NAVY'S SHIPBOARD SOLID WASTE MANAGEMENT PROGRAM

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Abstract

The Shipboard Solid Waste Management Program is a prime example of how the Navy can move quickly to develop, acquire, and deploy new technology, integrating diverse requirements into a shipboard system affecting all surface ships in response to emergent needs. The Navy developed the Plastics Waste Processor (PWP), Large Pulper (LP), Small Pulper (SP) and Metal/Glass Shredder (MGS) to meet new environmental legislation and requirements and efficiently manage the solid waste generated onboard ships. This Navy-developed equipment has been adopted by Congress. In fact, specific Fleet completion milestones for installation of the Plastics Waste Processor has been codified in Federal Regulations. The Navy is currently procuring and installing Plastics Waste Processors, the Request for Proposals for production of the pulpers and shredders was recently released. To-date, the Navy has met all congressionally imposed milestones for the Plastics Waste Processors and is on track to meet the Fleet installation completion deadline for the pulpers and shredders. The successful planning and execution of this program relies on close coordination of personnel within the Naval Sea System's Command, its field activities, Chief of Naval Operations, Office of Legislative Affairs, congressional staff, other agencies and the environmental community. The Shipboard Solid Waste Management Program is a keystone of CNO's vision of the "Environmentally Sound Ship of the 21st Century." U.S. Navy ships must be able to perform their mission worldwide with minimal constraints from regulation and at a reasonable cost to the Navy.

Abbreviations/Definitions

ACAT - Acquisition Category
AIT - Alteration Installation Team
APPS - Act to Prevent Pollution from Ships
ARB - Acquisition Review Board
ASN/RDA - Assistant Secretary of the Navy, Research, Development and Acquisition
BAFO - Best and Final Offer
BUMED - Bureau of Medicine and Surgery
CD/NSWC, AD - Carderock Division, Naval Surface Warfare Center, Annapolis Detachment
CM - Configuration Management
CNO - Chief of Naval Operations
COMOPTEVFOR - Commander, Operational Test and Evaluation Force
CRADA - Cooperative Research and Development Agreement
DASN(E&S) - Deputy Assistant Secretary of the Navy for Environment and Safety
DASN/RDA (Ships) - Deputy Assistant Secretary of the Navy for Research, Development and Acquisition, Ships
DODI - Department of Defense Instruction
EMI/EMC - Electromagnetic interference/Electromagnetic compatibility
FMPMIS - Fleet Modernization Plan Management Information System
ft^3 - Cubic Feet
FY - Fiscal Year
ICW - Interactive Courseware
ILS - Integrated Logistics Support

ISEA - In-Service Engineering Agent
lb - Pound
LP - Large Pulper
MARPOL - International Convention for the Prevention of Pollution from Ships
MCM - Mine Countermeasure ship
MGS - Metal/Glass Shredder
MPPRCA - Marine Plastic Pollution Research and Control Act
MRC - Maintenance Requirement Card
MS - Milestone
NAVMAC - Naval Manning Analysis Center
NAVSEA - Naval Sea Systems Command
NAVSUP - Naval Supply Systems Command
NEPA - National Environmental Policy Act
nm - Nautical Mile
NSA - Navy Supervising Activity
NSWCCD Bethesda (formerly CD/NSWC) - Carderock Division, Naval Surface Warfare Center
NSWCCD-SSES - Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station
O&MN - Operations and Maintenance, Navy
OPEVAL - Operational Evaluation
OPN - Other Procurement, Navy
PRIME - Plastic Removal in the Marine Environment
PWP - Plastics Waste Processor
R&D - Research and Development
RDT&E - Research, Development, Test and Evaluation
RFP - Request for Proposal
SARS - Ship Alteration Records
SBIR - Small Business Innovation Research
SIDS - Ship Installation Drawings
SP - Small Pulper
STEP - Ship Training Enhancement Program
TDA - Technical Design Agent
TECHEVAL - Technical Evaluation

List of Figures

Appendices

Tables

Introduction

The Shipboard Solid Waste Management program exemplifies how the Navy is able to rapidly execute a program affecting virtually every major surface ship in the Fleet; on-time, and on-budget, while satisfying a diverse variety of stakeholders including the Fleet, environmental protection governmental and non-governmental interest groups, and the public.

The Navy's approach for shipboard solid waste management as outlined in the Shipboard Solid Waste Management Plan of April 1993, the "Green Book," was eventually adopted by Congress. The FY94 Defense Authorization Act required shipboard installation of plastics processors to meet the worldwide plastics discharge at sea prohibition and imposed the Navy's proposed compliance schedule as law. The FY97 Defense Authorization Act allowed pulping and shredding of non-plastic waste in the MARPOL Special Areas and anywhere at sea and maintained the compliance deadline of 31 Dec 2000.

The Navy is now in the process of manufacturing and installing plastics waste processors in the Fleet, and is on course to meet the congressionally mandated 100% compliance date of December 1998. This tremendous effort is due to the combined contribution of the Environmental and Fluid Systems Group (SEA 03L) Program Office; representatives of SEA 91, PMS-400, PMS-312 and many other NAVSEA ship program office personnel; NSWCCD Bethesda laboratory personnel; NSWCCD-SSES In-Service Engineering personnel; planning yard personnel; installation shipyards; and the development and production contractors.

The pulper and shredder program was delayed during FY93 because that program would still allow discharge of some form of solid waste. Congress was concerned that the program did not comply with the provisions of the Act to Prevent Pollution from Ships (APPS) regarding zero

discharge in MARPOL Special Areas. The FY94 amendment to the APPS required the Navy to perform detailed analyses of alternative technologies, and to develop and submit a report to Congress on the Navy's plan for the MARPOL "Special Area" compliance. In response to this requirement, the Navy established an Executive Steering Committee, chaired by Ms. Elsie Munsell, DASN(E&S), and composed of representatives from N45, DASN/RDA (Ships), and NAVSEA, to oversee the development of this report. A series of equipment studies, ship impact studies, and environmental fate and effect studies were performed to examine all of the relevant issues. The Navy concluded that the use of pulpers and shredders was the most technically practicable solution.

The Navy Secretariat determined that the use of pulpers and shredders could be perceived as a major federal action and directed that the requirements of NEPA be met prior to its implementation. Accordingly, an Environmental Impact Statement was prepared in conjunction with a series of public hearings to present the Navy's findings and to obtain feedback from all of the stakeholders, including environmental protection groups and the public. These proceedings culminated in the Navy's Report to Congress of November 1996 and the National Defense Authorization Act for FY97 which allowed Navy to use pulpers and shredders to achieve compliance with APPS in MARPOL "Special Areas." The Navy is now in the process of procuring pulpers and shredders and has laid out an aggressive schedule to meet the congressionally mandated date of 31 Dec 2000 for completion of the program.

This paper outlines the Shipboard Solid Waste Management Program from its inception, including early-on tailoring of specific requirements; the concurrency of testing, production, and installation phases; and the intensive program management effort which has allowed this very aggressive schedule to become a reality.

The Requirement

Unlike most Navy acquisition programs which are driven by military threats, the environmental programs are driven by the need to comply with environmental laws and regulations. Table 1.1 presents a recent chronology of solid waste legislation and summarizes their effect on Navy ships. Throughout these events, the Navy has worked closely with other agencies, congressional committees, non-governmental environmental interest groups, the international community, and the public to identify cost-effective and affordable strategies with sensible timetables to comply with environmental requirements.

