Report No. CG-D-05-93

AD-A265 624

On-Site Marine Inspection Data Capture

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FINAL REPORT
December 1992

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Prepared for:

U.S. Coast Guard
Research and Development Center
1082 Shennecossett Road
Groton, Connecticut 06340-6096

and

U.S. Department Of Transportation
United States Coast Guard
Office of Engineering, Logistics, and Development
Washington, DC 20593-0001

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Technical Report Documentation Page

1. Report No. CG-D-05-93	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle ON-SITE MARINE INSPECTION DATA CAPTURE		5. Report Date December 1992 6. Performing Organization Code
7. Author(s) Edward F. McClave and Michael J. Goodwin		8. Performing Organization Report No. R&DC 01/93
9. Performing Organization Name and Address MAR, Inc. 6110 Executive Boulevard, Suite 410 Rockville, MD 20852		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTCG39-91-D-E33A21
12. Sponsoring Agency Name and Address U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, Connecticut 06340-6096	Department of Transportation U.S. Coast Guard Office of Engineering, Logistics, and Development Washington, D.C. 20593-0001	13. Type of Report and Period Covered Final Report May 1992 to December 1992 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

U.S. Coast Guard marine inspectors were surveyed to determine their needs for improved on-site data management. The results of this survey were used to develop performance requirements for a portable computer system to improve the collection and management of inspection data and to provide inspectors with enhanced access to reference materials.

Fundamental changes in inspection data collection, documentation, and data storage procedures are recommended, based upon a computerized implementation of the CG-840 series inspection booklets incorporating computerized access to reference and regulatory materials.

A computer system comprising a hand-held pen-based computer, a notebook computer, a portable printer, a CD-ROM reader and a removable hard drive is recommended. A digital camera could also be integrated into the system. All hardware components will be commercially available and will utilize standard desktop and pen-computer operating systems.

A pilot project is recommended to test the new procedures which have been proposed, to determine the level of custom software development required, and to evaluate the performance of specific hardware and software items in the field.

17. Key Words	18. Distribution Statement
Inspection Documentation Marine Inspection On-Site Data Management Portable Computers	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. SECURITY CLASSIF. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

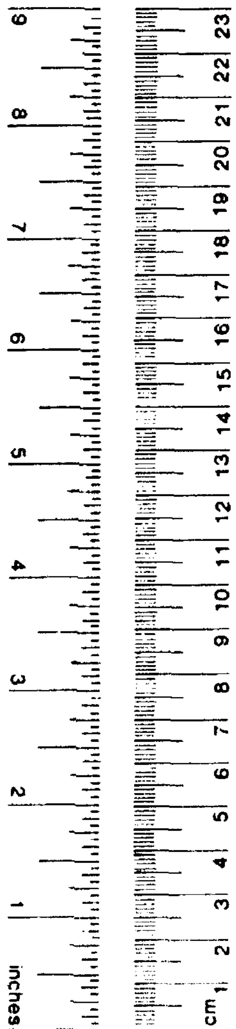
Form DOT F 1700.7 (8/72) Reproduction of form and completed page is authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
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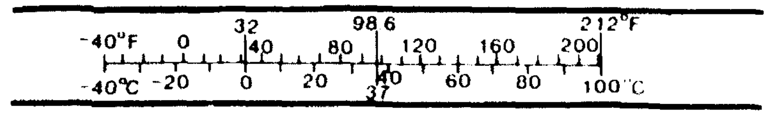

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Acknowledgements

MAR, Inc. gratefully acknowledges the cooperation of the many Coast Guard marine inspection personnel, from senior officers to the most junior inspectors, who made valuable contributions to this project. Despite heavy workloads, a large number of inspectors in many locations made themselves available for lengthy interviews and enthusiastically contributed answers to the questionnaires and original ideas as well. A number of inspectors freely offered and gave further assistance after the interviews, offered future assistance, and requested to be kept abreast of developments in the project. Others, on their own initiative, reproduced and distributed additional copies of the survey questionnaire to their colleagues. Those inspectors with whom MAR has dealt have made it clear that the U.S. Coast Guard inspector corps is a group of very dedicated, professional men and women who, despite the somewhat traditional nature of their duties, are not only willing, but eager, to incorporate modern technology into their profession.

MAR would also like to to acknowledge John Hannon (G-MVI-1) for his help in coordinating meetings at CGHQ, keeping the appropriate personnel informed, providing training schedules for coordinating workshops, and generally for his enthusiastic interest in the project.

Bert Macesker (CG R&DC) is also acknowledged for his continued support and guidance over the course of this project. Mr. Macesker played the leading role in setting up the meetings with marine inspection personnel.

Executive Summary

U.S. Coast Guard marine inspectors were surveyed to determine their needs for improved on-site data management. Based upon the results of this survey, performance requirements were developed for a portable computer system to improve the collection and recording of inspection data and to improve access to reference materials required by the inspectors.

This report recommends fundamental changes in the way U.S. Coast Guard marine inspectors conduct and document vessel inspections, and in the way the Coast Guard keeps records of those inspections. The recommended changes are not a response to any present inadequacies or deficiencies in the performance of inspections. Rather, this is an attempt to improve the efficiency of inspectors by exploiting current data management technology. Most of the recommendations for improvements in inspection data management in this report result directly from suggestions made by a representative cross-section of working inspectors and administrative personnel.

Part 1 of this report describes the field survey, reports field survey findings, and presents inspectors' requirements. Part 2 presents detailed performance requirements for a computer system to meet those requirements. Part 3 reports the results of a survey of non-developmental hardware and software items which can partially or completely satisfy the performance requirements developed in Part 2.

Detailed conclusions and recommendations are contained in sections 9 and 10 of Part 1. The recommended inspection system comprises two major hardware items. Pen-based computers will be carried by inspectors during the inspection and will record inspection data and provide access to a limited graphical and textual reference database. A notebook computer will serve as an on-board base station, merging inspection data from the pen-based computers, providing conventional word-processing capability, and providing access to a larger reference database. Peripheral equipment such as digital cameras, a portable printer, and support equipment such as power supplies and battery chargers will also be available.

The principal software will be a computerized implementation of the CG-840 series inspection booklets, which will be linked to a reference material database.

Improvements in data management will allow more detailed inspection records to be kept and will provide the inspectors and other users of the marine safety database with access to a greater amount of information about vessels and their inspection history.

All hardware to implement the inspection system is or will soon be available off-the-shelf. Some software development will be required, but existing or soon-to-be-released application development software tools will make it possible to develop the needed applications with a minimum of code-level programming.

A pilot project is recommended to test the concept of computerized inspection data management, to define the required application development effort, and to evaluate specific hardware and software in the field.

PART 1 - DISCUSSION

1 INTRODUCTION

1.1 Objectives of the Project

The objectives of this project were to determine the needs of Coast Guard marine inspectors for improved management of inspection data, to specify performance requirements for computer hardware and software to meet those needs, and to identify non-developmental products which satisfy the performance requirements.

1.2 Scope of the Project

The project comprised five separate tasks as defined in the Statement of Work:

4.1 Development of Questionnaire
4.2 Field Survey
4.3 Inspector Workshops
4.4 Development of Performance Requirements
4.5 Survey of Nondevelopmental Hardware and Software

1.2.1 Development of Questionnaire

A questionnaire, see Appendix A, was developed to determine inspectors' overall and specific needs for an information management system. This questionnaire was given to a number of inspectors from various locations, and the completed questionnaires were returned to the contractor. In addition, the questionnaire was used as a guide by the contractor in conducting direct interviews with groups of marine inspectors in various inspection ports. Questionnaires were filled out by inspectors present at interviews and workshops, and through their cooperation in distributing additional copies, by other inspectors not present at the interviews or workshops.

In connection with this task, before commencing the field surveys (Task 4.2), a representative of the contractor attended a two-day conference on Pen-Based Computing, a newly emerging technology which is expected to make important improvements in information management for mobile workers, and which has direct applications to this project. The contractor's summary of pertinent findings from that conference is Appendix B to this report.

1.2.2 Field Survey

A preliminary interview was held with personnel of the Marine Vessel Inspection (G-MVI) branch at U.S. Coast Guard (USCG) Headquarters, which resulted in refinement of the questionnaire and the identification and clarification of several key issues.

Interviews were conducted with groups of marine inspectors in the following Marine Inspection Office (MIO) and Marine Safety Offices (MSOs):

MIO New York, NY
MSO New Orleans, LA
MSO Honolulu, HI

In addition, questionnaires were distributed and valuable information pertaining to this project was obtained at MSO Portland, OR, during an interview conducted for another project, entitled Innovative Inspection Techniques.

Questionnaires were distributed by the inspectors interviewed within the offices visited, and the rate of return was excellent from all locations. Questionnaires were also distributed to offices other than those visited through the personal cooperation of several inspectors; additional questionnaires were filled out and returned from Seattle, WA, Buffalo, NY, and Morgan City, LA. A total of fifty-three questionnaires were returned completely or partially filled out.

Appendix A contains the full survey questionnaire with a summary of the responses to each question.

1.2.3 Inspector Workshops

Two inspector workshops were held at which the findings from the Field Survey were discussed, and preliminary system requirements developed in response to those findings were also presented to field inspectors and to administrative personnel.

The first of these workshops was held in New Rochelle, NY, with field inspectors from a number of different inspection ports who were attending a training course. A simplified version of the original questionnaire which focused on inspectors' information needs was distributed to attendees at this workshop, who in turn distributed copies to their colleagues at various inspection ports.

The second workshop was held at CG Headquarters with Marine Vessel Inspection (G-MVI) staff personnel, members of the traveling inspection staff, and others, including personnel involved in marine safety information management.

1.2.4 Development of Performance Requirements

This task began with the analysis of the questionnaires and interview findings from the Field Survey and Inspector Workshop tasks. Based upon this analysis, the overall characteristics of a portable system which would satisfy the inspectors' needs were defined. Performance requirements were then developed for the hardware and software of the portable marine inspection information management system.

As part of this task, the contractor conducted a study on the applicability of expert-system or knowledge-based software to several aspects of computerized inspection assistance.

1.2.5 Survey of Non-Developmental (NDI) Hardware and Software

This task was a survey of hardware and software which is capable of fulfilling some or all of the performance requirements discussed in Part 1 of this report and formally presented in Part 2. This survey covers products which are presently commercially available or which are expected to become available before the end of 1993.

2 BACKGROUND

2.1 The Coast Guard's Inspection Responsibilities

The Coast Guard is required by Title 46, U.S. Code (USC) to periodically inspect certain vessels registered in the United States or operating in U.S. waters to verify seaworthiness, structural integrity, and passenger and crew safety. Inspections also verify conformance with the pollution laws of Title 33, USC. Virtually all cargo-carrying and passenger vessels which use U.S. ports are subject to Coast Guard Inspection. A large number of previously uninspected U.S. registered commercial fishing vessels have recently become subject to inspection under the Commercial Fishing Industry Vessel Safety Act of 1988 and the regulations resulting from that legislation.

The Coast Guard maintains a corps of professional inspectors to carry out its inspection responsibilities. Most inspectors are uniformed Coast Guard officers, warrant officers, or senior petty officers, although many inspection departments have a few civilian inspectors and some have a significant number of civilians. Most of these inspectors are based at regional Coast Guard Marine Inspection Offices (MIOs) or at the inspection departments of regional Coast Guard Marine Safety Offices (MSOs) under the direction of the local Officers in Charge of Marine Inspection (OCMIs) and Chiefs of Inspection Departments (CIDs). A small group of highly experienced senior inspectors (the travelling inspection staff) operates out of CG Headquarters, functioning mainly in an advisory and troubleshooting capacity.

U.S. flag vessels are required to have a current Coast Guard Certificate of Inspection (COI) in order to operate legally in U.S. waters or elsewhere. This certificate is issued after an extensive initial inspection conducted during construction or upon entry of the vessel into U.S. registry. Periodic reinspections (generally every two years, with some exceptions) are required to maintain the COI. For each reinspection, CG inspectors are required to conduct a close-up visual inspection of the exterior and all interior spaces of U.S. flag vessels.

Foreign-flag vessels operating in U.S. waters are required to have current Certificates of Inspection (COIs) issued by their countries of registry and must satisfy the requirements of the United Nations Safety of Life at Sea conventions of 1974 and 1983 (SOLAS 74/83). USCG marine inspectors conduct periodic safety inspections of these vessels to insure compliance with SOLAS and to insure that they meet reasonable standards of seaworthiness and structural integrity. These inspections are generally not as extensive as those of U.S. flag vessels, particularly with respect to structural integrity.

2.2 The Marine Safety Database

The Marine Safety Information System (MSIS) is the Coast Guard's current computer database of marine safety related information. Part of this system serves the needs of the marine vessel inspection program, giving users across the country access to background information and current inspection status for each vessel inspected by the Coast Guard.

The vessel information in the MSIS is referred to, and some of it is updated, at every reinspection. The information includes permanent background information about the vessel's design, construction, and configuration which is entered during the initial certification process for the vessel. The vessel's current inspection status including outstanding deficiencies and mandated repairs is also part of the MSIS record. Whenever a vessel is inspected, issued deficiency reports, or when repairs are mandated or confirmed by reinspection, the MSIS record for the vessel is updated by the inspector or by administrative personnel in the inspection office.

