California in conjunction with USCG ARSC Engineering Division, and the Original Equipment Manufacturer (OEM) of the two components, determined the material properties. The transducer material was SS17-4PH steel and the bolt material was 4340 steel.

2. After the material type was accurately determined, the BNA materials library was searched for existing test reports pertaining to these specific materials and Yag laser marking. No test data was located.

3. BNA acquired several 1x2-inch material test coupons for each material from an approved materials company. Multiple 2D symbols with different laser settings were applied in a row on each test coupon.

4. After the coupons were marked, they were sent to the BNA M&P Lab for metallurgical testing. This test consisted of placing each mark under a 100x and a 500x microscope to determine which 2D mark caused the least damage to the metal.

5. Once the optimal laser marking parameters were determined, the BNA 2D Symbology Center in Huntsville marked several coupons for each material type with the marking setting derived from step 4 above. These coupons were shipped to the M&P Lab for a four week, 24 hours a day salt spray test.

6. After six days, both materials were evaluated. The 4340 steel bolt coupon failed the test. Rust covered the entire coupon, including the marked area. The SS17-4PH transducer coupon was acceptable. The SS17-4PH coupons remained in the salt spray for approximately three more weeks. Following an examination after removal, the metallurgical properties of the material were still intact.

7. Several 1x6-inch SS17-4PH dogbone coupons were prepared in Huntsville for high cycle fatigue testing. Each coupon was marked in the center with one 2D symbol containing 12 characters of data. The coupons were shipped to the M&P Lab, where they were subjected to vibrations simulating flight environments. This test ensured the laser markings did not introduce pits or stress cracks in the material.

8. Once all testing was completed, a test report was written by the M&P Lab and reviewed by BNA-Huntsville personnel. (Reference Appendix F, Evaluation of Laser Identification Marking on SS17-4PH and 4340 steel.)

9. Once the review process was complete at BNA, the report was sent to the USCG ARSC in Elizabeth City to be reviewed by the Engineering Division.

10. Once the ARSC Engineering Division completed the review, and approval was granted, a formal request (reference Appendix G) was submitted from the USCG ARSC to BNA, requesting permanent markings on 10 torque transducers.

11. All 10 transducers were successfully marked in Huntsville using the Yag Laser. The information etched in the 2D symbols consisted of 12 numeric characters ranging from 000000000501 to 000000000510. All transducers were successfully read and verified for accuracy, marking/background contrast, and print growth prior to being shipped back to Elizabeth City. USCG personnel successfully read each transducer using the Metanetics reader prior to installation onto an aircraft.

6. EVALUATION PROCESS

A total of 500 components on 18 aircraft were marked with unlaminated (no clear label covering) labels consisting of a 2D symbol and a human-readable identification number. The labels were applied at ARSC, Air Station Elizabeth City, Air Station New Orleans and Air Station Savannah. Successful label markings had to meet the following requirements: the labels must be durable, providing unique identification of the part "from cradle to grave"; the labels must be mechanically accessible for ease of electronic reading; and, the labels must remain readable under all normal operational, environmental and overhaul conditions. Air Station personnel were asked to report any label discrepancies to ARSC Engineering for program monitoring.

USCG personnel visited seven air stations and the ARSC PDM to collect data on label performance. (Reference Appendix H, USCG Units Visited.) The adhesiveness of the labels was found to be highly effective. Of the 500 labels installed, only 5% were found missing. These occurred on the rotor head components, which have a rough casting surface. All other labels were found adhered, intact and readable. Discrepancy reports and their disposition are discussed in the following paragraphs.

6.1. Discrepancy Reports 1 and 2.

The first two discrepancy reports were received from Air Station Savannah six days after applying the labels. (Reference Appendix I - Discrepancy Reports 1 and 2.) They reported two labels had fallen off from the upper and lower attach beams and the starflex assembly. These components have a rough casting surface that is difficult to mark with a label. Although the labels seemed to adhere to the surface, the lack of a smooth surface on the component allowed lubricating products to get under the label and cause the label adhesive to fail.

The upper and lower attach beams and the starflex assembly are manufactured with a course, rough surface that is not conducive to the adhesive labels, unless a smooth area is found. The upper attach beam does provide a smooth area that allows an excellent adhesive bonding as well as being accessible for hand-held reading. The lower attach beam has one, small smooth area that provides excellent adhesive bonding, but the label has to be cut to fit into the area and positioned for portable reading/decoding.

For the attach beams, two options were considered:

- Relocating the 2D label to a smoother area.
- Marking the attach beam with a direct laser mark.

BNA marked a scrap attach beam with a test 2D laser mark and returned it to ARSC for review. The mark did not require material testing as the laser only removed the painted coating on the flange. After inspecting the laser mark, the USCG concurred that direct part marking via laser is a viable option for the attach beam.

The starflex assembly does not provide a smooth area for label application. A label was reapplied after particular attention was paid to surface cleanliness. However, direct part marking is the most likely long-term solution.