Table 1.1. Shipboard Solid Waste Legislation

- MARPOL Annex V 73/78
  - ⇒ Prohibits all plastics discharge from ships
  - ⇒ Provides distance from shore restrictions for non-plastic solid waste
  - ⇒ Prohibits discharge of solid waste in MARPOL designated "Special Areas"
  - ⇒ Exempts Warships and Naval Auxiliaries

- Act to Prevent Pollution from Ships (APPS) –1987 Amendment implemented the Marine Plastic Pollution Research and Control Act (MPPRCA)
  - ⇒ Required full compliance by all ships, including U.S. Naval vessels to MARPOL by Dec 1993

- Navy Solid and Plastic Waste Management Plan, "The Green Book," Apr 1993
  - ⇒ Sought extension to Navy compliance with MPPRCA by Dec 98
  - ⇒ Sought permission to discharge non-plastic, non-floating processed solid waste in MARPOL "Special Areas" As a Quid Pro Quo, the Navy will process non-plastic waste everywhere at sea

- FY94 Legislation Amending APPS
  - ⇒ Accepted plastics processor plan and extended the compliance deadline to Dec 1998
  - ⇒ Codified the Navy's 1989 self-imposed 3/20 day rule
  - ⇒ Required a Navy MARPOL "Special Area" compliance plan
  - ⇒ Imposed incremental milestones (25, 50, 75 and 100%) for the installation of Plastic Waste Processors on Navy ships
  - ⇒ Extend the compliance deadline to Dec 2000 for non-plastic waste for surface ships
  - ⇒ Extended submarine compliance deadline to Dec 2008

- Navy's Report to Congress – Nov 1996
  - ⇒ Navy evaluated all existing technologies
  - ⇒ Navy proposed a compliance plan to use pulpers and shredders in the "Special Areas" to achieve a non-floating discharge
  - ⇒ Acquired Public and Federal Agency Participation
  - ⇒ Prepared Environmental Impact Statement

- National Defense Authorization Act for Fiscal Year 1997
  - ⇒ Allowed use of pulpers and shredders to achieve a non-floating, non-plastic "Special Area" discharge
  - ⇒ Held solid waste discharge compliance date to 2000 for surface ships, 2008 for submarines

Table 1.2 presents the current Navy solid waste discharge policies resulting from these regulations.

Table 1.2. Current Navy Solid Waste Discharge Policies

- Plastics
  - ⇒ No discharge anywhere when equipped with PWPs

- U.S. and Foreign Coastline
  - ⇒ No discharge of any solid waste within 3 nm of shore
  - ⇒ Processed food, paper and cardboard may be discharged >3 nm from shore
  - ⇒ Non-floating metal and glass waste may be discharged >12 nm from shore

- All non-plastic solid waste shall be pulped and shredded everywhere at sea outside of the discharge restriction as specified above

The Problem

Navy ships are self-contained communities that generate large quantities of solid waste. While in port, this waste can be off-loaded and disposed of properly. While at sea, however, the trash must be either stored or discharged. Shipboard storage of waste creates sanitary, health, and safety hazards and environmental regulations severely limit the discharge.

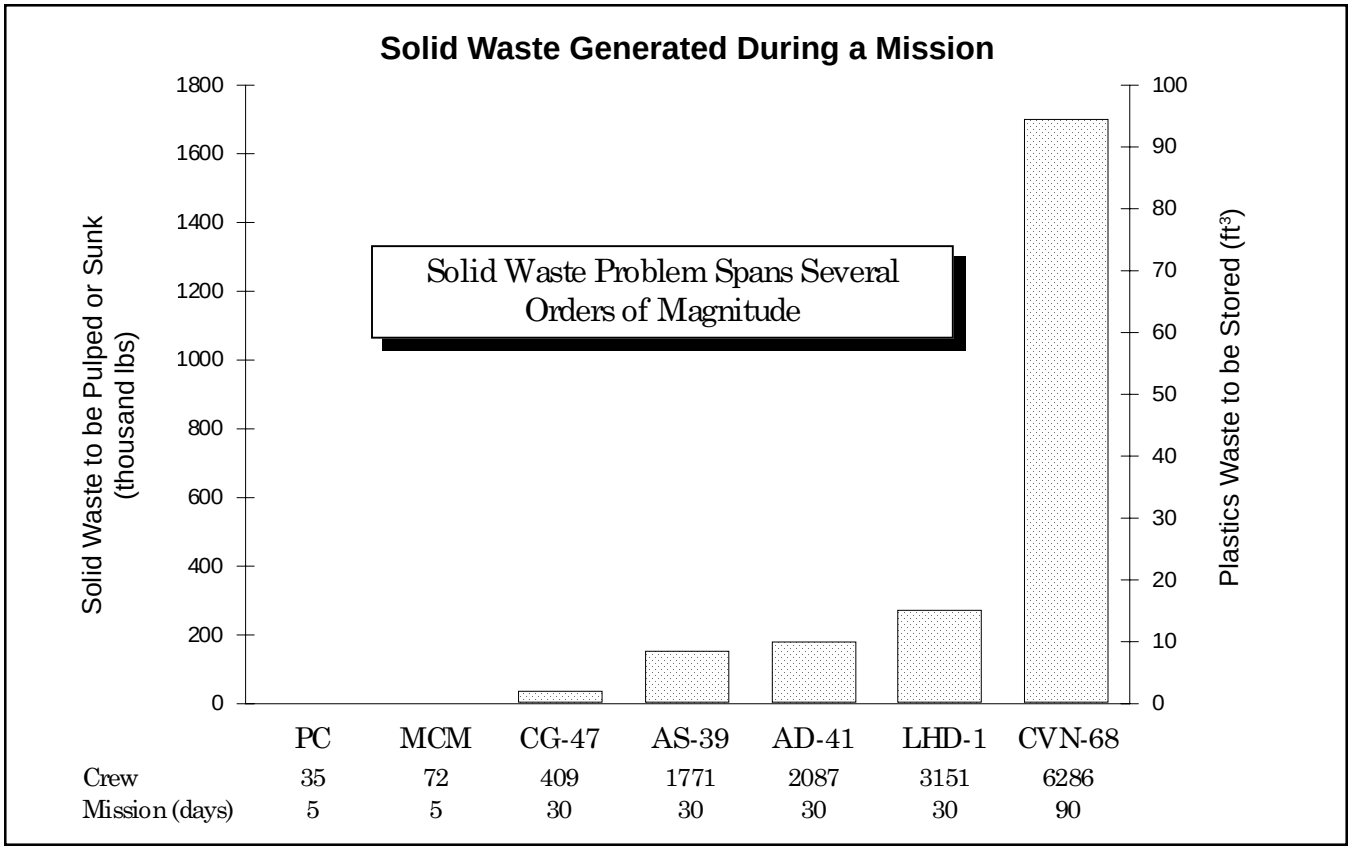
To establish the need baseline for this program, a series of shipboard trials and studies were performed to quantify, classify, and characterize waste streams; determine the waste sources; and measure the variability as a function of crew size, ship type, ship operations, and mission duration.

Figure 1. One Day's Worth of Trash from a Destroyer Tender (AD)

The results of these studies show that there is little variation in solid waste generation per person among ship classes and that the solid waste generation rates per person are similar to those at shorebased municipalities. Because the mission and crew complement of ship classes varies significantly, so does the solid waste generated between the classes. For example, a Sailor generates just over 3 pounds of solid waste per day aboard ship (equivalent to 0.43 ft^3/day) which means that an MCM with a crew of 70 generates only 1,050 pounds of solid waste (151 ft^3/day) during a 5-day mission. During a 3-month deployment, frigates or destroyers with crews of 300 generate over 82,600 lbs of trash (over 11,600 ft^3) and an aircraft carrier with a complement of 6,000 would amass over 3,304,000 lbs (over 464,000 ft^3) of trash during a 6-month deployment.