Most inspection departments currently experience delays between the inspection and the final validation of a vessel's inspection records in the MSIS. Due to these delays, a separate record of a vessel's current inspection and repair status, form CG-2832, the Vessel Inspection Record Card (generally referred to as the "Bridge Record Card"), is posted on each inspected vessel. All changes in a vessel's inspection status are recorded on this card; it is the first item checked when an inspector goes aboard a vessel to conduct an inspection, since it may contain more up-to-date information than was available through the MSIS.

Improvements to the MSIS are currently in progress. The improved version of the marine safety database is tentatively slated to be called the Marine Safety Network (MSN). Throughout the remainder of this report, the interfaces to the marine safety database will refer to the MSN rather than to the MSIS.

2.3 The Inspection Process

Vessels are often inspected overseas, and one inspection trip may involve the inspection of more than one vessel. Most inspections of deep-draft vessels are conducted while the vessel is in a shipyard, but this is not always the case.

Smaller ships, boats, and barges are generally inspected by a single inspector. A team of inspectors may be assigned to deep-draft vessels. In the case of a team inspection, the vessel is usually divided up among the team members, with only one inspector visiting each space. If a particularly dangerous space must be inspected or if rafting or another hazardous access technique is used, inspectors may work together.

Many inspections take more than one day to complete. During a multi-day inspection the inspector generally issues informal interim deficiency lists called *worklists* to the ship's crew. Worklist deficiencies are often corrected by the crew before the inspection is completed, and if they are, they do not appear on the final inspection report.

Inspections conducted during overhauls may extend over a considerable period of time, with repairs and reinspections of those repairs occurring during the inspection itself, rather than after the inspection, as is the case when an inspection is completed within a few days.

In many cases, inspectors are accompanied by ship's crew members, owner's representatives, shipyard personnel, classification society surveyors or independent surveyors working for the shipowner.

On infrequent occasions, an inspection begun in one location may be completed by another inspector or team in a different location. It is not unusual for repairs required as a result of an inspection to be completed in a location other than the inspection port, or in more than one location. In such a case, an inspector or inspectors other than the one who conducted the initial inspection may conduct a reinspection to verify that the repairs were completed properly.

Because of the rotation schedule for uniformed Coast Guard inspectors, it is rare that the same inspector conducts two consecutive inspections of the same vessel, or that the inspector who conducted the previous inspection is even stationed in the same geographical location when the next inspection is conducted.

2.4 The Phases of a Typical Inspection

An inspection of a vessel by USCG marine inspectors involves at least four distinct phases, preparation (at the office), the inspection itself (aboard the ship), documentation of the inspection (aboard the ship and at the office), and reinspection of corrected deficiencies.

Figure 1, which follows, shows the flow of a typical inspection with multiple inspectors.

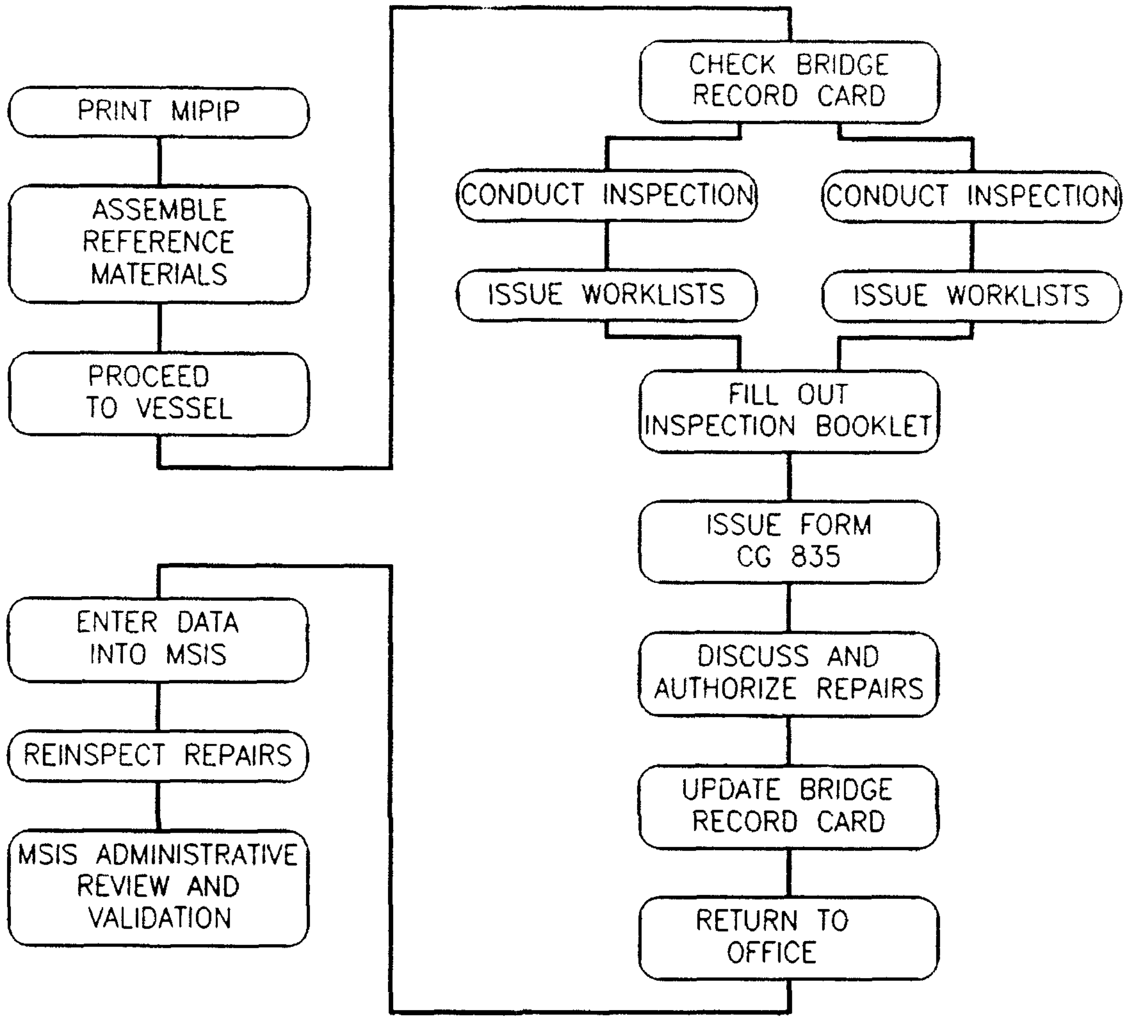


Figure 1 Flow Chart of a Typical Inspection

2.4.1 Preparation

This first phase of the inspection takes place in the office. The inspector obtains a printout from the MSIS of background information about the vessel's configuration, equipment, machinery, structure, and manning requirements. In addition, the MSIS listing of the vessel's current inspection status is printed out. The combined printout is the Marine Inspection Pre-Inspection Package (MIPIP or "PIP"). If available, records of previous inspections are obtained from files in the office. Vessels are frequently inspected in a port other than the vessel's port of registry, in which case the inspectors may obtain copies of the printed records of past inspections from the CG inspection office in the home port. Other information may be obtained from inspectors who conducted previous inspections, if they can be contacted.

The inspector also assembles a package of regulatory and reference materials (in text form) which might be pertinent to the inspection. These materials are generally carried to the ship by the inspector. Due to space and weight limitations, inspectors are often unable to carry with them all reference materials which might be needed during an inspection.

2.4.2 Conducting the Inspection

The inspector (or possibly more than one inspector in the case of larger vessels) proceeds to the vessel. Immediately upon arriving on board, the Bridge Record Card is checked to verify or update the vessel's current inspection status contained in the MIPIP printout. Pertinent information from the Bridge Record Card may be copied down for inclusion in the inspection records.

Once aboard the vessel, the inspector (or inspectors) generally set up a temporary office in a stateroom or other space where their reference materials and other paperwork are kept, and where they meet with ship's crew and representatives of the vessel owners and the shipyard.

The inspector(s) then make the rounds of the ship, recording inspection findings in handwritten or sketch form on a pad. Copies of the inspection booklet may be carried for reference, but the official booklet is generally not filled in until the inspection has been completed.

2.4.3 Documenting the Inspection

After completion of the inspection, the inspector (or the inspection team for a large vessel) assembles the notes from the inspection, and completes the inspection booklet (CG-840) appropriate to the vessel and to the type of inspection being conducted. The results of the inspection are discussed with the ship's master, chief engineer, or other crew members. The vessel's officers, in consultation with owner's representatives and shipyard personnel, may propose repairs to correct deficiencies found during the inspection. Repair proposals may be approved by the inspector immediately or may be referred to the CID or OCMI.

The inspector (or the head of the inspection team) writes the official textual narrative (the *inspection diary*) of the inspection findings. The diary is often handwritten on board, then transcribed to a computer file at the office. Some inspectors who own notebook computers carry them on inspection trips to facilitate preparation of the diary. Before the inspector(s) leave the vessel, a deficiency report (form CG 835) is issued to the master of the vessel, and the bridge record card is updated.

Back at the office, the inspection book, the inspection diary and a copy of the CG-835 form are placed in the vessel's hardcopy file. Either the inspector or an administrative assistant extracts the appropriate information from the inspection documentation, applies the proper codes, and enters the record of the inspection into the Marine Safety Information System (MSIS) database. At the discretion of the inspector, a narrative synopsis of portions of the inspection diary may be entered into the MSIS as an attached file. After review, editing, and correction by senior administrative officers at the MIO/MSO, the MSIS entries made by the inspector are validated and then become available to all users of the system.

2.4.4 Reinspection of Deficiencies

Repairs of other actions to correct deficiencies may be required immediately or within a specified time period after completion of the inspection. These corrective actions are often verified by inspectors. The inspector reinspecting the repairs may not be the same inspector who conducted the initial inspection, and the reinspection may be done by a different office.

2.5 The Inspector's Equipment

Inspectors generally carry a minimum amount of equipment during the actual inspection since crawling into tight spaces and climbing is almost always necessary, and any equipment interferes with their mobility. The inspector's tool kit is typically limited to a flashlight, a hammer for scaling rust, a wire brush for removing debris from surfaces, and possibly an inspection mirror.

Protective equipment includes a hard hat, safety glasses, coveralls, gloves, and steel-toed shoes. Safety equipment may include a life vest (when needed), a safety harness, an emergency breathing apparatus, a portable oxygen analyzer, and an explosive gas indicator. Many inspectors chose to do without some or all of this safety equipment because it restricts their mobility.

The inspector's data collection equipment is typically limited to a pencil and a small paper pad. A small percentage of inspectors occasionally use portable voice-activated tape recorders in addition to the pad and pencil.

A significant number of inspectors choose not to bring any equipment into a dangerous location like a tankship's cargo spaces which cannot fit into their coveralls pockets or be clipped to their coveralls or belt. Some inspectors carry a small tool bag with a shoulder strap. Such a bag requires some handling and attention and interferes with hands-free climbing.

2.6 Potential Areas for Improvement

The workshops and discussions preceding this project indicated potential areas for improvement of the inspection information management process. These needs were identified in a high level workshop conducted in June of 1989 and reported in reference 1. This workshop addressed both the short and long term needs of the Coast Guard's Marine Safety, Security, and Environmental Protection (M) Program. The findings from the field survey and inspector workshops conducted as part of this project have confirmed those needs and revealed several other potential areas for streamlining the management of inspection information.

The Statement of Work for this project suggests three broad categories for potential improvement which are detailed in the following subsections. Discussions held with inspectors as part of this project substantiated these suggestions.

2.6.1 Data Collection and Management

The process by which inspection information flows from the initial collection point aboard ship to its eventual entry into the Marine Safety database needs to be streamlined to eliminate some or all of the intermediate steps of transcription and re-entry of data inherent in the current process. A data collection system which eliminates unnecessary data manipulation by the inspectors would help to minimize the delays which often prevent inspection information from becoming available in the Marine Safety database in a timely manner.

Aside from the summary of inspection data entered into the MSIS, the official records of an inspection are presently in paper form and are fully accessible only in the vessel's port of registry. Replacement of the present inspection records (the CG-840 series inspection booklets and the inspection diary) by electronic equivalents would not only eliminate the transcription and re-entry of data during the inspector's documentation of the inspection, but would make these records readily available to inspectors in any location, provided the Marine Safety database had provisions for this.

2.6.2 Access to the Experience of Senior Inspectors

The average experience level of current inspectors is quite low. If the less experienced inspectors had access to a distillation of the inspection techniques and decision-making processes developed through experience by senior inspectors, their efficiency and effectiveness could be improved. A computer-based inspection guidance and decision-making aid might provide this access. Such a capability would fall in the general category of Artificial-Intelligence (AI), and more specifically in the category of expert-systems or knowledge-based syste

2.6.3 Improved Access to Reference Materials

The body of statutory, regulatory, and reference materials with which inspectors must be familiar continues to grow and many of its components are frequently updated. The physical volume and weight of the text and graphical materials involved, the growing complexity of the reference materials, and the low average experience level of inspectors indicate a need for digital storage and a computerized reference database with a searching capability. Context sensitive help could also be used to bring up specific information on an issue at hand.

3 QUESTIONNAIRE DEVELOPMENT AND FIELD INTERVIEWS

3.1 Questionnaire Background

A questionnaire was developed to determine the needs of inspectors for a data management system and to determine the physical limitations and constraints placed on such a device by the inspection environment. The questionnaire was also intended as a guide for conducting interviews and discussions with field-based inspectors.