6.2. Discrepancy Reports 3 and 4.

The third and fourth reports, also from Air Station Savannah, were received approximately 30 days later. (Reference Appendix I - Discrepancy Reports 3 and 4.) Maintenance personnel reported that while undergoing preventative maintenance on the tail section of the HH-65 helicopter, hydraulic fluid and a preservation compound caused the print on the labels to be easily wiped off, leaving a blank label. Although the ink used in the label printing was degraded, the label adhesive was unaffected.

This issue led to a follow-up evaluation of all 500 marked components. USCG performed in-house experiments in the Hazardous Materials Shop at ARSC. Various common aircraft hazardous materials were applied to the same type labels that had been applied to the aircraft components. The print on labels suffered in almost all cases. USCG then applied the same materials to labels covered with a clear laminate. The print on the laminated labels was unaffected. Based on these results, USCG conducted follow-up visits to the pilot project sites to apply clear labels over the original printed labels. BNA provided the USCG with instructions on how to apply the laminates. This approach allowed ARSC to salvage the labels from any future ink deterioration.

6.3. Discrepancy Reports 3 and 4, Additional Considerations.

Prior to covering the original labels with laminate, two other evaluations were made:

- Why was the print being removed?
- How permanent were the labels?

Before a label could accept a clear label laminate, the label had to be thoroughly cleaned. The printed labels were first wiped with a dry paper cloth, then an alcohol pad. The part was allowed to air dry before the laminate was applied. In each case, the components were found with some type of fluid, preservative or dirt covering the label. The print was easily removed when touched by a finger, cloth or alcohol pad. Many labels were replaced and all labeled components were covered with the clear laminate label.

When labels had to be replaced, a permanency test was performed. As each label was removed, the length of time it took to remove the label and the destructiveness of the label was measured. The removal time varied, but never took longer than 20 seconds using a finger nail. Once a corner of the label was loosened, the label could be pulled off and the adhesive residue that remained on the component could be rubbed off. The label was not destroyed during removal. The destruction of a label during removal is an advantage in preventing unauthorized label use. The labels chosen for this pilot did not include this feature. "Super-destructive" labels, i.e., those which are destroyed during removal, are available through Computype.

The evaluation process led to several modifications in label requirements and to the use of direct laser etched marking on parts with rough surfaces or small marking areas. The location of the 2D symbol was vital to the reading/decoding process, so that data could be extracted while parts are installed on the aircraft.

A further study should be conducted to test the applicability of the Super-Destruct label. See paragraph 7.1.1 for a complete list of recommended label materials.

7. LABEL AND DIRECT PART MARKING RECOMMENDATIONS

7.1. Labels

7.1.1. Label Material

After the issue of the degradation of ink by oils and other fluids became an issue, BNA investigated several label options.

The following two labels should be considered when marking components that reside in oily areas. Both of these labels contain a permanent adhesive, but with effort can be removed and reused if additional adhesive is added. (Reference Appendix J for the following material specification sheets.)

- **FLAP Label.** This is a two-piece label set comprised of a chemical resistant clear flap label. This flap was developed to withstand chemically rigorous environments and can be printed by the user. To apply this label, the user removes the protective cover from the back of the printed label, applies it to the surface, then applies the attached flap.

- **Super Compucode.** This is a pre-printed tamperproof label with a clear overlaminate resistant to heat, cold ultra-violet (uv) rays, water, mild acids, salt and alkalis, most petroleum based greases, oils and lower aliphatic solvents.

The next two labels should also be considered when marking components that reside in oily areas. Both of these labels contain a permanent adhesive, but the removal of these labels is more difficult, as described below:

- **Void Pattern.** This pre-printed label is covered with a clear overlaminate and is lined with a permanent adhesive, that when applied, the word "VOID" appears on the surface of the component when the label is removed. This label cannot be reused, since the adhesive is removed from the lining of the label to create the "VOID". This label is resistant to water, acids, salt and alkalis, most petroleum based greases, oils and lower aliphatic solvents.

- **Super-Destruct.** This tamperproof pre-printed label is covered with a clear tamperproof overlaminate and lined with permanent acrylic. When this label is removed, the label self-destructs, leaving tiny label pieces to be removed one at a time. This label is resistant to heat, cold, uv rays, water, acids, salt and alkalis, most petroleum based greases, oils and lower aliphatic solvents. The labels are available in a 3/4x3/4-inch size, optimum for use in the USCG applications seen during the pilot project.

7.1.2. Additional Label Testing

BNA recommends that the USCG conduct a test program for the Super-Destruct labels described in 7.1.1 above. The labels should be subjected to flight conditions and their performance tracked and documented. To ensure continuity with the results and records of the pilot program, the part identification numbers for the Super Destruct labels should begin with

000000000511, the number following the last number used in the pilot, and run consecutively until the study is complete.

Air Station Kodiak is a suitable candidate location for conducting the additional testing. The extreme climatic conditions at Kodiak provide the greatest challenge for environmental and operational testing of system components.