The amount of waste to be processed during most missions spans 3 orders of magnitude, which makes arriving at one solution; to provide a standard family of equipment suitable for all ship classes, a significant challenge. The Program Office adopted a modular or equipment building block approach rather than developing specialized equipment to suit each individual ship class. Standardized sets or suites of the same equipment will be provided to suit the crew size and mission duration of every ship.

Figure 2. Volume and Weight of Trash Generated Per Deployment by Major Ship Class



Early Research and Development (R&D)

Naval Surface Warfare Center, Annapolis Division (CD/NSWC-AD), the Navy's lead shipboard environmental protection laboratory, began investigating commercially available solid waste processing technologies in 1985. Existing pulpers were capable of processing paper and food waste (70% of the solid waste generated) into a sea water slurry for overboard discharge at very high processing rates. These machines were relatively simple in design, easy to operate, and did not interfere with flight operations. In addition, MARPOL recognized that pulped waste is more environmentally friendly than raw waste, causing MARPOL to allow pulped waste to be discharged closer to shore than unprocessed waste.

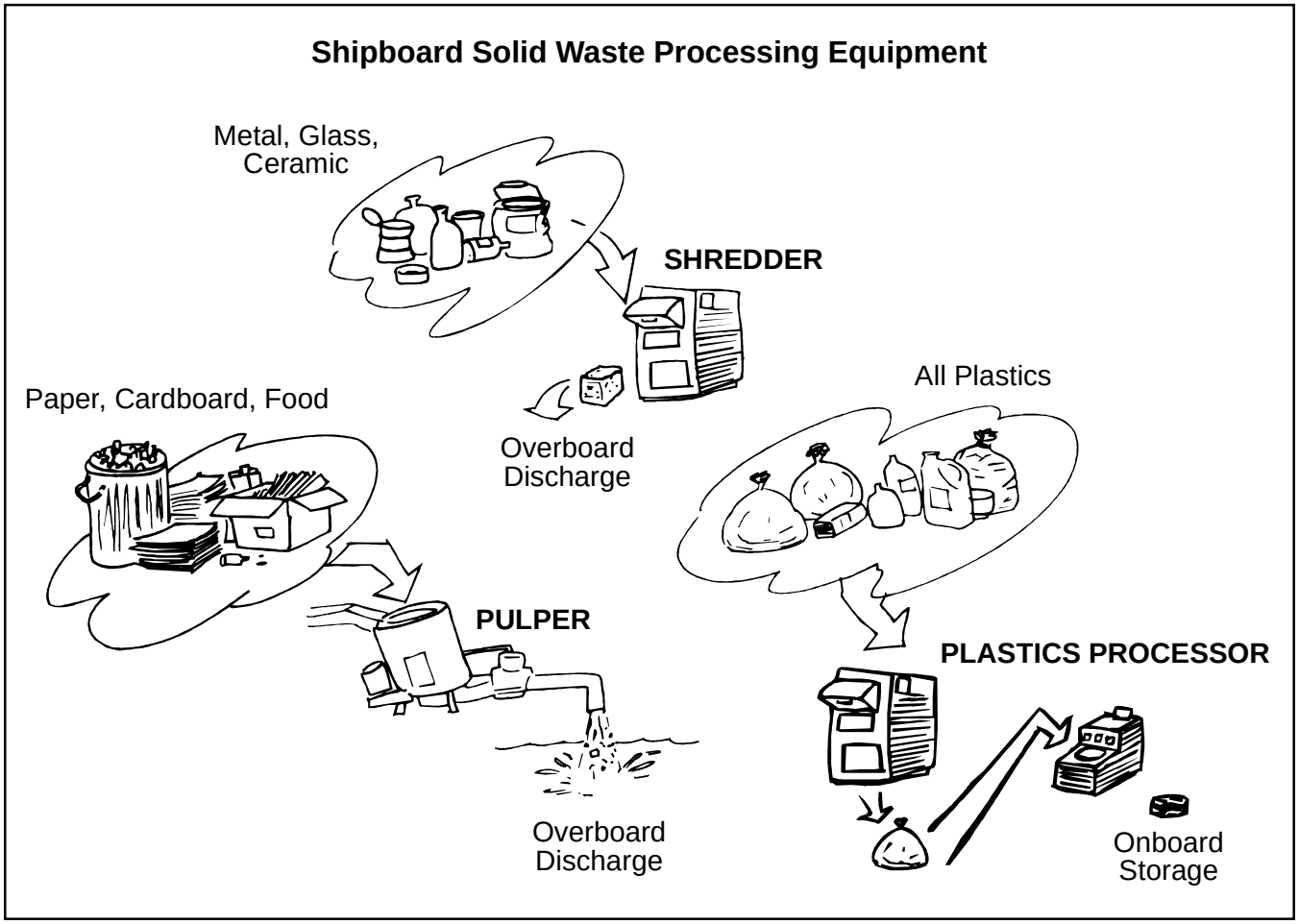
In 1986, a series of laboratory tests conducted at CD/NSWC-AD on a commercial pulper proved the concept to be feasible and as a result, a competitive RDT&E contract was awarded to SOMAT Corporation in 1987 to develop a pulper suitable for use on Navy ships. The resulting SOMAT machines were able to meet the Navy requirements for processing rate in the laboratory, but shipboard tests indicated that they had significant reliability and maintainability problems in the bearing and drive systems and the rather complex active water level control systems.

CD/NSWC-AD also began investigating processes for reducing the volume of plastics waste and "sanitizing" it so it could be held onboard ship. Extensive parametric studies were conducted to determine the most appropriate processes. The combination of shredding, compacting, and melting plastic waste was selected as holding the most promise and a series of brassboard designs were developed and evaluated both in the laboratory and onboard ship to refine this process.

Shipboard Equipment Concept

These studies indicated that virtually all of the Navy's shipboard solid waste management requirements could be addressed by the equipment conceptualized in the cartoon at Figure 3. Shown in Figure 3 are a pulper for processing paper, cardboard, and food waste; a shredder for metal and glass; and a plastics processor for plastics and food-contaminated plastics waste.

Figure 3. Solid Waste Equipment



The plastics processor is composed of two elements; a shredder, which is nearly identical to the Metal/Glass Shredder, for preprocessing plastics, and a compress melt unit for reducing, stabilizing, and sanitizing plastic waste. Ships will receive one or more compress melt units, depending on how much plastic waste is expected to be generated during a mission. The number of plastics shredders installed are dependent on the number of CMU's supported; one plastics shredder can serve three to four compress melt units. Two pulpers are envisioned; a large pulper for most ships and a geometrically similar smaller pulper for the smallest ships.

This modular approach provides for standardization across ship classes and simplifies Fleet-wide installation and logistics support. Installation is further enhanced by designing the equipment to be "hatchable," negating the need for expensive hull cuts.