The first draft of the questionnaire was introduced during the first interview of inspectors and G-MVI staff personnel at CG Headquarters on May 7, 1992. Based upon the results of this session, the questionnaire was modified to eliminate questions which were found to be unnecessary. A group of questions dealing with graphical information requirements was expanded, and more detail was added to the section regarding inspectors' needs for reference materials.

The final version of the questionnaire comprises Appendix A of this report. The questionnaire in Appendix A has the percent of responses received to multiple choice questions. Comments entered on the questionnaires have not been included but are discussed in the following sections.

3.2 Areas of Inquiry Covered by the Questionnaire

The questionnaire covered four principal areas which are detailed in the subsections which follow. These are: type of system, physical characteristics, information requirements, and data management requirements.

3.2.1 Type of System

The first section of the questionnaire explained the various general types of data collection systems which might be employed, asked the inspectors specific questions about each type, and solicited their preferences for system type.

An initial screening of potential automated data collection devices reveals five fundamental categories of equipment:

<u>Voice Recorders</u>

Voice recording is accomplished by simple pushbutton or voice-activated cassette and microcassette tape recorders. They are small and easily carried and offer the possibility of hands-free data recording. However, transcription of the recording is required in order to prepare the permanent inspection record.

Speech-Recognition Computer Systems

Speech-recognition systems use a computer to convert spoken words into computer text files which can be manipulated by word processing programs. Speech-recognition devices do exist, however, portable speech-recognition equipment with the capability of recognizing a large number of technical terms is presently not available, nor is it likely to be in the near future. When available, this technology will offer the advantages of voice-recording without the need for transcription.

Digital Data-Loggers

These are computerized devices of limited scope, generally with one-line displays and calculator-type keyboards, used for recording repetitious, mostly numerical information. They are widely used by meter-readers, land-surveyors, and shipping and delivery personnel to record simple numerical information without paper and in a form which can be directly downloaded into a computer system.

Pocket-sized data-managers are similar but have slightly larger display screens and calculator-type alphanumeric keyboards, and the ability to use simple software.

Notebook (Laptop) Personal Computers

These are portable versions of the standard desktop keyboard-based personal computer. They operate on rechargeable battery or line power, generally weigh 4-7 lbs, and have processing capabilities equivalent to desktop systems but generally have somewhat lower volatile (random-access memory) and non-volatile (hard-disk drive) storage capabilities.

Pen-based Computers

These are a recently developed type of hand-held computer which uses a pen-like device for input, with the ability to recognize words printed neatly on the screen with the pen and convert them into computerized text. The technology, including hardware, operating systems, application software, and application development environments, are designed specifically around mobile workers. Processing and volatile memory capabilities equivalent to those available on current notebook computers will be available soon. Solid state non-volatile storage is available for systems which are designed for use in harsh environments, but solid state memory capacity is considerably lower than that of notebook computers which use hard disk drives. Hard disks can be damaged by shocks although some are able to take considerable shocks without damage.

3.2.2 Physical Characteristics

Inspectors were asked to comment on physical requirements for a data collection device, such as size, weight, visibility of screen displays, and the required degree of resistance to shock and adverse environmental conditions. Arrangements for carrying the device were an important consideration.

3.2.3 Information Requirements

Inspectors were asked to specify which regulatory and reference materials they used regularly, occasionally, or not at all. These materials included various sections of the Code of Federal Regulations (CFR), Coast Guard Navigational and Vessel Inspection Circulars (NVICs), United Nations International Maritime Organization (IMO) publications such as United Nations Safety of Life at Sea (SOLAS), U.S. Coast Guard Marine Vessel Inspection (MVI) Policy Letters, and standards and rules published by private organizations such as the American Bureau of Shipping (ABS), and the National Fire Protection Association (NFPA).

3.2.4 Data Management Requirements

This group of questions addressed the inspectors' needs and desires for the display, recording, and transfer of information. The total information management package is expected to include access to reference materials, vessel background information, previous inspection records, and current vessel inspection status, as well as manipulation and transfer of the current inspection information being collected.

3.3 Distribution of the Questionnaire

The questionnaire was given to inspectors present at the field interviews. A large percentage of these were returned completed, either immediately after the interviews or later by mail. A number of inspectors present at interviews requested additional questionnaires for colleagues who were not present at the interviews, and senior inspection personnel passed out questionnaires to other inspectors in the same office. Eventually, more completed questionnaires (a total of fifty-three) were returned to the contractor than were actually distributed, since many inspectors present at interviews and workshops, on their own initiative, reproduced and distributed the questionnaires to their colleagues.

3.4 Interview Format

The questionnaire was used as a guideline for the interviews conducted at various inspection ports, however, filling out the questionnaire was not the principal focus of those interviews. The interviews took the form of discussion sessions during which inspectors explained their particular duties and problems to the interviewer, the interviewer explained the possible applications of various types of data collection and management systems in the marine inspection environment, and the inspectors discussed those applications. The inspectors were candid and helpful in pointing out which potential applications might be beneficial to them and in evaluating the likelihood of inspectors accepting and using various types of systems. In several cases inspectors suggested additional applications for computer systems which were not originally anticipated in the questionnaire.

3.5 Workshop Format

Two workshops were conducted, one with field inspectors and one at CG Headquarters with primarily G-MVI administrative personnel in attendance. At both of these workshops, a summary of the information gathered from questionnaires and field interviews was discussed. The contractor presented a preliminary proposal for an inspection data management strategy based upon a pen-based computer system. At each workshop, a pen-based computer running a simple marine inspection demonstration program was shown to the attendees.

Additional questionnaires were distributed to those workshop attendees who requested them.

4 QUESTIONNAIRE, INTERVIEW, AND WORKSHOP FINDINGS

4.1 Significance of Questionnaire and Interview Findings

Thirty three (33) complete questionnaires and 20 of the shortened version of the questionnaire dealing with information needs were returned to the contractor. The questionnaire respondents represent a cross-section of the inspector corps in terms of both geographical location and experience level. The tabulated results of the questionnaires provide a quantitative base of information but the responses do not elaborate on the issues or provide additional details. Approximately 40% of the questionnaire respondents were not present at the interviews. Discussions during those interviews clarified and elaborated upon many of the issues raised in the questionnaires. Those interview participants who subsequently filled out questionnaires did so with a more informed viewpoint.

OCMIs and CIDs in the inspection ports visited by the contractor were requested to make experienced inspectors available for the interviews, and this request was complied with in every case. All interview groups included at least several highly qualified senior inspectors, and most included junior inspectors as well. In some cases, administrative personnel who had never been field inspectors were also present. The senior inspectors present at these interviews contributed the most to the discussions, partly due to their level of experience and partly to the deference of the more junior people. It was apparent that the senior inspectors felt more comfortable about suggesting changes to the current inspection system in the presence of an outsider than did the junior inspectors.

Reports of the findings from the individual interviews and workshops are contained in Appendices C through H. A summary of the most important points raised by inspectors during the interviews is contained in sections 4.2 through 4.7. These sections also summarize the applicable questionnaire responses. The interview findings given below are more slanted toward the viewpoint of the senior and experienced personnel than are the questionnaire responses which give equal weight to all responses. While questionnaire respondents generally answered the questions and made a few short notes, the people interviewed raised a number of new issues and were generally more critical of present methods.

The summary of interview findings and the tabulated questionnaire responses constitute the base of information used for developing system performance requirements.

4.2 Findings: Type of System

The questionnaire explained each of the primary candidate technologies for data recording. Inspectors' preferences were as follows:

Notebook Computer:	17%
Pen-based computer:	58%
Data Logger:	17%
Voice Recorder:	8%

However, 64% of the respondents indicated they would not carry the device they chose into a space with restricted mobility.

4.2.1 Voice Recording

Interview Findings

Several inspectors have used micro-cassette recorders to record inspection results. These have the advantage that they are very small and can be carried in a coveralls pocket. Inspectors who had used them liked the small size, however, they pointed out two major drawbacks: the effects of background noise and difficulty in verifying that a good quality recording has been made.

High levels of noise are generally encountered in cargo space inspections, due to ventilation blowers and shipyard operations in adjacent spaces and outside the ship. The noisy environment interferes with clear recording and with voice-actuation features. Voice-activation is essential to conserve tape and to eliminate "dead spots" between entries which make later transcription difficult.

Verification is the second drawback which users of voice recording pointed out. An inspector cannot be sure of having made a usable recording without rewinding and replaying the recording. Not only does this take valuable time, but the replay itself may not be audible due to the same background noise which caused the quality of the recording to be suspected in the first place. With a pad and pencil, verification that the data has been actually recorded is visual and virtually instantaneous.

In addition, transcription of voice-recordings is required in order to write the diary and make out the inspection book, and this type of transcription is often more difficult than transcribing written notes. Inspectors frequently use sketches to show locations or details of structural problems; this is not possible with sound recording.

Interviewer's Comments

In general, while a few inspectors have successfully used voice recording in limited circumstances, most inspectors did not feel that voice recording was a generally suitable means of recording inspection data, nor would it be a significant improvement over the pencil and paper method.

However, those inspectors who have used voice-recording have relied upon the small built-in microphones supplied with the recorders. One inspector who had not used the method but was interested in it pointed out that special headset-type microphones are available which can do a much better job of discriminating close-up speech from background noise. A system which incorporated advanced microphones might solve the problems of background noise interfering with recording and with voice-actuation features. Such a system might prove reliable enough that frequent verification of entries by rewinding and replaying would not be necessary.

A common request of inspectors at each of the interviews was that the inspection book format be changed to a menu-driven, vessel-specific format in which simple menu choices would serve for many of the entries, with text entry used where needed to add detail. The inspectors who suggested this had in mind a graphical display, and did not feel that voice recording would adapt to this scheme.

Questionnaire Responses

Only 8% of respondents indicated a preference for voice recording over other techniques. Eighty percent of respondents felt that shipboard noise would present a problem in voice data recording and 55% felt that inspectors' voice entries should not be overheard by vessel crew members.

Twenty-three percent (23%) indicated that voice recording would be and improvement over present methods, and none felt that voice recording would be preferable to a portable computer system.

4.2.2 Voice Recognition Computer Systems

Interview Findings

Voice-recognition systems which convert speech to computer files are not yet generally available. When the subject was brought up to inspectors, the general response was that the same problems which accompany voice recording (noise and difficulty of verification) would also be present with voice recognition.

G-MVI administrative personnel felt that a computer text file which was a direct record of an inspector's spoken comments would not be suitably presentable for direct use as the permanent record of an inspection, and that considerable cleanup, editing, and elaboration would be required to put the text in a usable form.

Inspectors who urged an electronic version of the inspection book did not feel that voice recognition would help in such an implementation.

Questionnaire Responses

Twenty-one percent (21%) of respondents felt that voice recognition would be an improvement over present methods, and 23% indicated that a voice recognition system would be preferable to a hand-held computer.

4.2.3 Digital Data Loggers

Interview Findings

A few inspectors felt that a data logger with a small display screen and an alphanumeric calculator-type keyboard, similar to the electronic pocket organizers now on the market, would allow implementation of an electronic inspection book, with most entries made by one-key selections. The pocket-size of these devices was considered to be an important advantage.

Other inspectors, however, felt that management of the information they need as well as of the information they record should be a major requirement of an inspection data collection device. They did not expect that simple data loggers would be able to provide the storage and database searching capabilities which would be necessary.

Questionnaire Responses

17% of respondents preferred data loggers as a data collection device.

4.2.4 Notebook Computers

Interview Findings

A number of inspectors presently use notebook computers (their own) in their inspection work. Many of those who use the notebook computers carry them onboard large vessels during inspections, but they do not carry them on their inspection rounds. Some doubted that inspectors would be likely to actually carry a computer along with them on inspections. They felt that the pencil-and-pad method of data collection combined with a standard notebook computer with word-processing capability and containing an on-site database of reference materials would satisfy the needs of most inspectors. Others, however, felt that the portability of a pen-based computer would offer advantages in many situations.

Specific objections raised to notebook computers as data collection devices included the difficulty of using a keyboard in a dark place, or while wearing gloves, the size and weight of the device, the inability of a notebook computer to withstand shock and exposure to harsh environments, and the inconvenience of having to open and close the clamshell case every time the device was needed.

Many inspectors would like to have a notebook computer on board, but not on-site, that is, they would like to be able to sit down in front of it immediately after the inspection and use it for preparing worklists, writing their diary, and filling out forms.

Questionnaire Responses

17% of respondents expressed a preference for notebook computers as an on-site data collection device.

4.2.5 Pen-based Computers

Interview Findings

Since pen-based computers were just becoming widely available at the time of this survey, inspectors had no experience with them. A few inspectors had read of pen-based computer technology, and some Headquarters personnel had seen demonstrations of pen-based computers. However, for the majority of the inspectors interviewed, the discussions held during the interviews were their introduction to the concept.

As a result, the general lack of enthusiasm among the interviewed inspectors for a hand-carried data collection device like a pen-based computer must be evaluated with due consideration of their lack of experience with such devices and their lack of familiarity with the potential capabilities of this technology.

The majority of inspectors who commented on the use of pen-based computers expressed concern that the device selected be rugged enough for the extremely hostile environments and rough handling to which it would be subjected, and that it be small and light enough to be carried without encumbering the inspector.