7.2. Direct Part Marking

7.2.1. Marking Options

Direct part marking offers the most permanent and tamper-proof marking options. Marking via laser provides one of the fastest methods for permanently marking components. Before any laser marking is utilized however, metallurgical testing is required to determine the optimal laser settings. If the laser is not used properly, severe damage could be done to the component. If the laser is not an approved method for a given material, other options are available:

- **Ink Jet.** This marking method is most commonly used for aluminum cans and golf balls. The ink dries the instant it reaches the surface of the product, can be applied very quickly (assembly line speeds), there are a number of inks available, including MIL Spec inks, that are easily read by hand-held readers. However, the markings cannot survive extremely hot temperatures or scratching. Also, more testing is required to determine if the deteriorating inks produce gasses that might be incompatible with the operating environment.

- **Dot Peen.** This marking method actually enhances the properties of the metal instead of degrading it. As the peen presses into the material, the material compresses out to the sides giving the area added strength. The disadvantage to this method, with today's technology, is that hand-held readers require contrast between the symbol and the material to successfully decode. 2D symbols, at the current time, require approximately 50% contrast between the marking and the substrate. Chalk or a backfilling agent must be added to the dot peen markings each time the mark is decoded, to improve the contrast. Prototype readers are currently being developed to decode symbols with little contrast.

7.2.2. Bolt Marking

BNA recommends several options for marking the spherical bearing beam attachment bolt. They are provided below, in order of their effectiveness.

1. Mark the base of the bolt with a laser, then cover the entire base with a clear Mil spec coating. With a coating applied, the 4340 material does not corrode, due to the environmental affects. (Note: The 4340 steel requires additional testing to determine the safety of laser markings.)
2. Mark the base of the bolt with a Mil spec ink using an ink jet machine, then cover the base and ink marking with a clear Mil spec coating. Ink jet provides a fast and readable mark, but ink cannot withstand adverse settings such as extremely high temperatures, rubbing or abrasive settings. The clear coat covering provides the ink jet marking extra protection against adverse environments.
3. Mark the gray coated area of the bolt with a Mil spec ink using an ink jet machine, then cover the ink marking with a clear Mil spec coating. This method should be tested for contrast between the marking and the substrate color. The ink cannot withstand harsh environments.

8. CONCLUSION

The AFCPV system pilot project demonstrated the feasibility of applying 2D symbols onto flight critical components, and integrating the part identification data with USCG databases. The project revealed no significant technological, integration nor user-related weaknesses in the systems, processes and procedures chosen for this study. The pilot demonstrated that a 2D symbology-based API system can increase control of part tracking processes and improve the efficiency of inventory management systems. Implementation of an operational AFCPV can provide "cradle to grave" accountability for all flight critical parts, reducing the threat of unapproved/ and counterfeit parts. The USCG's investigation of API systems is breaking new ground in the field of aviation logistics management. BNA looks forward to continuing a productive relationship with the USCG that will build on the progress made and improvements demonstrated in this pilot project.

9. PROJECT RECOMMENDATIONS

The adoption of an API system utilizing 2D symbology technology is key to the successful transition from a manual or non-existent parts tracking system to an automated parts identification system. The following recommendations provide direction for operational implementation.

A logical first step is for the current contract to be extended to allow BNA to participate in evaluation of Super-Destructive labels (see 7.1.2 above); monitor and evaluate the direct part markings on the torque transducers; and, to conduct 2D symbology-based API system demonstrations as directed by the USCG.

In the longer term, it is recommended that BNA be required to perform the following tasks in close cooperation with and support from the USCG:

- Conduct a complete API analysis of each location (e.g. hangar, warehouse, shop, office).

- Determine optimum permanent marking methods for life-time parts tracking of USCG components.

- Determine optimum part numbering system.

    - Continue the use of the USCG 12-digit unique identification number used during the pilot project. Optional identification numbering systems are also available. The USCG should promote 2D symbology marking by the OEMs on all new USCG components. This identification number would consist of the vendors' cage code followed by a unique part identification number.

- Conduct an equipment (hardware and software) requirements analysis based on the needs of all USCG unit types.

    - If RF is determined to be the optimum communication link between warehouse or other areas and the host computer, conduct an RF sight survey to determine the number and placement of the RF access points.

- Conduct a cost analysis for implementing AFCPV systems throughout all areas of each USCG unit.

- Implement a system to enable the marking of all flight critical components on all USCG aircraft, and the integration of symbol data with USCG databases.

- Provide USCG personnel training for complete system implementation.

- Provide USCG ongoing technical support and expertise on all 2D/AFCPV systems used at the USCG.