Figure 4. Equipment Mix

Solid Waste Equipment Mix

Ship Class	Crew Compliment	Metal/Glass Shredder	Large Pulper	Small Pulper	Plastics Processor	
					Shredder	CMU
AGF-3, AGF-11, AO-177, AOE-1, AOE-6	554-831	1	1	0	1	3
ARS-50	90	1	0	1	0	1
AS-39	1771	1	1	0	1	4
CG-47	409	1	1	0	1	2
CGN-36	604	0	0	0	1	3
CVN-63	5624	0	0	0	2	11
CV-64, CV-67, CVN-65	5624-5815	2	2	1	2	11
CVN-68	6286	2	2	1	3	14
DD-963, DDG-51, DDG-993	303-396	1	1	0	1	2
FFG-7	220	1	0	1	0	2
LCC-19	1516	1	1	0	1	3
LHA-1, LHD-1	2922-3151	1	1	0	1	6
LPD-4, LPD-17, LSD-36 LSD-41, LSD-49	794-1487	1	1	0	1	3
MCS-12	1746	1	1	0	1	3

Program Planning and Execution

Early Planning, "The Green Book"

Initial planning for the program was performed in late 1992 by representatives of the NAVSEA Environmental Engineering Group (SEA 03V) under Dr. Frank Ventriglio, the Research & Development Office (SEA 03R16) under Mr. Art Smookler, and the Navy's lead laboratory for Environmental Protection (CD/NSWC-AD) under Mr. Craig Alig. This plan was detailed in the Navy's Shipboard Solid Waste Management Plan of April 1993, referred to as the "Green Book." The plan described the equipment, equipment performance requirements, and the schedule and budgetary requirements to implement the program. Subsequently, this plan has served as a guide for the successful execution of both the Plastics Waste Processor and the Pulper and Shredder programs.

"Milestone II" Review

The Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN/RDA) conducted a program review to validate the approach and executability of the plan on 9 Jun 93. At that time, much of the early R&D had been completed and NAVSEA had developed its plan to manage shipboard solid waste.

Following the Program Review, ASN/RDA concluded that the program was executable, verified the budgetary cost estimates for RDT&E, OPN, and O&MN, and directed the following key points:

- The program will consist of four separate ACAT IV(T) hardware programs (Large Pulper, Small Pulper, Metal/Glass Shredder, and Plastics Waste Processor acquisitions),
- ASN/RDA will conduct, at a minimum, annual reviews to ensure that the programs are receiving proper oversight and attention,
- DODI 5000.2 documentation requirements will be **tailored** to support MS III decisions,
- Tailoring includes the consolidation of TECHEVAL and OPEVAL, as appropriate, and participation with COMOPTEVFOR to determine basic suitability for shipboard service,

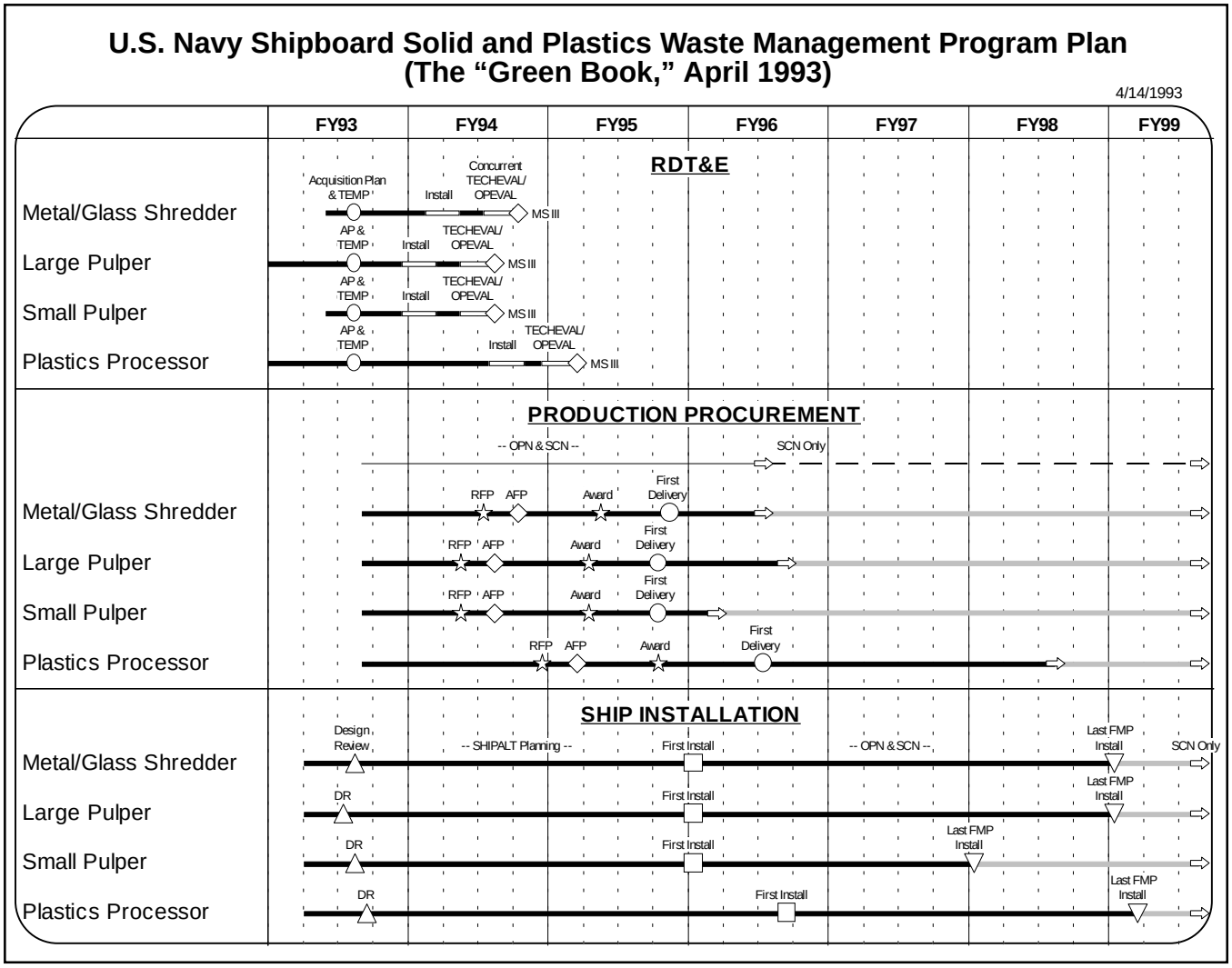
- No Operational Requirements Document is required because the requirement is legislative rather than operational. However, operational requirements were established by N45 for COMOPTEVFOR's testing during OPEVAL.

These decisions allowed the Program Manager to significantly compress the program execution schedule. As a result, the program satisfied all ACAT IV(T) requirements, but certain sequential activities overlapped and major activities of the program were performed concurrently and iteratively. Some significant examples of this approach included:

- Design, pre-production prototype construction, laboratory testing, and shipboard evaluations became concurrent and interactive,
- Integrated Logistics Support (ILS) documentation was actually developed concurrently with equipment development,
- NAVSEA conducted extensive parallel testing of components and subsystems,
- COMOPTEVFOR and BUMED input was sought early in the program,
- Request For Proposal (RFP) for the Plastics Waste Processor (PWP) was released incident to the design freeze at Certification of Readiness for OPEVAL.

Figure 5. "Green Book" Milestone Chart

This chart displays the concurrence, limited execution time, and the major features of the RDT&E, production and installation phases of the program as originally outlined in the "Green Book."



Program Team

Environmental and Fluid Systems Group (NAVSEA 03L), the Program Office for the shipboard solid waste management program, is responsible for the budgeting, procurement, and installation of the equipment. CD/NSWC-AD (now CD/NSWC), the Technical Design Agent (TDA), NSWCCD-SSES, the In Service Engineering Agent (ISEA), and GEO-CENTERS, Incorporated personnel (former Westinghouse MTD employees) fabricated the pre-production prototypes and developed production drawings, technical manuals, and other ILS documentation under the direction of NAVSEA and CD/NSWC.