Questionnaire Results

Despite the apprehension evident during the interviews over the concept of entering inspection data directly into a hand-carried computer, 58% of respondents preferred a pen-based computer to other on-site data recording devices. Sixty five percent expressed concern over the practicality of a pen-based computer's print-recognition capability, however, virtually none of those queried had any experience with pen-based computers.

4.3 Findings: Physical Characteristics of the Data Collection Device

Interview Findings

Virtually every inspector at every interview expressed concern over the size and weight of proposed automated inspection data collection devices. Most of those interviewed felt that a device of page size and weighing 3 to 6 lbs. (the size and weight of current full-sized pen-based machines) would be too cumbersome to carry into any space which required climbing or presented difficulties in access.

Many of these inspectors chose not to carry important safety equipment, such as their emergency breathing apparatus, into places where access is tight and climbing is required. To them, any data recording device significantly larger or heavier than their pad and pencil would be too large. Concern over the size and weight of the data recording device was by far the most frequently heard criticism of the concept of automated data recording.

Many inspectors also expressed concern over the visibility of a computer screen in a dark location, and in the presence of oil, dirt and dust which might smear on the screen, obscure it, and possibly interfere with pen input.

Although few inspectors would be willing to carry a full-sized pen-based computer into a dangerous location like a tanker's cargo spaces, a number of inspectors would use a computer for direct data entry in other situations; on deck, in engineering spaces, etc.

Most of those who were open to the possibility of carrying a computer preferred either a shoulder strap carrying arrangement or a chest harness. The shoulder strap would not fix the unit permanently to the inspector's body, and would allow the inspector to push the device ahead or pull it along when crawling through constricted passages, however, it would require a certain amount of handling attention and would interfere with climbing. A chest harness, on the other hand, would fix the unit to the inspector's body and would allow hands-free carrying at all times, but would interfere with access into tight spaces and might upset an inspector's balance.

While most inspectors initially felt that battery life should be at least 4 hours, further discussions indicated that if batteries could be replaced quickly without data loss due to low voltage or during the replacement process, carrying spare charged batteries and making changes on-site would be acceptable if long battery life was unobtainable. Most inspectors preferred rechargeable batteries with an on-board recharging capability, A few felt that the device should also accept disposable batteries interchangeably as an emergency backup capability.

Questionnaire Responses

Maximum size for Hand-held data collection device:

69% page-size (approx. 8-1/2" x 11")
19% approx. 7"x 5"
13% approx. 9-1/2" x 7"

Maximum Weight:

55% 4 lbs.
25% 6 lbs.
20% 10 lbs.

Text Display:

Fewest Lines

35% 2-5
25% 10-16
20% 6-10
10% 16-25

Fewest Characters

85% 40
10% < 40
5% 80

Minimum Character Size

55% 10 pt.
30% 12 pt.
10% 14 pt.

Combining the responses to the text display requirements, a display which shows 16 lines and 40 columns of 12 pt. (1/6") characters is the minimum acceptable display size. A 6" diagonal screen could accommodate such a display.

Eighty one percent (81%) of respondents felt that the maximum overall size limitation was a more important constraint than the minimum display size.

Method of Carrying Preferred:

54% coveralls pocket
15% backpacks
15% chest harnesses
15% belt pack

This preference for carrying in a coveralls pocket places a severe restraint on device size; 8"x 5" x 1" is an approximate upper size limit for a device to be carried in a conventional coveralls pocket, although a specially designed pocket could handle a larger device.

Sixty percent of the respondents indicated that the screen should be visible in near or total darkness, and 90% indicated that it should also be visible in bright sunlight.

For a pen-based system, 95% preferred a tethered pen.

Minimum Battery Life:

55% at least 4 hrs.
10% 3-4 hrs.
25% 2-3 hrs.
10% 1-2 hrs.

The majority (92%) preferred rechargeable batteries with an on-board charger to disposable batteries, and 62% felt that it was not practical to make battery changes during an inspection.

4.4 Environmental Factors

Interview Findings

Inspectors were concerned over how a display screen would function and hold up in severe environments. In the cargo spaces of tankers and bulk carriers, the screen would be exposed to oil or abrasive dusts. Operation and visibility of a pen-input screen in oily conditions was a concern, as were the effects of the constant cleaning which would be required.

Questionnaire Results

Intrinsic Safety Required:

89% yes
11% no

[Note: Interview findings indicated that inspectors rarely enter spaces on ships which are not "certified for hot work". Intrinsically safe equipment is not required in spaces which are certified. Inspectors of Mobile Oil Drilling Units (MODUs) are more likely to be required to enter dangerous spaces.]

Worst Case Oil or Grease Contact:

65% occasional contact
25% shallow submergence

Worst Case Water Contact:

42% occasional splashes
31% submergence

Average Highest Operating Temperature Requested: 132°F

Average Lowest Operating Temperature Requested: 20°F.

4.5 General Response to Computer-Assisted Inspections

Interview Findings

A large proportion of the inspectors who contributed to the interview and workshop discussions were very enthusiastic about the potential for computers to enhance their efficiency and effectiveness. (It should be noted that those inspectors who were enthusiastic about computer applications were the more likely to be present at the interviews in the first place, and were likely to contribute the most to the discussions.)

In general, inspectors were not enthusiastic about actually carrying a computer into tight locations for on-site data collection. However, they were enthusiastic about the potential for a computer to streamline the flow of inspection information and to provide better access to reference material.

4.6 Findings: Information Requirements

Interview Findings

Regulatory and Reference Materials

A common theme which was heard in every interview was the need for improved management of the regulatory and reference materials upon which inspectors must rely. Many felt that the volume of this material was constantly increasing and that it was becoming more difficult for inspectors to keep up with the frequent changes in regulations, references, and policy instructions.

Many inspectors expressed the opinion that management of the reference materials used was as important as management of the inspection data they generate.

Inspection Documentation

A majority of the inspectors interviewed would like to have access on demand to an expanded amount of information from previous inspections of a vessel, regardless of where it was last inspected. While different inspectors mentioned a number of different types of information they would like to have available, the items most often mentioned were the CG-835 forms, the CG-840 inspection books, inspector's diaries, and inspection worklists from previous inspections, in addition to the information now available from MSIS. Several inspectors, including two CIDs, pointed out that the inspection records which are presently available system-wide over the MSIS are highly excerpted, "sanitized" information which does not carry with it the "flavor" of the inspection. Many inspectors would prefer to get the previous inspector's subjective opinion of the vessel's overall seaworthiness and state of maintenance as well as the objective information contained in the MSIS.

Several Headquarters G-MVI personnel and a few field inspectors felt that a graphical display of tankship internal tank structure, with zooming capability, would be beneficial, especially if notations in the form of sketches and notes could be overlaid and made part of the inspection record. Digital photographs linked to inspection diary entries for deficiencies were also discussed with inspectors and several inspectors felt that these would be useful as a part of the inspection record, to assist senior inspection department personnel with repair technique approval, to guide repair personnel, and to assist CG inspectors during reinspections of completed repairs.

Questionnaire Responses

Reference Materials

A wide and detailed selection of potential reference materials was presented in the information requirements section of the questionnaire. Inspectors were asked to check off those materials which they used. Respondents to the shortened version of the questionnaire which dealt only with information requirements were asked to indicate "always", "sometimes", or "never" next to each potential document.

Ninety percent (90%) of the inspectors queried indicated a need for the text of the following Subchapters of Title 46 of the Code of Federal Regulations:

Subchapter D - Tank Vessels
Subchapter F - Marine Engineering
Subchapter H - Passenger Vessels
Subchapter I - Cargo and Miscellaneous Vessels
Subchapter J - Electrical Engineering
Subchapter T - Small Passenger Vessels

A large number (and a very large volume) of other reference materials were requested by a much smaller fraction of the inspectors queried.

Inspection Records

An alternate source for evaluating inspectors' information requirements is LCDR Eric Nicolaus's inspection citation database. The 7,270 entries in this database were analyzed to determine the frequency of occurrence of various categories of reference materials. The relative frequency of occurrence of the various categories of reference materials in this database corresponds closely with the frequency with which those materials were cited as important in the questionnaires. The relative frequencies of occurrence of database entries are as follows:

Code of Federal Regulations	66.0%
NVICs	8.6%
SOLAS	6.3%
American Bureau of Shipping	5.3%
Marine Safety Manual	4.6%
Local OCMI Policy Guidance	4.1%
MVI Policy Letters	4.0%
IMO MODU Code	0.7%
Miscellaneous	0.4%

Seventy four percent of respondents felt that it was practical for inspectors to carry multiple memory packages such as floppy disks, CD-ROM disks, or solid-state memory modules in the field to provide necessary information storage capabilities.

Supporting Information Requirements

Several questions referred to supporting information which might be available through a computer system. Seventy one percent favored inclusion of the vessel's status from the previous inspection and 90% requested an electronic equivalent of the last inspection booklet.

Seventy three percent of inspectors would favor inclusion of the MSIS vessel profile and 70% requested a phone number directory.

Seventy nine percent favored inclusion of the MIPIP on the inspector's computer. Sixty seven percent favored the ability to load and display outstanding CG-835 forms from other OCMI zones.

4.7 Findings: Inspection Data Management Requirements

Interview and Workshop Findings

In every interview location, inspectors expressed an interest in improving the flow of inspection information.

Inspection Booklets and Other Inspection Documentation

The most commonly heard request was for a vessel-specific version of the inspection booklet, in which only the entries applicable to the vessel being inspected would be presented. Many of the inspectors who made this request thought that a computerized version of the booklet would accomplish this, although some felt that a paper booklet printed out specifically for each vessel would serve the same purpose.

Many inspectors requested that, whether on paper or computerized, all inspection documentation be pre-printed or pre-loaded with information about the vessel which is already known to the system. Presently, such information as the vessel's name, documentation number, owner's name, and physical characteristics, all of which is already on file, must be entered by hand onto each form by the inspector.

The majority of inspectors interviewed would be receptive to the elimination of most or all paper inspection support information and inspection records. This would mean that the pre-inspection package, the inspection book (CG-840), the inspection diary and supporting sketches, the CG-835 forms and possibly the Bridge Record Cards (CG-2832) would exist primarily in electronic form, with the inspectors having the capability of printing them out on site as necessary.

Questionnaire Results

Sixty eight percent of the respondents indicated that the current inspection booklet format in which entries are arranged by equipment category was suitable. The alternative, arrangement by location on the vessel, was favored by 32%.

Approximately half of the respondents felt that a more detailed list of memory jogger items would be beneficial. About half felt that multiple choice entries would adequately replace written comments.

The present inspection booklets include sparse citations to applicable sections of the Code of Federal Regulations. Ninety percent of respondents indicated that context-sensitive help which would link to and display the text and illustrations of reference materials should be incorporated into an automated inspection booklet.

Only 25% felt that digitally stored photographs should be made a part of the inspection record, but 75% felt that an inspector's simple sketches should be.

Eighty eight percent felt that the vessel's Construction Log should be stored electronically.

Fifty percent of respondents felt that, in inspections requiring more than one inspector, each should have a data collection computer and the results should be merged electronically; 35% favored assigning one computer to the senior inspector and paper inspection booklets to the others, with the official electronic version of the inspection record filled out later by the senior inspector.

Ninety percent of respondents felt that the current MSIS record for the vessel should be available on the inspector's computer so changes and additions can be made on-site.

4.8 Findings: Advanced Inspection Aids

The possibility of some form of knowledge-based or expert system assistance was presented to inspectors at interviews and in the questionnaire.

Interview and Workshop Findings

Very few inspectors felt that an expert-system approach would be used enough to justify the development effort. Most expressed the opinion that the present training process was adequate. However, a few senior inspectors who were directly involved in the training of junior inspectors felt that many junior people were being sent out without having the benefit of working with and absorbing practical knowledge from senior people. These few senior inspectors indicated that a computerized reference system which compiled the knowledge of a number of highly experienced inspectors might be of use to junior inspectors.

The particular expert-system application most often mentioned was assistance with the initial overall screening techniques which inspectors use when they first enter a space or board a vessel. The experienced inspectors use these techniques to focus their detailed inspection effort and time in those locations which their experience indicates are most likely to have problems. Junior inspectors might benefit from a computer-accessed compilation of the techniques of experienced senior inspectors in this area.

Questionnaire Results

Forty percent (40%) of the respondents indicated that an expert-system capability would be beneficial, while 60% felt it would not be.

4.9 Findings: Computer-Literacy Among Inspectors

Interview and Workshop Findings

While the questionnaire did not directly address inspectors' present level of proficiency with computers, it became apparent during the interviews that the level of computer-literacy among inspectors is already high.

Virtually all inspectors use the Coast Guard MSIS system through the CG Standard Workstations. Many inspectors own and use desktop or notebook personal computers at home, and some inspectors use their own machines in the office, as well. A significant number of inspectors carry portable computers with them on inspection trips for preparing their inspection diaries, worklists, etc.

The level of enthusiasm among inspectors for computerizing inspection tasks is high. Based upon their responses to initial proposals, it is expected that the level of cooperation will be high and that training inspectors to use an inspection computer system will be relatively easy.