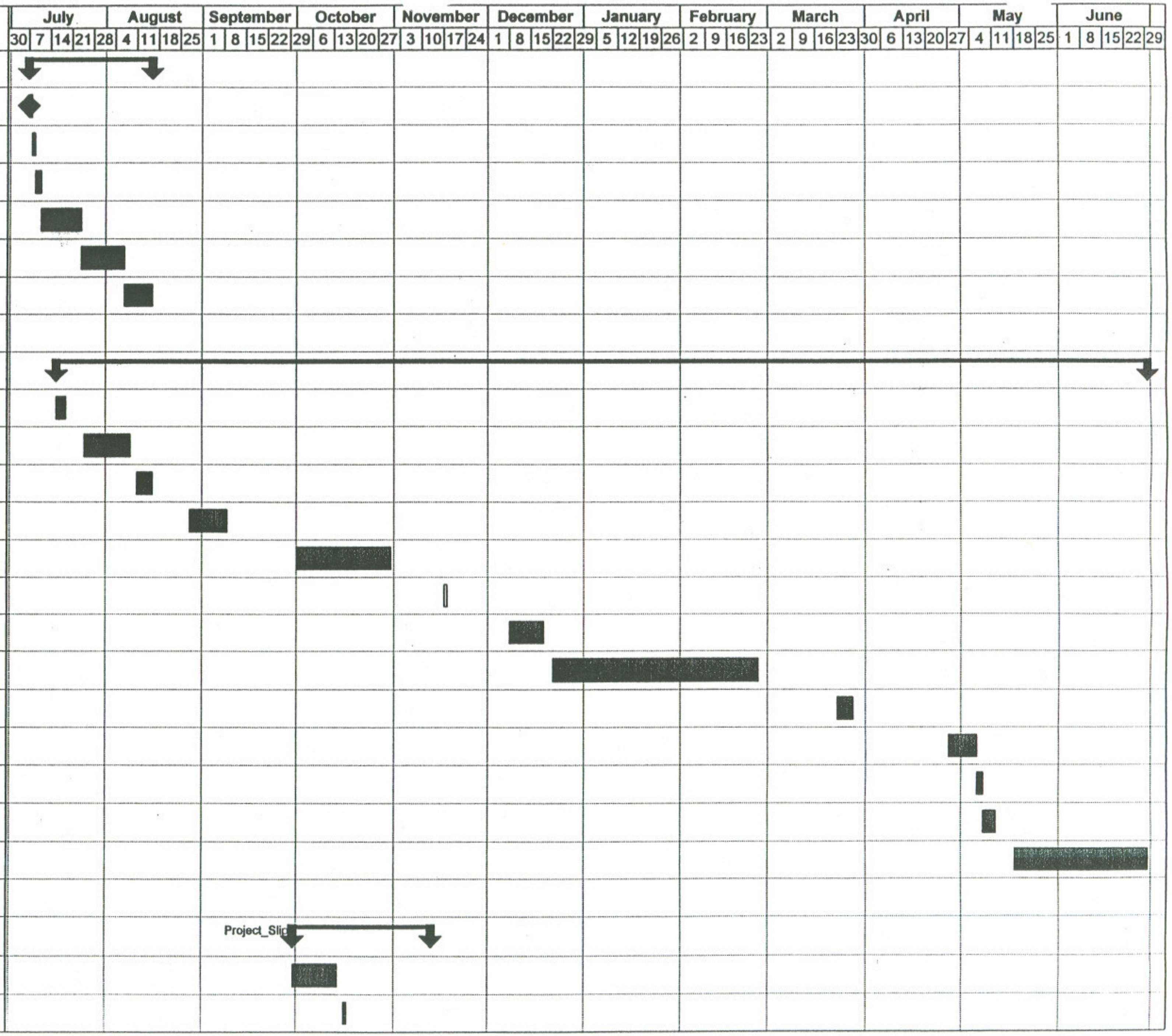
ACRONYMS

2D	Two Dimensional
4340 Steel	Corrosive Steel Material used on the Bolt
ACMS	Aviation Computerized Maintenance System
ALMIS	Aviation Logistics management Information System
AMMIS	Aviation Maintenance Management Information System
ANSI	American National Standards Institute
API	Automated Parts Identification
API&V	Automated Parts Identification and Verification System
ARSC	Aircraft Repair & Supply Center
ATA	Airline Transport Association
BNA	Boeing North American
DoT	Department of Transportation
EDAC	Error Detection and Correction
FAA	Federal Aviation Administration
FSCAP-PAT	Flight Safety Critical Aircraft Parts Process Action Team
M&P	Materials and Processes
MIL	Military
OEM	Original Equipment Manufacturer
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PDM	Post Depot Maintenance
RF	Radio Frequency
RFP	Request for Proposal
SS17-4PH	Corrosive Resistant Stainless Steel Material used on the Transducer
USCG	United States Coast Guard
UV	Ultra Violet