Due to the congressional-level visibility of the program and to ensure that all program requirements were met, periodic program reviews were convened by SEA 00, VADM Malley and VADM Sterner. These reviews ensured that all aspects of the R&D, procurement and installation phases of the program stayed on-track

Equipment Development

To ensure that the equipment would perform to the requirements of the shipboard environment, a set of top level operational design criteria for each of the machines was established. These parameters included processing rate, reliability, safety, maintainability, shock, footprint, vibration, weight, acoustics, maintenance envelope, EMI/EMC, shipboard services, human factors, and cost. Much of these criteria, such as weight, footprint, and operational envelope also defined the boundaries of ship interfaces. By establishing these boundaries early in the program, it was possible to develop ship Interface Control Drawings (ICD's) and detailed guidance for equipment location, arrangement, and installation; thus allowing concurrency of equipment design with ship installation planning.

Design Studies and Analyses

The solid waste processing equipment went through a comprehensive design analysis process to ensure that all performance criteria for shipboard compatibility and logistics supportability were addressed. Early in the design process, Failure Modes Effects and Criticality Analyses (FMECAs) were performed on each machine. These analyses determined the potential consequences of a failure of any component in the systems and characterized the severity of the resulting failure. The results of the FMECAs were then used to modify each system design to reduce the frequency and/or the severity of the occurrence.

As an example, the potential for pulper drive bearing seal and shaft failures were substantially reduced with an extensive redesign of the drive train. In addition, the active water level control system was replaced with a greatly simplified gravity flow and eductor design which significantly reduced the complexity and cost of the system. More than 10,000 hours of operating time aboard four different Navy ships over the past four years without a single critical failure of these components has shown the merit of these design improvements. Structural analyses and materials studies were performed to ensure that all materials and components would meet performance requirements as well as anticipated harsh shipboard environmental conditions. The producibility and manufacturability of all components were evaluated and cost estimates were developed to ensure affordability of the machines.

Other detailed design analyses included: finite element analyses of the equipment structure to ensure that the design was adequate for shock and vibration; bearing seal and lubrication studies to ensure that these critical elements were adequately designed; and ventilation studies and heat transfer analyses to determine the requirements for safe operation in a shipboard environment.

Maintenance Planning

Level of Repair Analyses (LORA) were also conducted concurrent with the design to determine the appropriate maintenance philosophies for each of the equipments and to develop data for onboard and depot level spares. The allowance parts lists, maintenance requirement cards, and technical manuals were then developed using this data. Early in the design process, safety and hazardous analyses were performed on each of the machines. These analyses were performed in conjunction with both the Failure Modes Effects and Criticality Analyses and a series of human engineering studies to ensure that all Sailors from the 95% percentile male to the 5% percentile female populations could safely operate and maintain the machines.

Early Preproduction Prototypes

Concurrent to these design efforts, testing of candidate brassboard components, subassemblies, and equipment was taking place to evaluate the systems' processes, design parameters, and configurations. Because there was virtually no previous data or experience for shipboard processing of plastic waste, extensive parametric studies and testing went into optimizing the CMU to achieve high processing rates to footprint ratio. Laboratory component performance tests optimized the impeller

speed, horsepower, and feed tray configurations of the pulpers. The blade design of the solid waste shredder was optimized to handle either plastics or metal and glass and endurance tests were performed to ensure that the shredder blades, motors, and electrical circuits could survive the anticipated shipboard cyclic loads.

Figure 6. Shock Test on the Large Pulper

TECHEVAL/OPEVAL

Several identical preproduction units of each prototype were then manufactured and tested. Test machines were installed at the NSWCCD Bethesda lab and on board USS GEORGE WASHINGTON (CVN-73). The aircraft carrier, with its 6,000 man crew, was chosen as the test platform in order to maximize equipment usage in a short period of time. Each system accrued several thousand hours of operating time during Technical Evaluations prior to OPEVAL. All performance and maintenance problems experienced during this period were corrected with redesigns or improved components and were then installed for additional testing. Prior to the formal OPEVAL, all aspects of the system's performance were evaluated aboard the USS GEORGE WASHINGTON. This included reliability, processing rate, maintainability, effectiveness of training materials, technical manual validation and adequacy, and mean logistics delay time (the time to retrieve a part from the supply system).

Concurrent testing of the preproduction prototypes at Annapolis evaluated the equipment's compliance with airborne and structure-borne noise requirements, electromagnetic interference and compatibility, and vibration endurance. Additional testing was conducted to verify design processing rates with various waste types and to determine if the equipment could withstand the introduction of unprocessable foreign objects and survive a jam. System wear and its effects on equipment performance was evaluated for each machine. Human factors and women-at-sea experiments were conducted to ensure that

all Sailors could safely operate and maintain the equipment as designed. Heating and cooling load experiments were conducted to validate shipboard ventilation requirements, and sensor and control system experiments were conducted for each machine to assess these subsystems. The results of these tests were incorporated back into equipment redesign and the machines that were ultimately tested aboard the USS GEORGE WASHINGTON in OPEVAL.

Figure 7. Estimated Operating Hours and Waste Processed for Shipboard Installed Solid Waste Management Test Equipment

Estimated Operating Hours and Waste Processed for Shipboard Installed Solid Waste Management Test Equipment

Ship	Equipment	Operating Hours	Waste Processed
USS THEODORE ROOSEVELT (CVN-71)	Engineering Design Model Large Pulper	>7500 hrs	>1500K lbs
USS GEORGE WASHINGTON (CVN-73)	Preproduction Prototype Large Pulper	>5000 hrs	>1000K lbs
USS GEORGE WASHINGTON (CVN-73)	Preproduction Prototype Small Pulper	>3500 hrs	>140K lbs
USS GEORGE WASHINGTON (CVN-73)	Preproduction Prototype Metal/Glass Shredder	> 480 hrs (motor)	>50K lbs
USS GEORGE WASHINGTON (CVN-73)	Preproduction Prototype Plastics Waste Processor (3 CMUs + Plastics Shredder)	> 7500 hrs	>110K lbs
USS WASP (LHD-1)	Preproduction Prototype Large Pulper	3170 hrs	650K lbs
USS WASP (LHD-1)	Preproduction Prototype Plastics Waste Processor (2 CMUs + Plastics Shredder)	>3700 hrs	>50K lbs
USS VANDEGRIFT (FFG-48)	Preproduction Prototype Small Pulper	>850 hrs	>43K lbs
USS VANDEGRIFT (FFG-48)	Preproduction Prototype Plastics Waste Processor (2 CMUs) replaced with production units	>250 hrs	>4K lbs
USS STETHEM (DDG-63)	Preproduction Prototype Small Pulper	>38 hrs	>1K lbs
USS CORONADO (AGF-11)	Preproduction Prototype Large Pulper (from LHD-1)	>200 hrs	>40K lbs
USS KEARSARGE (LHD-3)	Preproduction Prototype Plastics Waste Processor	>37 hrs	>0.4K lbs

Configuration Management

A configuration management (CM) program was established at Certification of Readiness for OPEVAL and maintained throughout the production phase. This assured that any design changes would not adversely impact the concurrent ship installation designs which were underway. It also enabled all design changes to be centrally controlled and allowed the program manger to upgrade all supporting technical documents to reflect the latest designs. These documents include technical manuals, trouble shooting instructions, maintenance requirement cards, training documentation, ship installation guidance, interface drawings and all provisioning documentation. The CM program was an essential feature of the program to ensure that the equipment design would be controlled and that the systems could be correctly procured, installed, operated, and supported once they reached the Fleet.