Several inspectors have developed inspection aids on personal computers. Most notably, in New Orleans, Assistant CID LCDR Eric Nicolaus has developed, on his own time and on his own computer, an extensive database of reference materials frequently used by Coast Guard marine inspectors. This database includes over 7,000 entries and provides citations to the Code of Federal Regulations, SOLAS and IMO publications, NVICs, MVI and local OCMI policy instructions, statutes, other reference materials used by inspectors. The program offers subject and keyword searching capability. LCDR Nicolaus distributes this database unofficially to any CG inspectors who want it, and many inspectors are currently using it. He maintains the database to keep it current with the frequent changes in the many regulations and sources it references, also on his own time.

LCDR Nicolaus's project, besides providing a valuable service to many inspectors and increasing their effectiveness, has introduced many inspectors to the concept of computer-assisted inspection. His efforts in making his system comprehensive and accurate, and user-friendly as well, have paved the way for widespread acceptance of a more extensive computer-based inspection assistance system by the people in the field. LCDR Nicolaus and others feel that the logical next step is to provide the text and graphics of the reference materials in addition to citations only.

LCDR Ellis in Honolulu has developed a similar database which allows inspectors access to a limited amount of the actual text of a small body of selected reference materials.

Many other inspectors showed a familiarity with DOS-based personal computing technology at levels much deeper than that of the normal business or casual user. Some have had experience in the development of applications. Many have made valuable recommendations about both the overall concept and the technical details of an inspection computer system.

In addition to generally being familiar with the capabilities of computers, the majority of the inspectors interviewed were enthusiastic about the potential for computers to streamline their jobs, particularly in terms of improving access to reference materials.

In general, it is anticipated that marine inspectors will be receptive to a computer system and that training them to use the system will not present a major problem. In addition, it can be expected that a number of the many computer-literate inspectors will be extremely helpful in the development of a pilot testing program and in the continued evolution and improvement of a full-scale system, once it is implemented.

4.10 Detailed Interview Reports and Questionnaire Results

Detailed reports of the findings from each of the inspector interviews and workshops are contained in the Appendices to this report. A sample questionnaire containing tabulations of all multiple choice answers is contained in Appendix A.

5 DISCUSSION OF INSPECTORS' DATA MANAGEMENT REQUIREMENTS

Based upon the interview and questionnaire findings, the following sections identify principal areas where improvements are needed in the management of inspection data. The sections are ordered roughly in descending order of the importance which inspectors placed upon these needs. The performance requirements developed in Chapter 8 are focused directly upon fulfilling the needs identified here.

5.1 Improved Inspection Booklet Format

The inspection booklet should be vessel-specific. A menu-driven electronic form of the inspection book, tailored to a vessel's actual configuration, with context-sensitive help and access to reference materials, would be the ideal.

In order to fulfill this requirement, a data collection system must have sufficient data processing and storage capabilities to graphically display a menu and record the inspector's menu choices, and to record written comments when menu choices are not sufficient. The system must also be capable of uploading vessel configuration information from the Marine Safety database, converting the information into a form usable on the field computer, converting inspection data into a form usable by the MSN, and directly downloading the results to the Marine Safety database.

5.2 Access to Reference Materials

Better access is needed, at the inspection site, to reference and regulatory materials and to Coast Guard inspection policy guidance documents. These documents are primarily textual, but many incorporate a small number of important illustrations.

In order to fulfill this requirement, a system must have the ability to use index-based searching software and must have sufficient non-volatile data storage space for the data itself and for the search software. This access to reference materials should be incorporated into the program which implements the electronic version of the inspection booklet.

5.3 Streamlining of Data Collection

There is a need to eliminate or, at least, greatly reduce the transcription, re-entry, and copying of inspection data between its origination and its incorporation into the Marine Safety database as the final official record of the inspection. Text and sketch entries into the inspection diary should be made on board the vessel and should become part of the permanent inspection record without transcription or additional manipulation other than editing and amplification.

In order to fulfill this requirement the system must provide word-processing and simple Computer Aided Drafting (CAD) capabilities on-board the vessel.

5.4 Access to an Increased Amount of Inspection Documentation

Inspectors need access to more documentation from not only a vessel's previous inspection but from past inspections as well. This includes the actual inspection booklets (forms CG-840), inspection diaries and inspector's sketches, vessel repair histories, correspondence with vessel owners, deficiency reports (form CG-835), inspection worklists, and waiver letters. This information should be accessible not only at the vessel's port of registry, but to all users of the Marine Safety database.

A well-designed data-management strategy is necessary to prevent this additional information from becoming a burden. The system should present information to the inspector only upon a specific request. For example, the inspector is now presented with an abundance of information in the MIPIP, such as equipment serial numbers, which is rarely of use to inspectors on-site.

In order to fulfill this requirement both the Marine Safety database and the inspector's computer system must have sufficient storage space for the past inspection records. The inspector's system must be able to upload this information directly from the Marine Safety database.

5.5 Access to Vessel Plans

If vessel plans are available in digitized form, it will be beneficial for inspectors to have access to at least the general arrangement drawings on a portable computer screen with zooming capability. Machinery plans, piping and electrical diagrams would all be useful as well. Vector-based graphics files created by Computer-Assisted Drafting (CAD) would provide the most flexibility in display, but scanned images (bit-mapped files) of hard-copy plans would also be usable.

In order to fulfill this requirement, the system must have a high-resolution graphics display, storage space for graphics data files, and processing capability to run a CAD program and to support screen graphics. The system must be able to upload the graphics files from their permanent storage location.

6 EVALUATION OF DATA MANAGEMENT STRATEGIES

In order to evaluate the best strategy for inspection data management, the potential data management systems were compared in terms of how well they fulfilled identified needs and requirements.

6.1 Potential Systems and Evaluation Criteria

The system requirements presented in Chapter 5 and other requirements identified by inspectors were combined, resulting in 9 primary criteria for evaluating potential data management strategies. These criteria are:

- Ease of carrying
- Ease of use on-site
- Verification of on-site entries
- Elimination of transcription
- Access to textual reference materials
- Access to graphical reference materials
- Implementation an electronic version of the inspection booklet
- On-site text entry
- On-site sketch entry

Cost was not used as a scoring criterion in this analysis.

Seven current and potential data collection and management strategies were evaluated against these criteria. These strategies are:

- Pencil and paper (the predominant current method)
- Digital data-loggers
- Voice recording
- Voice-recognition computer systems
- Notebook computers (keyboard-input)
- Palm-size pen-based computers
- Page-size pen-based computers

6.2 System Evaluation

Table 1 shows the comparison of the seven on-site data collection strategies, each one evaluated according to how well it fulfills the nine primary criteria. "On-site", in this context, means the inspectors use the method of data recording while actually conducting the inspection. Ratings were assigned on a scale of 0 to 5 for each criterion. Ease of carrying and ease of use on-site were given double weighting in this analysis (scaled 0 to 10) because of the extreme importance attached to these factors by the inspectors. The pen-based computer strategy was divided into two categories based upon size, palm-size and full-size, again

Table 1 Evaluation of On-Site Data Collection Strategies with Regard to Primary Criteria

	Pencil and Paper	Digital Data Logger	Voice Recording	Voice Recognition System	Keyboard-based Notebook Computer	Palm-Size Pen-Based Computer	Full-Size Pen-Based Computer
Ease of Carrying	Excellent (10)	Good (6)	Very Good (8)	Good (6)	Poor (1)	Very Good (8)	Poor (3)
Ease of use On-Site	Excellent (10)	Good (6)	Good (6)	Good (6)	Poor (1)	Very Good (8)	Excellent (10)
Verification of On-site Entries	Excellent (5)	Excellent (5)	Fair (2)	Fair (2.5)	Excellent (5)	Excellent (5)	Excellent (5)
Elimination of Transcription	None (0)	Limited (2)	None (0)	Fair (2.5)	Excellent (5)	Excellent (5)	Excellent (5)
Text Reference Access	None (0)	None (0)	None (0)	None (0)	Good (3)	Very good (4)	Excellent (5)
Graphical Reference Access	None (0)	None (0)	None (0)	None (0)	Good (3)	Very Good (4)	Excellent (5)
Electronic Inspection Book	None (0)	None (0)	None (0)	None (0)	Good (3)	Very Good (4)	Excellent (5)
On-site Text Entry	None (0)	Poor (1)	None (0)	Good (3)	Good (3)	Fair (2)	Fair (2)
On-site Sketch Entry	None (0)	None (0)	None (0)	None (0)	Poor (1)	Very Good (4)	Excellent (5)
Score	25	20	16	20	25	44	45

because of the importance which inspectors attached to ease of carrying.

The scores from Table 1 indicate that pen-based computers meets the criteria for an on-site inspection data collection device considerably better than the other possible devices.

6.3 Combinations of Individual Strategies

In addition to on-site data collection and information access, other functions such as on-board text processing and access to very large CD-ROM based reference databases are desirable. Table 1 evaluates the devices only in terms of on-site capabilities. Several combinations or enhancements of the devices in Table 1 are of interest as overall on-board inspection data management strategies. These combinations combine efficient on-site data collection with on-board, (i.e., at a stateroom desk) keyboard-based computing capabilities.

In cases where multiple inspectors conduct an inspection, the actual final version of the electronic implementation of the inspection booklet will be completed after the inspection by merging the individual inspectors' entries, either manually or electronically, to create the final version of the inspection record.

The combined data management strategies are discussed below and evaluated in Table 2.

6.3.1 Pencil/Paper and Notebook Computer

This combination strategy is the same system used by a number of inspectors now. However, enhancements in data management and implementation of the electronic inspection book on the notebook computer would result in considerable improvements over the present system. Reference search capability would also be added.

6.3.2 Full-Size Pen-based Computer with Expansion Unit

This combination would use a full-size (page size) pen-based computer as the on-site data collection device. The same computer, attached to a bus expansion unit containing floppy and hard disk drives, an optional CD-ROM unit, and connected to a keyboard, would function as the display and processing unit of a desktop computer.

6.3.3 Palm-sized Pen-based Computer and Notebook Computer

In this strategy, a palm-size pen-based computer would provide enhanced mobility (compared to a page-sized unit) as an on-site data collection device. Since the screen of a palm-sized computer would not be adequate for word processing and other desktop computer functions, a standard notebook computer would provide desktop computing capability. A docking port, data transfer cable, or wireless modem would enable rapid communication between the pen-based computer and the notebook computer.

6.3.4 Full-size Pen-based Computer and Notebook Computer

This combination is similar to that of section 6.3.3. The full-sized pen-based computer would provide enhanced display and data entry compared to the palm-sized pen-computer, but would be more difficult to carry.

If operationally similar palm-sized and full-sized pen-computers were available, they could be used interchangeably, depending upon the situation, in conjunction with a notebook unit.

6.4 Evaluation of Combination Strategies

The four combination strategies presented in 6.3.1 - 6.3.4 were evaluated using the criteria of section 6.2, along with the addition of three additional criteria dealing with desktop computing capabilities. These criteria are desktop word-processing capabilities, limited desktop Computer-Aided Drafting (CAD) capabilities, and access to large reference databases. Table 2 shows the results of this evaluation.

The scores from Table 2 indicate that palm-size or full-size pen-computers in combination with a notebook computer, or a full-size pen-computer with an expansion unit (described in 6.3.2) are more or less equal. Two additional considerations must be taken into account in making a final choice of an appropriate strategy.

First, the use of a standard notebook computer as a desktop unit would allow the most flexibility, since either a palm-sized or full-sized pen-based computer could be used as the on-site data collection device, depending upon the type of inspection and the inspector's preferences. Using a palm-size pen-computer in conjunction with an expansion unit would require the screen of the pen-computer to be used as the display, and the small screen would be inadequate as a display for desktop applications such as word processing. This option

Table 2 Evaluation of Combination Strategies

	Pencil/Paper and Notebook Computer	Palm-size Pen-computer and Notebook computer	Full-size Pen-computer with expansion unit	Full-size Pen-computer and Notebook computer
Ease of Carrying	Excellent (10)	Very good (8)	Poor (3)	Poor (3)
Ease of Use On-Site	(10)	Very Good (8)	Excellent (10)	Excellent (10)
Verification of On-site Entries	Excellent (5)	Excellent (5)	Excellent (5)	Excellent (5)
Elimination of Transcription	Partial (2)	Excellent (5)	Excellent (5)	Excellent (5)
Text Reference Access	On-board, not on-site (2.5)	On-site Very good (4)	Excellent (5)	Excellent (5)
Graphical Reference Access	On-board, not on-site (2.5)	On-site Very Good (4)	On-Site Excellent (5)	On-site Excellent (5)
Electronic Inspection Book	On-board, not on-site (2.5)	On-Site Very Good (4)	On-Site Excellent (5)	Excellent (5)
On-site Text Entry	None (0)	Fair (2)	Fair (2)	Yes (5)
On-site Sketch Entry	None (0)	Very good (4)	Excellent (5)	Yes (5)
On-board Word Processing	Excellent (5)	Excellent (5)	Very Good (4)	Excellent (5)
On-board CAD capability	Good (3)	Very Good (4)	Excellent (5)	Excellent (5)
Access to Large Databases	Excellent (5)	Excellent (5)	Excellent (5)	Excellent (5)
Score	47.5	58	59	63

does eliminate the need to transfer data between the pen-based computer and the notebook computer, however.

Second, an expansion unit for a pen-based computer will likely be a custom item, while notebook computers are widely available; initial cost and maintenance costs are expected to be lower for standard commercially available hardware items.