APPENDIX A
USCG PILOT PROJECT SCHEDULE

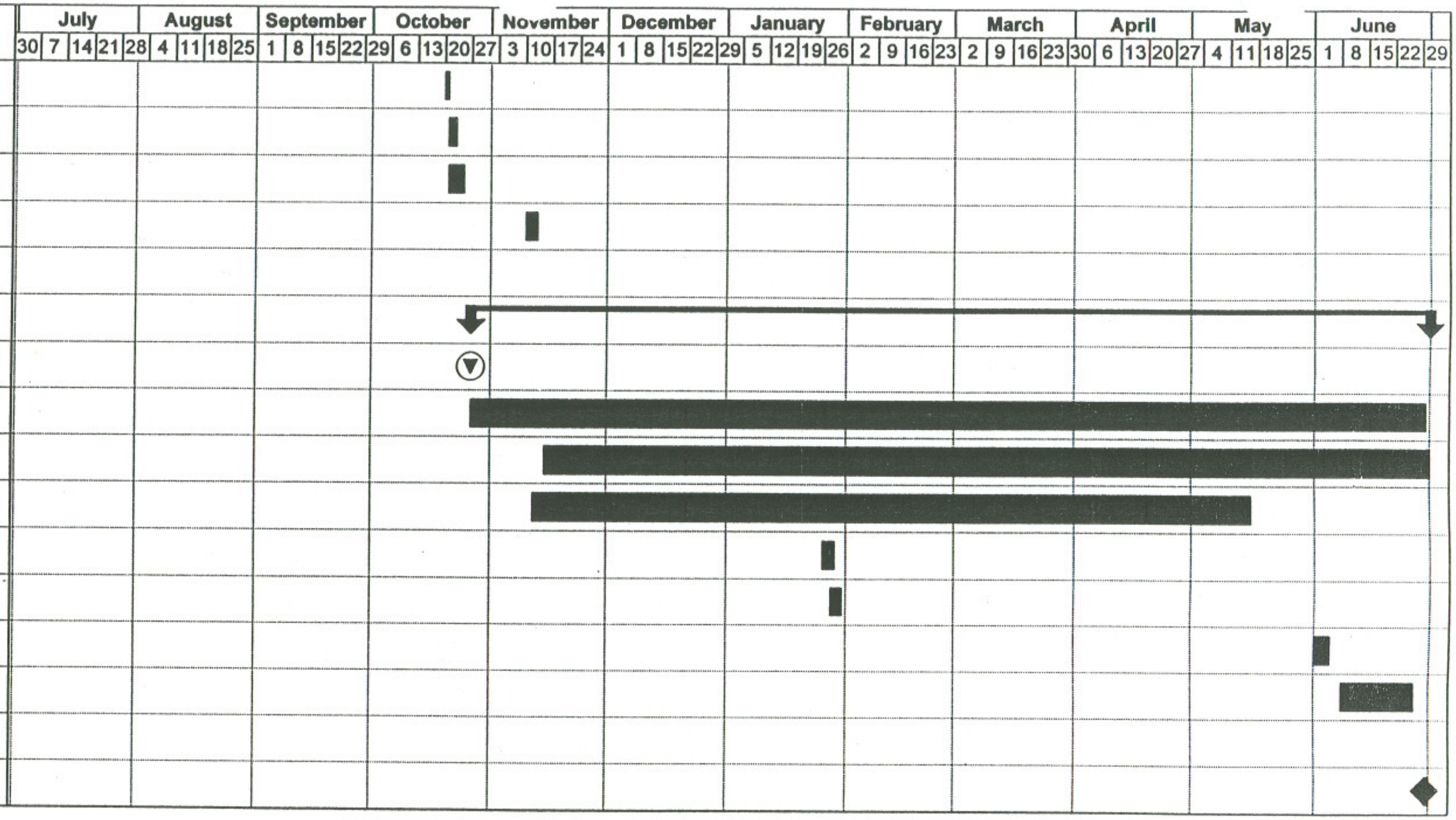
US . . ?ilot ct S . . . ule

ID	Task Name
1	**Label marking**
2	Receive ok-to-start
3	Design part labels
4	Design label input software
5	Analyze label requirements
6	Procure label samples
7	Test materials & procure stock
8	
9	**Permanent marking**
10	Review laser test data with OEM
11	Obtain test coupons - 2 materials
12	Mark test coupons
13	Metallography & SEM analysis
14	Conduct environmental testing
15	Review M&P Rpt w/OEM & decod
16	Obtain fatique test specimens
17	High cycle fatigue testing
18	Coordinate test data with team
19	Obtain CO's approval to mark part
20	Ship flight parts to Huntsville
21	Mark parts & return
22	Install Transducers
23	
24	**System Dev. & Installation**
25	Integrate hw/sw at HSV
26	Deliver system to USCG



U: Pilot ect S ule

ID	Task Name
27	Conduct on-site functional tests
28	Perform data transmission tests
29	Conduct on-site user training
30	Mid Term Review
31	
32	**Marking & Decoding Operations**
33	USCG to initiate part marking
34	Monitor USCG label marking
35	Monitor USCG decoding tests
36	Eval. alternate marking methods
37	Travel to Savannah, Ga
38	Travel to New Orleans, LA
39	Jointly write Final Report
40	Write final project report
41	
42	**Deliver Final Report**