Drawing Validation

An additional step was taken in the design development process to validate production drawings. This assured the Navy that the detailed production drawings were correct and could be used by a production contractor to produce the equipment as it was designed and tested. To validate the drawings, a separate manufacturing team that was not involved in the initial development was brought in to fabricate preproduction units of the final design of each of the machines. As discrepancies in the design drawings were discovered, they were resolved and fed back into the technical data package through the CM system. These preproduction units were later made available to the production contractors as Government Furnished Equipment to assist the contractors in fabricating the production systems.

Integrated Logistics Support

Several progressive strategies were employed for the Integrated Logistic Support (ILS) of the equipment. The following are some key strategies:

- Common equipment components were used whenever possible for all of the machines. For example, the plastics shredder and the metal/glass shredder are essentially the same with one different subassembly. All of the electrical systems utilize the same components, including the same programmable logic controller, and the large and small pulpers use virtually identical electrical control systems.
- Enough spare parts to cover the first two years of equipment operation were procured with the production equipment to ensure that adequate spares would be available in the Navy stock system.
- The Plastics Waste Processor program was one of the first programs to utilize Interactive Courseware (ICW) on ships. This is part of the Navy's Ship Training Enhancement Program (STEP) initiative.
- All of the pulpers' components and most of the PWP and shredder components were commercialized to eliminate/minimize the use of military specifications.

As the design of the equipment changed, associated ILS elements were modified concurrently. The commercialization of equipment components was notable because in addition to making significant changes to the design and the ILS system, commercialization required extensive additional tests, analyses, and evaluations to ensure performance was not degraded.

Procurement and Production

To expedite the procurement process, a pre-solicitation conference with industry was conducted prior to release of the RFP's for the Plastics Waste Processor and Pulpers and Shredders. These conferences allowed industry to examine the detailed design drawings and the government fabricated pre-production prototypes.

Because the major risks of the program reside in the aggressive delivery schedule and manufacturing process quality, a dual source acquisition strategy was used for both the PWP and the pulpers. Dual sourcing provides several key benefits:

- Provides for three technical teams (including the Government design agent) that continually verify, validate, and upgrade the technical details of the data packages.
- Competition among the two vendors to be the best performer in terms of delivery and quality is established.
- Two providers enable the Navy to better evaluate any cost growth caused by engineering change proposals or modifications to the system.
- Minimizes the risk in the event one provider fails to make delivery on schedule and provides more flexibility to deliver equipment on schedule to the installing activities.

Figure 8. PWP Production Line

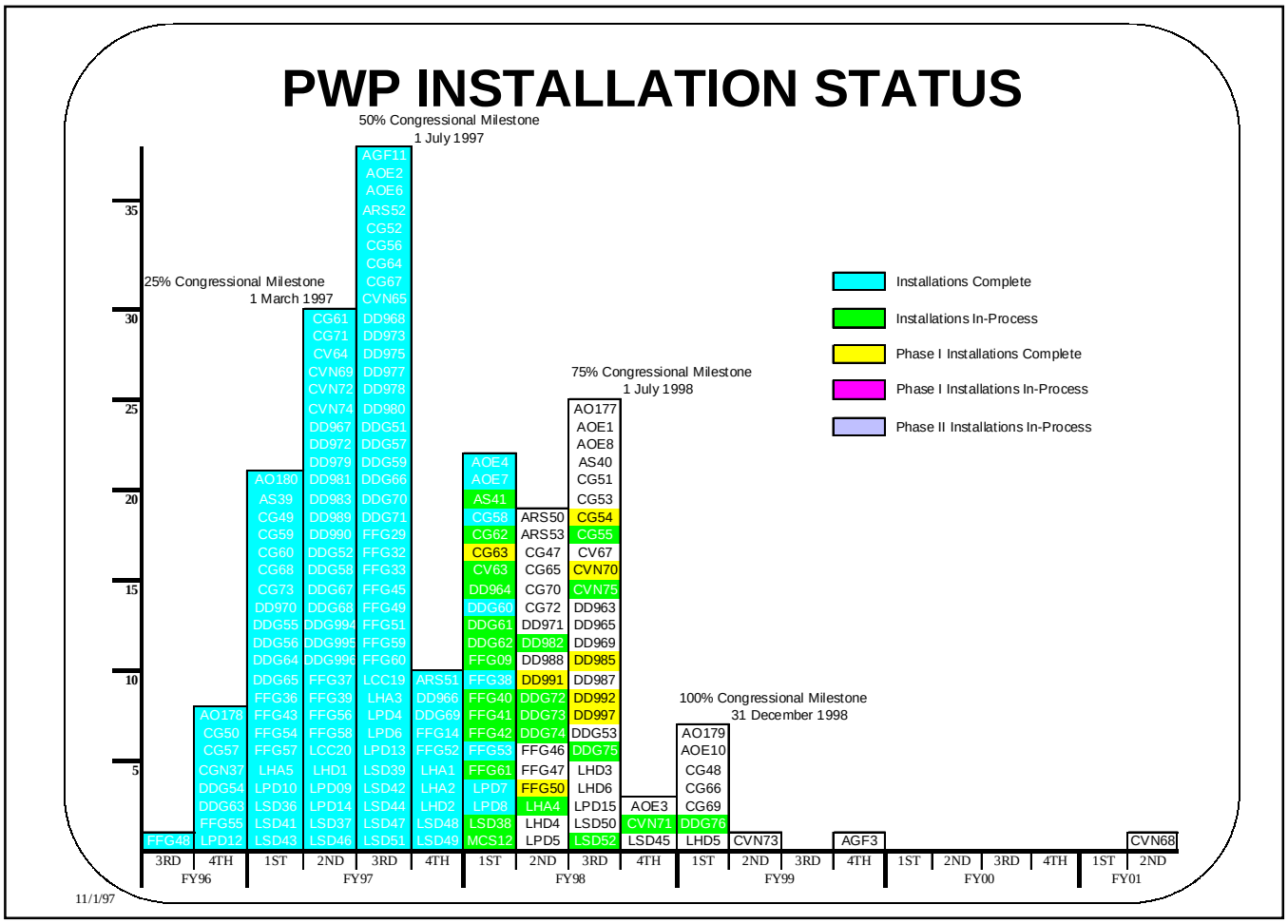
Schedule

Both the PWP and pulper and shredder programs are on schedule. The PWP procurement was awarded in July 1995 and the Navy, to-date, has met all of its installation milestones mandated by Congress.

Detailed ship installation schedules were developed and coordinated with the latest Fleet Modernization Program Management Information System (FMPMIS) and new construction ship program manager schedules. Scheduling strategies included establishing the in-yard need dates two months before the ship availability commenced and scheduling the PWP installations during the next to last availability prior to the congressional deadline of 31 Dec 1998; this provided a fall-back installation availability in case of production delivery difficulties. If equipment was unavailable and no additional availability period existed before compliance deadline, the installation was divided into two phases; space preparation to be completed during a Phase I availability and equipment installation during a future Phase II availability.

Pulper and shredder procurement was initially delayed until the Navy obtained legislative relief provided in the Defense Authorization Act of FY97 from the "zero discharge" in MARPOL "Special Areas" requirement. The pulper and shredder RFP was released in February 1997 and the Navy is on track to award production contracts in November 1997. A similar production strategy as that used for the PWP procurement is being used to ensure that all pulpers and shredders will be procured, produced, and installed on ships by December 2000.