6.5 Conclusions - Hardware Strategies

Based upon the results of the analyses presented in 6.2 and 6.4, it is concluded that the best inspection data management system will be a combination using a standard notebook computer as an on-board base unit and a pen-based computer as a mobile on-site data-collection unit. Depending upon whether a particular inspection situation favors a large, easily readable display and data entry area or ease of carrying, the pen-based computer might be palm-size or full-size (page-size).

7 TOOLS TO IMPROVE INSPECTOR EFFICIENCY

7.1 General

A computerized version of the inspection books could be implemented which does little more than copy down on the computer what the inspector now writes on paper. Such an implementation would do little to improve the current situation or take advantage of the productivity gains possible through use of a computer. A number of possible productivity tools were considered for the inspector's computer system. These are listed here and discussed in the paragraphs that follow.

a. Elimination of repeated data entry by use of a common database for different forms.

b. Providing ship specific inspection books to eliminate information that is not applicable.

c. Providing the inspector the option of displaying inspection requirements by category, fire extinguishers for example, or by location. In the latter case, all items needing inspection in a compartment or deck location would be displayed consecutively.

d. Providing a visual display of where past defects were found.

e. Providing context sensitive help.

f. Providing an expert system for defect severity assessment.

In addition, expert systems for guiding the inspector to possible trouble spots and for evaluating proposed repairs were considered. The system for guiding the inspector to possible trouble spots was rejected because it would be nearly impossible to implement. There are a few simple rules to follow such as: "If cracks are found near the bottom you better check below the deck at the same location because a high hull bending moment may have caused the cracks." What few rules there are are quickly learned by even the most junior inspectors. Vessel design rules continually change to eliminate defects that are repetitive in nature, the kind of defects that an expert system would be programmed to look for.

An expert system for proposed repairs would be used more in the office than on board, but there are some repairs proposed to the inspector before the inspection is complete. There are already excellent international guidelines on which types of repairs do and do not work. Any expert system would be little more than a computerized version of these guidelines and would provide little extra value.

7.2 Elimination of Repeated Data Entry

This tool has been mentioned previously. The inspectors spend a good deal of time repeatedly writing the ship's name and similar data on different forms. The computer can easily eliminate this by loading this type of data from a common, ship-specific database. This is an easy tool to implement and will improve efficiency at little cost.

7.3 Ship Specific Inspection Books

At the present time, the inspection books for a specific ship are chosen from a limited number that apply to a large group of vessels. As a result, inspectors must take the time to mark many entries as not applicable to the vessel being inspected. This takes time and must be repeated each time the vessel is inspected. A ship specific inspection book in electronic form can eliminate this step. Only those items applicable to the vessel will be shown for the inspector's consideration. Of course, the first time the vessel is inspected, the inspector will have to work with a nonspecific inspection book and mark the "not applicable" categories. The computer can then eliminate these categories for subsequent inspections. This process is also easily programmed and should be included as an enhancement to the electronic version of the inspection books.

7.4 Sorting by Category or Location

Present inspection books are arranged by category and subcategories. Often equipment or structure that must be inspected under a particular subcategory is located in more than one location on the vessel. In the case of some items, such as fire extinguishers, there may be many locations. It is difficult for an inspector to keep track of a category of information when equipment is encountered in many locations.

In certain cases, it may be more practical to have the computer display, in order, all the items needing inspection in a particular space. The computer can do the bookkeeping on the total number of items found. Thus, the computerized inspection book must have the capability to present a list of items located in a common location.

There are some categories, such as navigation equipment, where most of the equipment in the category is located in only one or two spaces. The inspector may elect to inspect this equipment as a group and complete the entire category at once. Therefore, sorting of data by category is an option that must also be available to the inspector.

In any case, the computer must keep track of which categories have yet to be completed. The inspector must be able to recall this list as the end of the inspection nears so that no items will be missed on the inspection.

7.5 Visual Display of Past Defects

As mentioned above, the use of an expert system to help the inspector choose the parts of the structure to concentrate on was rejected. Most of the benefits of such a system can be obtained through an easily implemented approach by visually displaying the location of past defects, provided the vessel has been inspected at least once using the computerized version of the inspection booklet. There are programs on the market which use computer aided design (CAD) technology to display vector or bitmapped drawings of the ship. These systems permit the inspector to add notes and sketches on separate layers to these drawings and store the added information with the drawing. Individual layers can be turned on or off. Thus, at the next inspection, for repairs or otherwise, the inspector can recall the notes from past inspections. These can be viewed independently by each inspection or as a group. The inspector can quickly determine where problems were detected in the past and concentrate on those areas. Of course, the inspection should not be limited to those locations or else other serious problems may be missed and the visual database of defect locations will never grow.

The disadvantages to using a drawing based system such as the one suggested are the amount of data storage required, the size of the drawing editing program, and the need to have drawings in a compatible electronic format. Storage capacity for laptop and pen-based computers is growing rapidly and is already able to accommodate the drawing files along with other database requirements so this is not a serious issue. The drawing program can likewise be accommodated easily and is not an issue.

Getting drawings into a compatible format is more of a problem. Most of the small computer CAD programs use a drawing format compatible with the AutoCAD™ computer program, sold by Autodesk, Inc. This program is widely used on desktop computers and compatible drawings may be available in the proper format. For inspection purposes, a bitmapped drawing is equally acceptable. Full drawing sized scanners are available for less than $5,000 that would serve very well to digitize any ship drawings in a compatible format. A little time is required at the home office to digitize the drawing data but it only needs to be done initially or when there is a major change in the design. A single digitizer for each inspection office should be sufficient to handle the drawing load.

7.6 Context Sensitive Help

A good portion of the inspector's time is spent looking up citations in the Code of Federal Regulations (CFR) or technical society publications. This is necessary to determine the specific requirements which cover a deficiency found during the inspection. At present, the inspector carries a car full of reference books and has to know where to look to find the information required. Many potential sources of information such as policy letters from CG Headquarters or the local CID may not be known to the inspector and thus overlooked. Also, the vessel's owners may have been granted a waiver to deviate from the standard requirements. The inspector seldom has such information readily at hand.

Most of the references needed by the inspector, the most frequently used 90 percent, can be stored in the memory of a pen-based computer along with the other programs and data needed to conduct an inspection. This information can and should be accessible by title or number much as the printed information is now. A more powerful tool, context sensitive help, should also be incorporated to access this information.

Context sensitive help requires that an index file be developed which links a category from the electronic inspection book to the reference data. For example, the category "portable fire extinguishers" would be indexed to requirements contained in the CFR, National Fire Protection Code, CG Headquarters or CID policy documents, and any waivers granted for that particular vessel. All of the above information with the exception of waivers can be kept in the computer for all inspections since it is common to all ships. Waiver information would have to be included with the ship specific inspection book.

LCDR Eric Nicolaus has developed a paper-based index which provides substantially what is needed in terms of a cross reference listing. Reference data stored in the computer needs location codes (bookmarks) so that specific text can be accessed. When the inspector requests context sensitive help, that is help for the category on the screen of the pen-based computer, the index file will provide pointers to all the applicable location codes. The inspector can read or skip through the references to find the information desired. The type of indexing used to find data on CD ROMs could be applied here.

A system with context sensitive help should prove to be a time saver for the inspector as well as reducing the chance that applicable requirements are overlooked. If it does nothing else it will eliminate the need for the inspector to carry around a car load of books.

7.7 Defect Severity Assessment

A number of expert systems were considered for use by the inspectors but only a defect severity assessment tool was considered to have sufficient merit to include it on the inspector's computer. This would be a stand alone application on the computer and could be added later. The purpose of this tool is to assist the inspector to decide what corrective action is required when one or more structural defects are found.

Two comments on expert systems were heard repeatedly during the inspector interviews. The first was that the inspectors considered themselves to be the experts and didn't need a machine telling them how to do their job. The second was that the expert system would be used as a crutch, reducing the reliance inspectors now must place on their own judgement. It was stated that the Coast Guard uses officers for marine inspectors because they are expected to exercise good judgement. Both of these arguments have undoubtedly come up in other industries that have adopted expert systems.

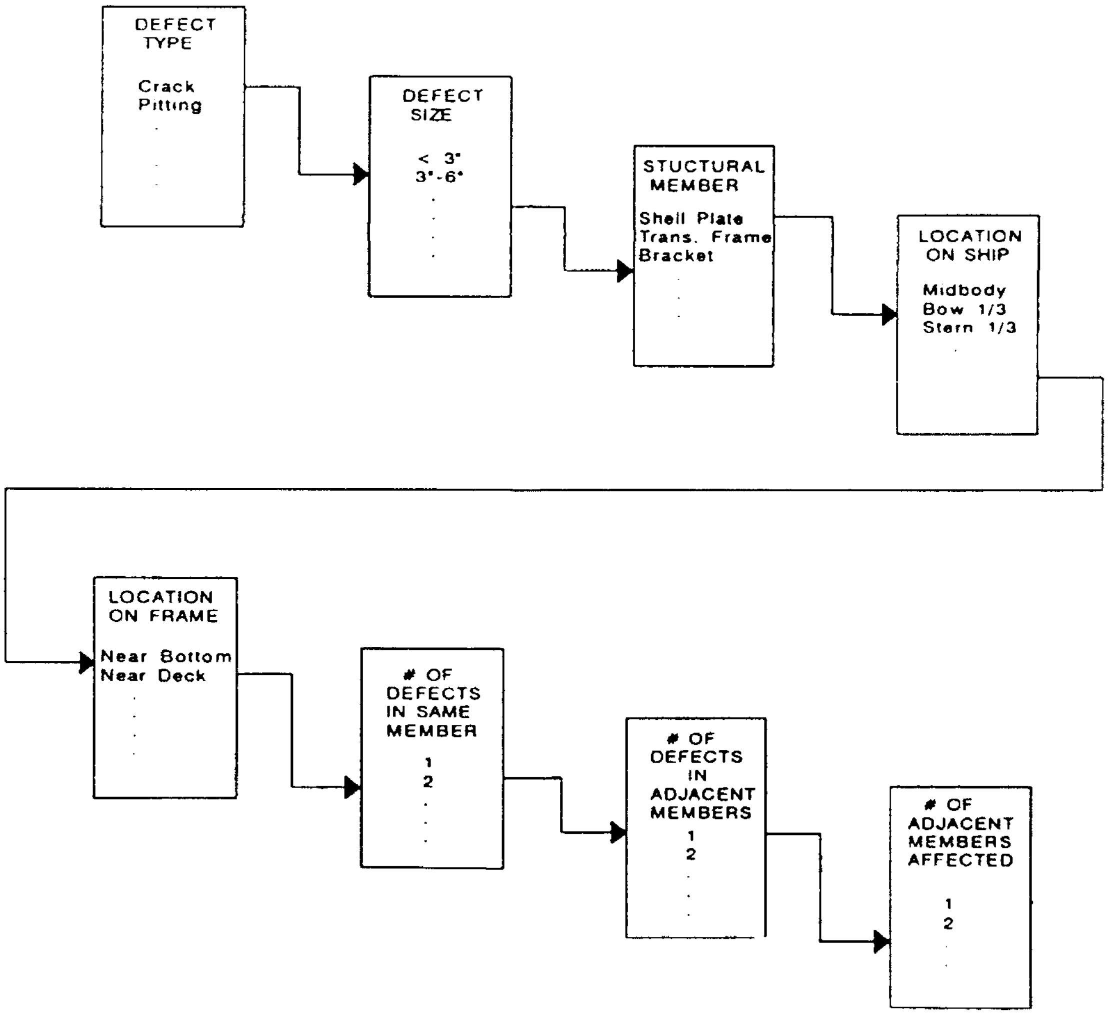
Few inspectors are really experts on all types of vessels, even very senior inspectors. This is evident from the number of times references are used to locate requirements. There are few people in the country who could give a truly expert opinion on whether or not to delay repairs or repair immediately a structure as complex as a ship's hull. Inspectors do make good decisions now, sometimes with the assistance of the CID or OCMI, but decisions are not always consistent between inspection zones or even different inspectors within a zone. It is unlikely that this inconsistency will ever be totally eliminated but an expert system can help.

Expert systems are only a tool, not much different than a reference book. The use of such a system is comparable to a doctor consulting a colleague about a difficult patient. The final decision will still rest with the inspector, but the more information the inspector has to make that decision, the better. Some inspectors might use the advice from the expert system as a crutch but most are likely to temper their judgement based on factors not considered in the expert system. For example, the defect severity assessment system might recommend immediate repairs but the inspectors knows that the repairs could be better accomplished at the next port of call and the weather is expected to be calm. Given these other factors, the inspector could decide to require repairs in the next port instead of immediately.

Development of a defect severity assessment (DSA) system is a major project in itself and beyond the scope of this study. The discussion below is included to give a flavor of what might be included in such a system.

The goal of the DSA system is to provide a recommendation on repair action given a set of defects located by the inspector. This recommendation would be based on information

Table 3 Partial List of DSA System Input Factors



on defect type, size, structural member involved, location on the ship, and other defects in the vicinity. Other factors, such as defect orientation and likely cause, could be included. Table 3 gives a breakdown of some of these factors.

For example, the inspector finds a 3 foot crack in a bottom longitudinal near the midbody. There are large cracks in both adjacent longitudinals but no others in the same longitudinal. Based on this set of inputs, the DSA system might recommend immediate repairs and also that the inspector check the structure beneath the overhead in the same area. As another example, if the inspector observes minor pitting over a small area, the DSA system may recommend only monitoring in future inspections.