APPENDIX B
PART MARKING MATRIX

HH-60J/HH-65A Part Marking Matrix

Part Number	Part Nomenclature	Material Type	Surface Coating	Surface Rough. Level	Environment	Max. No. of Char's	Data EDAC Level	Max.. Symbol Size	Proposed Marking Method
SC7282	Tail Rotor Servo	Aluminum	Painted	Smooth	C-MH, HU, DSW, P	20	140	1" X 1.75"	Label
SC8033-1	Primary Servo LH F/A	Aluminum	Painted	Smooth	C-MH, HU, DSW, P	21	140	1" X 1.75"	Label
950-36	Anticipator Ctrl. Box	Aluminum	Painted	Textured	C-MH, HU	TBD	140		Label
3327-100	Fuel Jettison Valve	Aluminum	Anodized	Smooth	C-MH, HU, DSW, F	12	140	1" X 1.75"	Label
82562-7	Alternator	Aluminum	Anodized	Smooth	C-MH, HU, SWS, P	11	140	.1" X 2"	Label
158991-1	Bottle, Flotation	Composite	Painted	Textured	C-MH, HU	TBD	140	2" X 2"	Label
204623-1	Cyl., Blowdown L/G	Composite	Painted	Textured	C-MU, HU, SWS	TBD	140		Label
30400022	Eng. Fire Bottle	Stainless Steel	Bare Metal	Smooth	C-HH, HU, SWS	16	140	2" X 2"	Label
150SG125Q	Starter Generator	Steel	Cad Plated	Smooth	C-HH, HU, SWS, P	15	140	1.5" X 2"	Label
270-0750-020	Series Actuator	Aluminum	Painted	Smooth	C-MH, HU, SWS	16	140	.50" X 2"	Label
270-0751-020	Trim Feel Actuator	Aluminum	Painted	Smooth	C-MH, HU, SWS	TBD	140	.1" X 2"	Label
365A31-1850-00	Lower Attach Beam	Composite	Painted	Textured	C-MU, HU, DSW	24	140	2" X 2.5"	Label
365A31-1850-03	Upper Attach Beam	Composite	Painted	Textured	C-MU, HU, DSW	24	140	2.5" X 2.5"	Label
365A31-1810-02M0	Starflex Assy. MRH	Composite	Painted	Textured	C-MH, HU, DSW	30	140	2" X 2"	Label
365A33-6005-02M	Tail Gear Box	Magnesium	Painted	Smooth	C-MU, HU, DSW, P	19	140		Label
366A11-0010-05	Main Rotor Blade	Composite	Painted	Smooth	C-MH, HU, DSW, P	30	140	2" X 2"	Label
365A23-4003-0501	Fenestron	Composite	Painted	Smooth	C-MH, HU, DSW, P	20	140		Label
366A25-0033-00010	Sliding Door	Composite	Painted	Smooth	C-MH, HU, DSW, P	20	140	3" X 3"	Label
366A32-0001-00	Main Gear Box	Magnesium	Painted	Smooth	C-HH, HU, DSW, P	22	140	2" X 2"	Label
365A31-1970-21	Spherical Bearing Beam Bolt	Steel	Painted	Smooth	C-MH, HU, SWS, P	16	140	.5" X .5"	Laser
70106-28000-048	Damper Assy. M. Rotor	Aluminum	Painted	Smooth	C-MH, HU, SWS, P	15	140	1" X 1"	Label
70200-27000-046	Stabilator Assy. Center	Aluminum	Painted	Textured	C-MH, HU, SWS	15	140	1" X 1"	Label
70200-27001-044	Stabilator Assy. L/H	Al/composite	Painted	Textured	C-MH, HU, SWS	15	140	1" X 1"	Label
70200-27001-045	Stabilator Assy.R/H	Al/composite	Painted	Textured	C-MH, HU, SWS	15	140	1" X 1"	Label
IPT-44DRT1-1000-100G	Torque Transducer	Stainless Steel	Bare Metal	Smooth	C-HH, HU, SWS, P	28	140	.5" X .5"	Laser

Environment Key: C = cold, **H** = heat, **MH** = moderate heat, **HH** = high heat, **HU** = humid, **SWS** = salt water splash, **DSW** = direct salt water, **P** = oil or hydraulic fluid, **F** = fuel

APPENDIX C
TWO-DIMENSIONAL DATA MATRIX CODE
PROJECT SUPPORT PLAN

TWO–DIMENSIONAL DATA MATRIX CODE PILOT PROJECT SUPPORT PLAN

REVISION NO. 1: November 20/97

To Holders of 2D Matrix Bar Coding Pilot Project Support Plan

HIGHLIGHTS OF

REVISION NO. 1, DATED NOVEMBER 20, 1997

Revision No. 1 incorporates the following changes to the original support plan (not dated):

1. Title changed from 2D MATRIX BAR CODING PILOT PROJECT SUPPORT PLAN to 2D DATA MATRIX CODE PILOT PROJECT SUPPORT PLAN. This change provides a more accurate discription of the code used in the pilot project.

2. Page 1, para. 1, first sentence: Changed to, "This Two–Dimensional (2D) Data Matrix Code..."

3. Para. 3, page 1, last sentence: The completion date is changed from February 28, 1997 to February 28, 1998.

4. Enclosure (1): Actuator, NSN: 1680–14–401–5782, P/N: 418–00570–000 has been deleted. Spherical Bearing Beam Bolt, NSN: 5305–14–448–2646, P/N: 365A31–1970–21 has been added.

5. Subheading II. Technical Documentation, para b.: Deleted last sentence.

6. Subheading III. Personnel and Training, para f.5.: Updated phone number from 919–335–6035 to 919–335–6250.

November 20/97

2D DATA MATRIX CODE PILOT PROJECT SUPPORT PLAN

This Two–Dimensional (2D) Data Matrix Code Support Plan documents the logistics support and planning for the Aircraft Flight Critical Component Verification (AFCCV) system. It promulgates the necessary information and defines those areas of responsibility required to initiate and support an automated parts identification (API) system. All Coast Guard support and operating unit personnel who initiate, use, and/or support this system shall comply with the approved support planning contained herein.