Figure 9. PWP Installation Status (with congressional milestones)



Installation

As described earlier, Congress established specific milestones for release of the Plastics Waste Processor RFP and for completion of 25%, 50%, 75%, and 100% of ship installations. To meet this aggressive installation schedule, the Fleet installation planning process proceeded concurrently with the design, test, evaluation, and production phases of the program. Early Interface Control Drawing (ICD) development provided design guidance to the planning yards to facilitate the ship installation design effort including Ship Alteration Records (SAR) and Ship Installation Drawings (SID).

As a result of the accelerated installation schedule, additional measures had to be taken to quickly identify and correct deficiencies and incorporate lessons-learned into future installations. Those measures include publication of the Shipboard Solid Waste Processing Equipment Basic Ship Installation Integration Package and technical assists by the ISEA during various stages of the installation.

Figure 10. Pulper and Shredder Installation Schedule

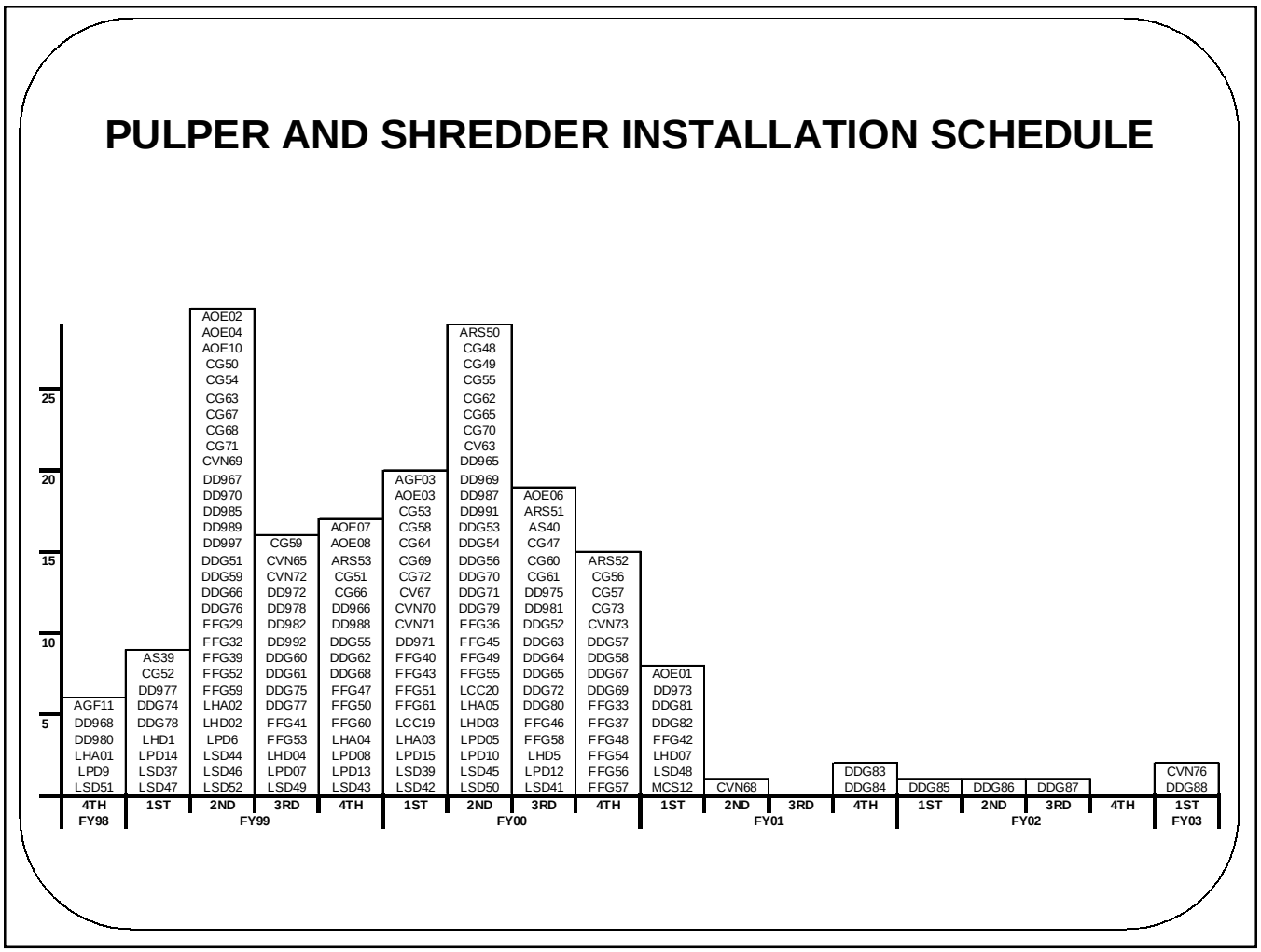
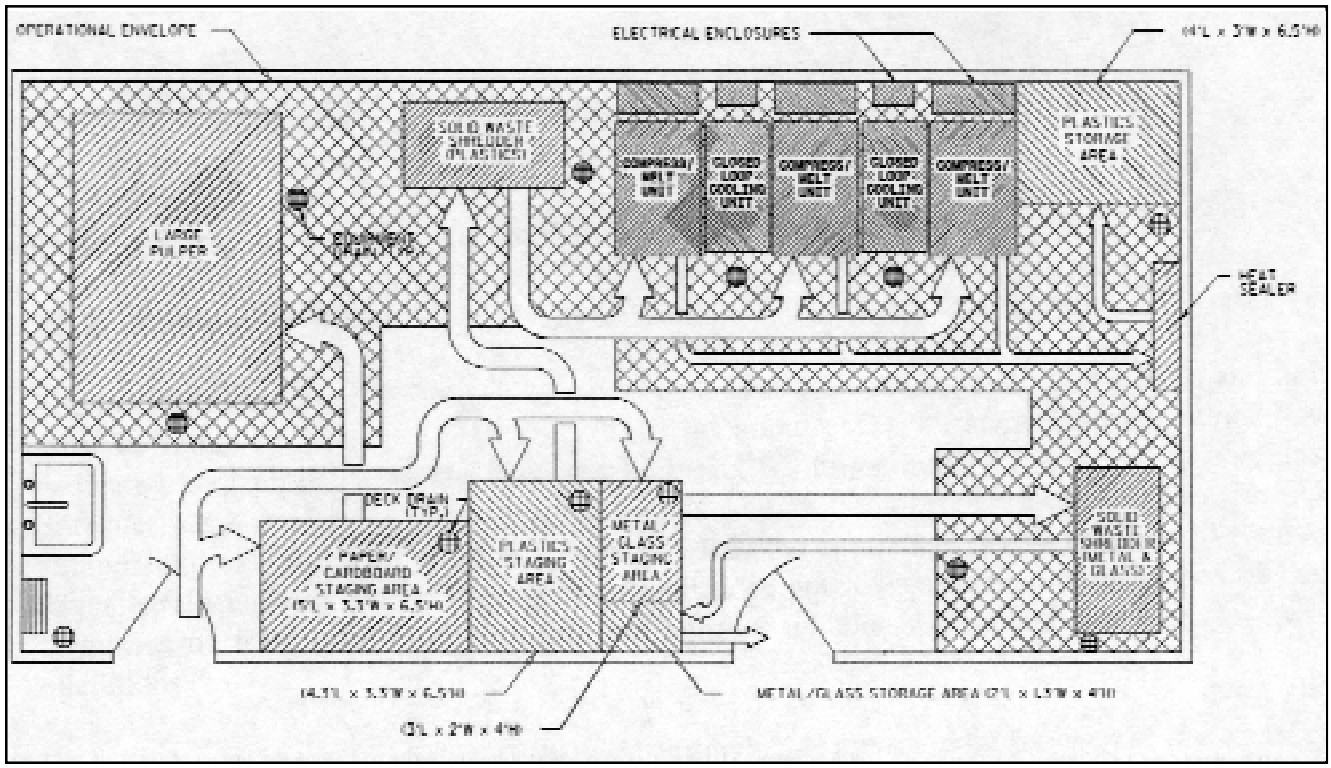


Figure 11. Typical Space Layout



"Shipboard Solid Waste Processing Equipment Basic Ship Installation Integration Package" Guidance

The Shipboard Solid Waste Processing Equipment Basic Ship Installation Integration Package installation instruction was developed by NAVSEA and NSWCCD-SSES concurrently with the equipment development and test and evaluation. It is continually updated to ensure that all installation lessons learned are fed back into the installation planning process. It maintains configuration control of the ICDs and provides installation and equipment location and arrangement guidance and suggestions, such as:

- Space preparation requirements, i.e., services, ventilation, etc.
- Locates the equipment close to the principal waste generation areas such as galley, food service, and supply areas,
- Co-locates solid waste equipment in one area, and examines the probable waste flow to determine crew traffic patterns,
- Suggests appropriate staging for each waste stream.