The above examples represent two extremes. The real use of the DSA system is for the questionable cases in the middle. What if a single 3 inch crack is observed in the weld of a transverse frame bracket? Should this be a cause of concern or not? These are the types of questions the DSA system could help answer.

Although it will take a good deal of effort to develop the DSA system, it should repay this effort by assisting all inspectors to make reasoned judgements about the severity of defects they observe. The level of professionalism of inspectors will be enhanced by such a tool as well. It is always better to start with an expert's advice before making a decision.

8 SYSTEM OVERVIEW

Based upon the needs identified, performance requirements have been specified for an inspection data management system based upon a pen-based computer as an on-site data collection device, a notebook computer as a supporting unit which could be carried on-board the vessel to be inspected, and peripheral equipment connected to and controlled by the notebook computer.

8.1 The Marine Inspection Computer System

The computer system will consist of two units, a mobile unit and an desktop unit. The mobile unit will be a pen-based computer which an inspector can carry during the inspection of a vessel. Its primary purpose will be the implementation of the automated electronic version of the inspection booklet.

The desktop unit will expand the capabilities of the mobile unit, providing desktop personal computer capabilities onboard the vessel being inspected. The desktop unit will include a floppy disk drive and a hard disk drive and will support a portable printer and an external CD-ROM unit. Battery chargers and power supplies will also be included in the package.

8.2 Implementation of the Electronic Inspection Booklet

The electronic inspection booklet will be an enhanced electronic replacement for the present CG-840 series inspection booklets.

Using vessel information uploaded from the Marine Safety database, software in the home-office computer system will format a vessel-specific electronic version of the inspection booklet and load it into the inspector's computer. This interface software must be developed. During a vessel's initial inspection for certification, the inspector will use the full version of the electronic inspection booklet and chose those entries which apply. During subsequent inspections, queries which were tagged as "not applicable" to that vessel during the initial inspection will not appear. The basic information for the electronic inspection booklet is the same as provided in the current written booklets.

During the inspection, the software will prompt the inspector for only those entries which pertain to the particular vessel. The screen prompts will serve several functions, just as the present inspection book entries do: memory-jogging, for reminding inspectors to check certain items; counting, for tallying up items such as floatation devices, liferafts, etc.; and entry of information about location and details of deficiencies.

Inspectors' responses to the screen prompts may include simply checking a box to confirm that an item has been inspected, picking a menu choice from several options, or entering simple textual responses to prompts by printing directly on the screen. The handwriting recognition capability of the pen-based computer will be used to convert printing to computer text.

The system will also allow entry and storage of textual notes or simple sketches which are not direct responses to prompts. These will be saved for later incorporation into the inspection diary. Support for a digital camera will be included, and digital photographs of deficiencies taken during the inspection will be stored for inclusion in the inspection record or for local office use in support of repair authorization and reinspection.

After the inspection is complete, that information which will become part of the permanent inspection record will be formatted and stored in an inspection record file which will be downloaded directly into the Marine Safety database. Alternatively, an interface software program could be written for use on the home-based computer which accepts information from the inspector's computer and formats it for the MSN.

On-line help available from within the electronic inspection booklet will include access to the text and illustrations of the most frequently consulted reference and regulatory materials and policy documents. Additional reference sources too large to be held in the memory of the pen-computer will available on board in large capacity storage devices such as CD Roms on the notebook computer base unit.

When possible, graphical guidance materials such as general arrangement and system plans of the vessel will be available for display on the screen.

8.3 Post-Inspection Documentation

The mobile unit of the system will dock with the desktop unit for completion of the inspection documentation. The inspection diary will be prepared by the inspector using standard word-processing software, and any textual or graphical notes or digital photographs made during the inspection and stored in the mobile module will be available for incorporation into the diary. Additional sketches may be produced during the diary preparation.

The inspector will prepare worklists, deficiency reports (CG-835) and other necessary documents on board the vessel by completing template files stored in the memory of the system and printed on a portable printer connected to the notebook computer base unit. These template files will be prefilled with data stored in the software, such as the vessel's name, documentation number. owner's name, etc.

8.4 Transfer of Inspection Records

The inspection computer system (specifically, the notebook computer base unit) will connect to the Marine Safety database and will download to the database the inspection record file (the product of the electronic inspection book) and related data files such as the inspection diary, worklists, and CG-835 forms issued at the completion of the inspection. These support files will be available over the database system as external files linked to the vessel's record in the same manner that narrative supplements are now linked to vessel files on the MSIS.

Provision will also be made for certain information recorded by the inspector but not intended for inclusion in the official inspection record to be retained at the local office but not downloaded. Such information, in the form of text, sketches or digital photographs might include data to support repair authorization decisions made by the OCMI or CID and reinspection of repairs by other inspectors.

Inspection Information Flow

At the office

The Marine Safety database office workstation would be used to load the following files into the hard disk drive of the inspector's notebook computer:

The notebook version of the electronic inspection booklet software assembles the data collected by one or more pen-based on-site data collection computers into the final inspection record, and provides access to the full CD-ROM version of the reference database.

A vessel information file similar to the present MIPIP

Records of the vessel's most recent inspection, including the inspection booklet, inspection diary, CG-835 forms, worklists.

Records of the vessel's structural history, repair records, etc.

Copies of important correspondence such as waivers.

Records of inspections previous to the most recent inspection, at the inspector's discretion.

The inspector would select CD-ROMs containing references that are expected to be needed.

The following files would be loaded from the office workstation into the memory of the pen-based computer (into each one if this is a multiple-inspector job):

The pen-based version of the electronic inspection booklet software, which manages the on-site inspection data collection and provides access to the reference materials contained in the pen-based computer's memory.

A file containing the text and graphics of all high usage reference materials. This information serves as the database for the electronic inspection book's context-sensitive help capability.

In cases where multiple inspections of different types or inspection of different classes of vessels are conducted on the same trip, different versions of the pen-based inspection booklet software can be stored in the notebook computer's hard disk drive and loaded into the pen-based computer when needed.

Aboard the vessel

The inspectors conduct the inspection, carrying pen-based computers with them. The electronic inspection booklet software provides inspection guidance, prompts for responses, and provides access to the full text of the limited reference database of the pen-based computer, and provides and saves reminders of citations from the full database for later inquiry if necessary. The computer also records comments, sketches, and digital photographs, if desired to be included in the diary or for internal use in the inspection office.

After the inspection, inspectors meet and load their inspection records into the notebook computer. The electronic inspection book program in the notebook computer merges the records and creates the completed electronic inspection record. One inspector then writes the inspection diary using word-processing software in the notebook computer. Template forms such as the CG-835 deficiency report, pre-loaded with vessel information, are completed and may be printed out on board with a portable printer.

At the office

The official records of the inspection, which are the inspection data file created by the electronic inspection book software, the inspection diary, and information from any official forms issued to the vessel owner, are loaded into the office workstation and are made accessible over the Marine Safety database in interim form. Additional support files such as inspection worklists are also downloaded and attached to the vessel's inspection record as supplements.

After editing and administrative review, the inspection records in the Marine Safety database are validated and become official and permanent.

9 CONCLUSIONS

This report recommends fundamental changes in the way U.S. Coast Guard marine inspectors conduct and document vessel inspections, and in the way the Coast Guard keeps records of those inspections. The recommended changes are not a response to any present inadequacies or deficiencies in the performance of inspections. Rather, this is an attempt to improve the efficiency of inspectors by exploiting current data management technology. Most of the recommendations for improvements in inspection data management in this report result directly from suggestions made by a representative cross-section of working inspectors and administrative personnel.

9.1 The Computerized Inspection System

The events which led to the initiation of this project and the field survey phase of the project identified a number of areas in which inspection data management could be improved. These are:

Elimination of transcription, copying, and re-typing of inspection data.

Better access to graphical and textual reference and regulatory materials.

Direct transfer of inspection records to the marine safety database.

Availability of a computer on board the inspected vessel for word-processing, form generation, and other tasks.

Access to and management of an expanded amount of vessel information, including plans, and past inspection records.

The inspection data management system recommended in this report to meet the needs identified above is based upon standard, readily available, portable, general purpose computers. These computers include hand-carried pen-based units and keyboard-based portable notebook computers. Software includes both custom-developed mission-specific applications and standard commercially available products.

9.2 Hardware Development Requirements

The results of the NDI Survey (Part 3 of this report) indicate that hardware to fulfill all of the performance requirements presented in Part 2 is either presently available on the open market or is presently under development and is expected to become available in 1993.

The pen-computer market is rapidly evolving. A number of manufacturers in addition to those referred to in Part 3 expect to release pen-based computers within the next year, and improvements in processing power and memory capacity are scheduled for many of those already available. In particular, a number of palm-size pen-computers with similar capabilities to the most advanced full-size pen-computers are expected to be announced or released in the near future. The capacity of solid state memory cards, which add greatly to the portability and shock-resistance of pen-based computers, is expected to double from 10MB per card to 20MB by the end of 1992 and again to 40 MB per card by the end of 1993.

Only one principal hardware requirement is not met by presently available palm-size equipment. Palm-size pen based computers which can use the Pen-Point™ and Windows™ operating environments (which require 80386 or higher level processors) are not presently available. Processor upgrades for existing units and releases of new equipment with advanced processors which will meet this need are expected within one year. A number of full-size pen-computers are already available with 80386 or higher level processors.

9.3 Software Development Requirements

The primary software of the inspection system, the computer implementation of the inspection booklets, must be developed as a custom application. One component which must be developed is the inspection book program which will run on the on-site pen computer. This program will prompt the inspector for input, provide reminders, record responses to prompts, and record sketches and comments. This program will also provide access to that part of the reference database which will be resident in the on-site machine.

A similar program, which must also be developed, will run on the on-board notebook computer. This program will merge inspection data files from multiple on-site computers into one inspection file which will become part of the final inspection record. It will also provide access to the rest of the reference database, which will be resident in high-capacity storage devices connected to the on-board computer.

Part 3 of this report (NDI Survey) lists a number of application development packages which appear to be suited to development of such an application. Application development packages are examples of Computer-Aided Software Engineering (CASE), which allow custom programs to be developed by a menu-driven process which assembles pre-written subroutines, eliminating the need for actual programming. A pilot project should evaluate the specific suitability of these application development packages to the development of inspection software.

9.4 The Marine Safety Database

Included in Part 1 are recommendations that an increased volume of past inspection records be kept in the marine safety database. Such a change will require an increase in data storage capacity per vessel file in the marine safety database.

The inspection system will generate a file of inspection data for direct downloading to the marine safety database via a home-office workstation. This transfer will be effected by loading the inspection data files onto the removable hard drive of the on-board notebook computer, then removing the hard drive from the connector attached to the notebook computer and inserting it into a similar connector in an office workstation for the marine safety database.

The notebook computer can use the DOS and Windows™ file format which is standard on IBM-compatible desktop PCs. Presently available removable hard disk drives use the Integrated Drive Environment (IDE) drive control format. Any database file format differences between the inspection system and the marine safety database can be handled by the use of a conversion program in the home-office workstation. An IDE drive controller will be required in the office workstation to operate the removable hard drive unit.

10 RECOMMENDATIONS

10.1 On-site Computer

This report recommends that inspectors be provided with a pen-based computer for use while conducting inspections. This computer will implement an electronic adaptation of the particular CG-840 series inspection booklet appropriate to the inspection being conducted. The computer will prompt the inspector for responses to standard entries, and will allow entry of sketches and textual comments. The program will store the entered data in a database for use with the on-site computer, the on-board computer, and a home-office computer which prepares a record of the inspection for storage on the MSN.

The on-site computer will also provide for searching and display of reference and regulatory materials which are frequently used by inspectors.

10.2 On-Board Computer

A keyboard-based notebook-type portable computer, carried on board the vessel to be inspected, but not carried by inspectors while actually conducting an inspection, is recommended as an on-board base station. Data collected by the on-site computer (or more than one on-site computers in the case of inspections conducted by more than one inspector) will be merged by a program in the on-board computer. The on-board computer, in addition, will provide access to a more extensive database of reference and regulatory materials than can be accommodated by the on-site computers, and will be used for word-processing tasks such as filling out and printing forms and creating the inspection diary. The software will allow sketches prepared on the on-site computer and digitally stored photographs to be included in the diary.

The on-board computer will have an internal hard drive and floppy drive, and will connect to an external removable hard drive and to a CD-ROM unit.

The collected inspection data will be stored on the removable hard-disk drive of the on-board computer. The removable drive will allow the records of the inspection to be transferred from the on-board computer to a desktop workstation connected to the marine safety database. The home-office workstation will provide any necessary format conversion between the inspection system and the MSN.

10.3 Inspection Records

It is recommended that the digitally stored inspection record file in the marine safety database (which may also be stored for back-up purposes at the inspection office) be designated as the official record of the inspection. Paper copies of inspection records would no longer be kept.

Computerized storage of information will allow a greater amount of information about each vessel (including plans) and more detailed records of past inspections to be kept and made available to inspectors. Most of the vessel information and past inspection records will be available to users of the marine safety database at locations other than the vessel's port of registry.

10.4 Pilot Project

It is recommended that a pilot project be conducted to test the concept of electronic inspection data management and to evaluate the strategies proposed in this report. This project should be limited in scope with respect to the types of inspections covered and in the extent of the custom-developed applications. This will allow the project to be implemented quickly and with moderate expense. However, within the limited scope, the project should include a wide range of hardware and existing application software and include as many inspectors as possible.