The AFCCV system pilot project is part of a larger initiative being conducted by an interagency task force known as the Flight Safety Critical Aircraft Parts Process Action Team (FSCAP–PAT). The team charter is to investigate the useability/adaptability of API systems used in the aerospace industry. The primary requirement of the pilot project is to develop, test, and implement a USCG 2D symbology–based AFCCV system for marking and tracking flight critical components. The objectives of the API system are to reduce the threat or use of counterfeit/unapproved parts; improve inventory/logistics management and parts traceability; reduce technical risk involved in marking, tracking, replacing, and storing flight parts; improve flight and aviation maintenance environment safety; and, improve operations efficiency, and reduce costs.

The API pilot is a six month project that commenced July 7, 1997 with an initial visit to ARSC by Boeing North American (BNA) to discuss project agenda and procedures. It was suspended for two months until completion of the CFO Audit. It will continue October 20 with the arrival of BNA personnel at ARSC to begin the 2D marking process and on–the–job training. The scheduled completion date is February 28, 1998.

I. SUPPORT EQUIPMENT

Materiels Branch will designate a warehouse location accommodating to the various HH–65 and HH–60 components chosen for the marking process (enclosure 1). The worksite will be equipped with a desk, work table, electrical power, forklift and/or handtruck, and adequate lighting.

Management Information Services Division (MISD) will provide a 10Base–T, Ethernet, network to the worksite to enable the personal computer to verify that the system components are compatible and can successfully exchange data in both directions.

Engineering Technical Data Section will provide warehouse location markers to identify the selected components in the 2D pilot project.

II. TECHNICAL DOCUMENTATION

All documentation will be the responsibility of the project officer and/or the assistant project officer.

a. Loan documents will be required if components are removed from the warehouse.

b. A SCHR entry will be made for each component marked. The SCHR entry will state, "This component has been marked with a 2D symbol and is undergoing an automated parts identification (API) pilot project managed by ARSC."

c. A SIS remark on the AMMIS MID will be added to each part number involved in the pilot project. The SIS remark will state, "This part is being monitored in the 2D automated parts identification (API) pilot project."

III. PERSONNEL AND TRAINING

a. BNA's AFCCV system development team includes Mrs. Lisa Johnson, 2DCenter Principle Investigator; Mr. John Ford, Senior Engineering Specialist; and Mr. George Frey, Materials and Processes Engineer who will oversee the M&P activities associated with this project.

b. ARSC personnel includes Petty Officer Deborah Walsh, Project Officer, Engineering Support Branch; and David White, Assistant Project Officer, Engineering Product Assurance Branch.

c. The training program is designed to familiarize personnel with operation of the pilot AFCCV system. Training requirements for ARSC personnel will vary according to their level of involvement. Training by BNA personnel is scheduled for October 20–24. Training sessions will address the following major areas:

1. System overview
2. Label parameters definition and label printing
3. Data capture system (hand–held camera and computer) operation and maintenance
4. Data transmission
5. Recording of symbol reading test results
6. Problem reporting

d. Personnel scheduled for training in the 2D matrix symbol marking procedures includes 6–10 ARSC personnel, other than the Project Officer and the Assistant Project Officer. The selected personnel includes two to four material handlers, one expediter, and one equipment specialist from the HH–65 and HH–60 Inventory Management Sections. Other personnel may be added as necessary to fill the allotted training slots. Training sessions will be short and should not keep personnel from doing their normal work duties. A training schedule will be distributed the week of October 20.

e. A future trip to USCG Air Station New Orleans and/or Savannah may be necessary to perform system demonstrations, identify unique requirements, and identify the most efficient and cost–effective communications interface mechanisms that will be utilized between the Air Stations and ARSC. Training unit supply personnel in 2D matrix symbol marking procedures would be included at that time.

f. Points of contact are listed as follows:

1. AE1 Walsh, Project Officer, 919–335–6830
2. David White, Assistant Project Officer, 919–335–6817
3. LCDR D'Andrea, Chief Inventory Management Branch, 919–335–6132
4. LT Limbacher, Chief Materiels Section, 919–335–6828
5. Eddie Paul, General Foreman Assembly Section, 919–335–6250
6. CWO Daugherty, Air Station Savannah, 912–652–4656
7. CWO McMahon, Air Station New Orleans, 504–393–6055

IV. SOFTWARE SUPPORT

a. API System configuration for the AFCCV Pilot Project will be provided by BNA with the exception of one component which will be provided by ARSC.

b. The following is a list of equipment with their product description provided by BNA:

1. Label Design Software; Label Matrix label design software package for Windows
2. Symbol Generation software; DataMatrix (0 to 200 redundancy levels)
3. Decoding Software (1D); Codabar, Code 39, Code 128, EAN, Interleave 2–of–5 & UPC
4. Decoding Software (Stacked); PDF417, Macro PDF417 & Supercode
5. Decoding Software (2D); DataMatrix & Maxicode
6. Desk Top Computer; IBM or Compatible 486 or Pentium with Microsoft Windows
7. Symbol Readers; Welch Allyn Imageteam 4400 & Metanetics IR–2220
8. Computer (Portable); Norand Pen Key 6300 with accessories and software
9. Data Transmission. Equipment; Norand 6710 RF Access Point, PCMCIA RF Card & Antenna and software

c. The following is a list of equipment with their product description provided by ARSC:

1. Desk Top Printer; Computype 300 dpi

HH–65A COMPONENTS

NSN	PART NUMBER	NOMENCLATURE
1560–14–404–8798	SC7282	SERVO, TAIL ROTOR
1560–14–465–1496	365A23–4003–0501	FAIRING ASSY
1560–14–485–2103	366A25–0033–0010	DOOR SLIDING, RH
1615–14–390–1437	366A32–0001–00	MAIN GEARBOX
1615–14–439–6128	365A31–1850–00	FLANGE LOWER
1615–14–446–6466	365A33–6005–02M	GEARBOX, TAIL
1615–14–447–1445	365A31–1810–02MO	MAIN ROT HUB STAR
1630–01–HR1–9574	204623–1	CYLINDER
1630–01–HR2–0518	158991–1	CYLINDER ASSY
1650–14–451–4636	SC8033–1	SERVOCYLINDER
1680–01–HR1–9092	30400022	BOTTLE EXTINGUISHER
1680–01–164–0432	270–0750–020	SERIES ACTUATOR
2925–01–HR1–9178	150SG125Q	STARTER–GENERATOR
4820–01–HR2–3313	3327–100	VALVE, FUEL DUMP
5305–14–448–2646	365A31–1970–21	SPHERIC. BRNG BEAM BOLT
5999–01–HR2–0933	950–36	CONTROL BOX
6115–01–HR1–9211	82562–7	AC GENERATOR
6115–01–HR2–3169	366A11–0010–05	BLADE, MAIN ROTOR
6150–14–447–2803	365A31–1850–03	FLANGE, UPPER
6615–01–125–1024	270–0751–020	TRIM/FEEL ACTUATOR
6685–01–440–8921	IPT–44DRT1–1000–100G	SENSOR, TORQUE PRES.

HH–60J COMPONENTS

NSN	PART NUMBER	NOMENCLATURE
1560–01–202–7150	70200–27001–044	STABILATOR ASSEMBLY
1560–01–202–7151	70200–27001–045	STABILATOR ASSEMBLY
1560–01–222–5123	70200–27000–046	STABILATOR ASSEMBLY
1615–01–347–0735	70106–28000–048	DAMPENER, VIBR, DR SH

APPENDIX D
532P LABEL SPECIFICATION

Computype
Sigma Systems

Material Description
TS532P

DESCRIPTION:

TS532P is ideal for printed circuit board applications. The polyester is resistant to water, mild acids, salt and alkalis, most petroleum based greases, oils, and lower aliphatic solvents. The adhesive offers excellent high temperature performance, has good resistance to cold and moisture, and the peel adhesion is high and increases over time. This material provides good image clarity, abrasiveness and chemical resistance when used with Computype's premium resin ribbons. The polyester liner makes this product a good choice for automatic label applicators.

CONSTRUCTION:

TOP COATING	NA - material is compatible with hard resin ribbons	
BASE MATERIAL	Thickness	.004" nominal
	Material	white heat stabilized polyester
ADHESIVE	Thickness	.002" nominal
	Material	permanent acrylic
LINER	Thickness	.002" nominal
	Material	clear polyester

RIBBON COMPATIBILITY:

	Datamax All except Ovation	Zebra All Models	Eltron TLP2242/3642	Intermec 3240/3440
1st Choice	TR607	TR607Z	TR611HZ	TR607Z
2nd Choice	TR601	TR601Z	NA	TR601Z
3rd Choice	TR605	TR605Z	NA	TR605Z

Datamax Ovation: 1st - TR611H.

CHARACTERISTICS:

Service Temperature Range: -40 F to +400 F (-40 C to +205 C)

Minimum Application Temperature: +40 F (+4 C)

Typical Minimum Narrow Bar Width: Step Ladder Orientation - .010", Picket Fence Orientation - .005"
Using certain printer, ribbon, heat, and speed combinations a smaller narrow bar width may be achieved.

Typical Automatic Applicator/Dispenser Use: Never Tested Poor Fair Good EXCELLENT
Label size and orientation will affect performance. Specific designs must be individually tested for viability.

To assure maximum performance, Sigma Systems materials have been designed and tested for compatibility between the label stock and thermal transfer ribbon. All Sigma Systems materials are sold as a packaged system containing label stock, transfer ribbon and a print head cleaning kit.

All technical information and recommendations are believed to be accurate but do not constitute a guarantee or warranty. Suitability for any given application is the responsibility of the user. Computype reserves the right to change specifications without notice.

If you have further questions, please call Sigma Systems at 612-633-0633 or 800-328-0852. Revised: 2/25/97

APPENDIX E
INSTRUCTIONS AND TRAINING MANUAL