In addition, this installation instruction provides detailed footprint and maintenance envelopes for space arrangements and other requirements to facilitate equipment cleaning and compartment sanitation.

In-Service Engineering Agents Installation Verification

As the final step in the installation process, the In-Service Engineering Agent (NSWCCD-SSES), performs an equipment and space check-out and inspects the installation against the design drawings. The ISEA also provides equipment technical manuals and MRCs, verifies that onboard spares and provisioning technical documentation is in-place, that the Interactive Courseware is onboard and operational, and provides hands-on training to the ship's crew. The purpose of the ISEA's installation verification is to ensure that the total solid waste processing system has been provided and is operational (a turn-key operation). At the end of the installation check-out, the ISEA issues a report which is used to correct and track deficiencies for both the equipment and the equipment installation.

To address Fleet and Navy Supervising Activity concerns, NAVSEA recently revised the process and

procedures for monitoring and controlling shipboard solid waste equipment installations. The revised process includes:

- Increased NSWCCD-SSES equipment inspections at various stages of each installation. This allows for concurrent correction of deficiencies as the installation progresses,
- Greater involvement of the Naval Supervising Activity (SUPSHIP) and Planning Yard during these interim inspections to ensure early identification and correction of installation deficiencies,
- Issuance of a message from NSWCCD-SSES to NAVSEA identifying installation discrepancies,
- NAVSEA to alert the Supervising Activity of installation discrepancies so they can be corrected within the warranty period,
- NAVSEA to certify to the ship that equipment is operational,
- For equipment installations which are out of the warranty period, NAVSEA, through NSWCCD-SSES, will immediately correct safety deficiencies. Other deficiencies will be corrected with later ship alterations,
- After the first installation inspection of the first ship of each class, NAVSEA and NSWCCD-SSES will discuss installation and design problems with the planning yard.

NAVSEA/Fleet Solid Waste Conferences

NAVSEA hosted the first annual NAVSEA/Fleet Solid Waste Conference, one on each coast, on 25/26 August 1997 in San Diego, CA, and 4/5 September in Norfolk, VA. These conferences were held to exchange information on shipboard solid waste treatment equipment; its operation, installation, and design; installation schedules; and all other facets of the program. Participants included Fleet representatives, Navy Supervising Activities, Planning Yards, and TDA, ISEA and Program Office personnel. The free exchange of information at theses conferences allowed NAVSEA to address many issues and to gage how well the program meets shipboard needs.

NAVSEA will host additional annual conferences in order to capitalize on lessons learned during installation and operation of solid waste equipment, and to ensure that the solid waste program continues to support Fleet mission accomplishment by providing the Navy with the tools required to easily meet its environmental responsibilities.

Shipboard Solid Waste Management Equipment Guide

The Shipboard Solid Waste Management Equipment Guide was published in September 1997. This Guide was developed to assist ship commanding officers and Sailors in managing solid waste from waste generation to final processing.

The Guide is very similar to the owner's manual provided with each new car. It describes solid waste management equipment operations and functions, highlights waste handling procedures, the duties and responsibilities of everyone onboard, and points out important safety and health issues. The Guide also talks about operator training, both in the electronic class room and on the job, and discusses the logistics support elements associated with the equipment.

Most importantly, the Guide promotes the development of a ship-specific plan that addresses the flow and processing of shipboard solid waste from start to finish. An example of such a plan is included in the Guide as a starting point for each ship's own, tailored plan.

Manning issues are also discussed in the manual. NAVSEA has requested a NAVMAC study to review manning impacts resulting from the installation of shipboard solid waste equipment. This study is tentatively scheduled for completion by the Spring of 1998. The USS JOHN C. STENNIS (CVN74) has been chosen as the study platform. The results of the study will be incorporated in the next promulgation of the Shipboard Solid Waste Management Equipment Guide.

Summary

Subsequent to the issuance of its Solid and Plastic Waste Management Plan of April 1993, the "Green Book," the Navy has made significant strides in addressing the management of shipboard solid waste. A new technology for effectively dealing with shipboard plastic waste, the plastics waste processor, was developed, evaluated in the laboratory, and tested for thousands of hours on ships at sea. All of the logistics required to efficiently support the processors is complete and production systems have been procured through competitive production contracts. Dual sourcing strategies have been employed and both producers are on schedule and hundreds of systems have been fabricated and delivered. Shipboard installation of these systems are well underway and over 50% of Fleet ships have received plastics waste processors. All congression-

ally mandated milestones have been met and the Navy is on course to meet the 100% compliance deadline of 31 December 1998.

The remaining essential solid waste equipment, pulpers and shredder, have also been developed, evaluated in the laboratory, and tested onboard ship. The environmental community and Congress have publicly reviewed the Navy's plans and have accepted the Navy's solution for complying with the MARPOL "special areas" restrictions. Pulper and shredder ship installation design began in 1996 and the RFP was released in February 1997 for a November contract award. The Navy is on course to complete Fleet integration of pulpers and shredders by December 2000, as required by the National Defense Authorization Act for Fiscal Year 1997.

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Biography

Ye-Ling Wang is an Environmental Engineer with the Naval Sea Systems Command. She manages the Shipboard Solid Waste Pulper and Shredder (ACAT IV) programs. Ye-Ling is responsible for the continuing technical development of the equipment, procurement, program planning and budgeting, and the Fleet-wide integration of this program.

Prior to her current position, she was a DOD Legislative Fellow in the Senate Environment and Public Works Committee; her focus there was in Superfund reauthorization. She has also worked in the Office of the Under Secretary of Defense for Environmental Security, the Office of the Assistant Secretary of the Navy for Research, Development and Acquisition, the Office of Naval Research and the Environmental Protection Agency. In these assignments, she has drafted policies and guidance regarding the role of environmental protection in the Department of Defense Acquisition process, and prepared staff work on various environmental issues.

From 1987—1992, Ye-Ling was the environmental coordinator for Navy field stations and laboratories, a project engineer in Surface Ship torpedo fire control systems and the surface ship keel sonar domes program.

Prior to joining NAVSEA, she worked for Advanced Engineering and Planning Corporation and for the Celanese Fibers Company as a Development Engineer at the Celco plant in Narrows, Virginia.

Ms. Wang earned her Bachelor of Science degree in Chemical Engineering from University of Maryland; a Master of Engineering Administration from Virginia Polytechnic Institute, completed the Program Manager's Course at the Defense Systems Management College, and The Executive Program, at Darden Business School, of the University of Virginia.