10.4.1 Objectives of the Pilot Project

The objectives of the pilot project are as follows:

To evaluate the level of effort which would be required to develop the software for a full-scale implementation of a computerized inspection system.

To compare the suitability of various application development software packages for developing marine inspection software.

To allow inspectors to evaluate the concept of computerized inspection data management by actually using a working system.

To compare the PenWindows™ and PenPoint™ pen-computer operating environments.

To compare, in a realistic marine inspection environment, various items of hardware which, from their specifications, appear to be equally suitable.

To determine whether palm-size, on-site, pen-based computers are preferable to full-size units. A definite choice is not necessary here. The possibility that one type of pen-computer might be best in one group of situations while the other type might be favored in other situations should not be discounted.

10.4.2 Scope and Implementation of the Pilot Project

The pilot project should include two distinct phases. The first phase will be a development effort in which the hardware is procured, commercially available application programs are installed and configured for the task, and the custom software required to implement the electronic inspection book program is developed. The software development for the pilot project should be used as an opportunity to evaluate the suitability of various application development packages for developing software for a full-scale system, and for comparing the PenWindows™ and PenPoint™ environments from a software development viewpoint.

The input of a small group of experienced inspectors will be necessary in the development of the electronic version of the inspection booklet. These inspectors should be consulted about detailed inspection procedures, the types of data which must be recorded, the need for memory-joggers, and the reference materials which must be made available on the system. The marine inspection reference and regulatory material database developed by LCDR Eric Nicolaus, which he calls "The Inspector's Assistant", may be of value in developing the database interface between the inspection booklet and the reference materials which are to be linked to it.

Simulated inspections, conducted by working inspectors, may be useful during the software development phase.

The second phase of the pilot project will be actual testing of the hardware and software, as well as of the concept of computer-assisted marine inspection, in the field, by working inspectors.

It is recommended that the pilot project concentrate on implementation of one inspection booklet, preferably CG-840S (Tankship Hull Inspection Book). The tankship hull inspection involves the most severe environmental exposure for a computer system and imposes the most difficulties on the inspectors in terms of restriction of their mobility by the equipment they carry. This type inspection involves a wide variety of shipboard environments and lighting conditions from on deck to machinery spaces to cargo tanks. In addition, reference material requirements for this inspection are considerable, so this feature of the inspection system could be evaluated. Since many tankship hull inspections are conducted by more than one inspector, using this type of inspection in the pilot project will provide an opportunity to develop and evaluate programs and procedures for merging data from more than one pen-computer into a single inspection record.

The pilot project should make available on the on-site computer as much of the Category 1 reference materials as possible. Category 1 reference materials are listed in section 3.4 of the Functional Description (Part 2 of this Report).

The pilot project should involve at least several inspectors from each of several inspection offices chosen to provide the widest variety of conditions including extreme hot and cold climates, overseas travel, vessels inspected both in drydock and afloat, inspections involving multiple inspectors, and inspections of Critical Areas Inspection Plan (CAIP) and non-CAIP vessels.

The software development phase of the pilot program should produce a single set of custom-developed marine inspection application programs. However, the testing phase should employ the widest possible variety of functionally equivalent pen-based on-site computers capable of running those applications. On-site computers of various sizes and weights should be used, and, if possible, each inspector should have the opportunity to use more than one type of computer.

Inspectors having a range of experience levels should be chosen to test the system during actual inspections, and these inspectors should be given ample opportunity to become familiar with and to gain experience with the concepts, the hardware, and the software before they complete their evaluations.

PART 2 - FUNCTIONAL DESCRIPTION

This part provides a functional description of the hardware and software needed to implement the inspection system. It is intended to stand alone as a system description. The reasons why various items have been specified is not included here. Part 1 of this report provides the background on the need for these requirements. DOD-STD-7935A was used as a format for the functional description that follows. Section 6, Security, is not included as MAR was not tasked with writing this section.

1 GENERAL

1.1 Purpose of the Functional Description

This Functional Description for an on-board and on-site marine inspection computer system (referred to herein as the Inspection System) is written to provide:

a. The system requirements to be satisfied which will serve as a basis for mutual understanding between the user and the developer.

b. Information on performance requirements, preliminary design considerations, and user impacts.

c. A basis for development of a program for evaluation of computerized inspection data management.

1.2 Project References

MAR, Incorporated was tasked with developing this functional description under Contract DTCG39-91-D-E33A21, Delivery Order DTCG39-92-F-E00184. The statement of work is entitled "On-Site Marine Inspection Data Capture."

1.3 Terms and Abbreviations

On-site computer - refers to the computer used by the inspector while making inspection rounds on the ship.

On-board computer - refers to the computer used on board ship in a stateroom or other climate controlled space. The on-board computer is used on a desk or table with the inspector seated.

Marine Safety Network (MSN) - refers to the marine safety database and computer network linking marine safety offices. This system is being developed in parallel with the on-board and on-site computer systems.

2 SYSTEM SUMMARY

2.1 Background

The purpose of the Marine Inspection Data Capture System is to streamline the management of collected data and reference information used by Coast Guard marine inspectors during vessel inspections. The data flow to be managed by this system will begin and end at the Marine Safety Network (MSN). This project is concurrent with the development of the Marine Safety Network, which will be the successor to the Coast Guard's present Marine Safety Information System (MSIS).

2.2 Objectives

The objectives of the Inspection System are to increase the efficiency and effectiveness of Coast Guard vessel inspectors and to reduce the time between inspections and information availability on the MSN. The Inspection System will eliminate needless steps of transcription, copying, and re-typing of inspection information between the inspection site and inclusion in the official permanent record of the inspection. The current, hand-written inspection books will be replaced by electronic equivalents in most cases.

In addition, the system will provide better management of the large amount of reference information needed by the inspectors. Limited knowledge-based software may also be incorporated into the system. The system will utilize nondevelopmental hardware and software to the greatest extent possible.

2.3 Existing Methods and Procedures

The inspector obtains a printout of the Marine Inspection Pre-Inspection Package (MIPIP or "PIP") from the Marine Safety Information System (MSIS) and assembles a package of reference materials applicable to the inspection before leaving the office.

The primary data collection device presently used by inspectors is the pad and pencil. Paper inspection booklets (CG-840 series) are filled out during or after the inspection, and the inspector prepares a diary of the inspection. If deficiencies are found, form CG-835 is issued. These documents are the official permanent record of the inspection, and are retained in the inspection office at the vessel's port of registry. The first draft of the diary, prepared on-board the inspected vessel or soon after the inspection, is usually handwritten, with the permanent smooth copy produced at the office using a word-processor. Some inspectors use laptop

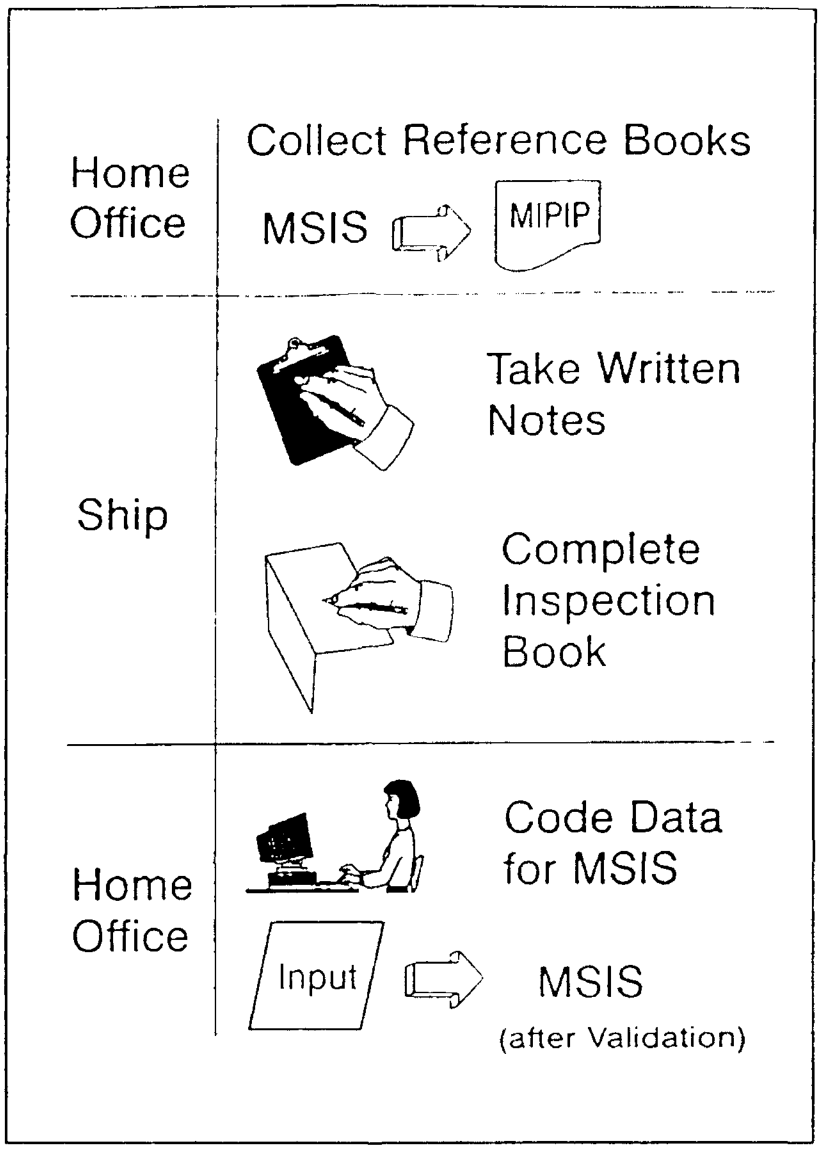


Figure 1 Diagram of Existing Data Management

computers for first-draft diary preparation. A brief summary of important inspection data based upon the information in the inspection booklets, the diary, and the CG-835 form is entered into the MSIS database after encoding. Following administrative validation, the information in the MSIS becomes available to all MSIS users. Figure 1 shows this simple data flow.

Delays are inherent in the present system from the time an inspection is conducted until the information becomes available on MSIS. These delays arise from several causes. Inspectors' workloads and the need to coordinate inspectors' schedules with vessel in-port availability often prevent inspectors from making MSIS entries immediately after an inspection is completed. In many offices, the number of working terminals available to inspectors is limited. Many MSIS entries are multi-character alphanumeric codes; any codes slightly out of the ordinary must be looked up by inspectors in a reference book as they enter their inspection data.

For example, when making an MSIS entry for an inspection, the inspector first completes the Marine Inspection Activity Report (MIAR), which includes codes for Certificate Action (Deactivate = DAC, Invalidate = INV, etc.) and Inspection Type (Annual = ANN, Deficiency Check = DEF, etc.).

Next, the Deficiency Report (MIDR), Special Notes (MISN), Certificate Amendments (MICA), and Inspection Status Details (MISD) categories are entered. For each deficiency noted, a separate MIDR must be completed, each of which contains 6 codes. Examples of these codes are: (1) System (Main Boilers = BM, Electrical = ES, Hull = HS, etc.); (2) Subsystem (Air Casings = BL01, Transformers = ES17, Watertight Doors = HS14, etc.); (3) Location (Cargo Tanks = CT, Midbody Area = MB, etc.); (4) Type (Buckled = BKD, Joint Wasted = JWS, etc.); (5) Cause (Improper Application = APP, Overload, Weather = OHW, etc.); (6) Q Number (15 = 160.018 Liferafts for Merchant Vessels, 5 = 160.000 Lifesaving Apparatus, etc.)

In addition, administrative review of all entries is required before they are validated and become available system-wide. Scheduling necessities and terminal availability can also delay the review process. During the period between inspection and validation of the MSIS entries, the ship may be inspected in another inspection zone without the inspector having access to detailed information about the previous inspection.

Inspectors now carry a car load of books containing reference and regulatory materials and policy documents likely to be used during the inspection to the inspection site. For overseas inspections, the amount of references available is limited to those that can be carried on a plane.

2.4 Proposed Methods and Procedures

The proposed Inspection System is a computer-based system utilizing a hand-held, pen-based computer for on-site data collection and an on-board keyboard-based desktop notebook computer for text processing and access to high-capacity storage devices. A menu-driven, vessel-specific computer program running on the pen-based computer will replace the present inspection booklets. In addition to providing data recording, the program will offer on-line access to important reference materials. In association with the electronic version of the inspection booklet, the pen-computer will allow the inspector to record textual comments, sketches, and digital photographs for incorporation into the inspection diary or for other purposes. Figure 2 shows the data flow for the proposed Inspection System.

A laptop computer, which will be carried on board the vessel being inspected, but which will not be hand-carried to the actual inspection site, will provide text processing for diary preparation and for filling out necessary inspection forms and for accessing a larger reference database. The pen-based computer will interface with this laptop computer to transfer inspection files back and forth.

Reference materials, including vessel plans, will be available on a removable hard disk drive connected to the laptop computer for on-board reference. Selected vessel plans will also be available on the pen-based computer. If required, access to larger reference databases will be available by the connection of an external CD-ROM drive.

When the inspector returns to the inspection office, the removable hard disk drive, containing all of the inspection data, will be inserted into a desktop computer functioning as a terminal for the MSN, and the permanent record of the inspection will be downloaded into the MSN database. An interface program may be used to reformat the data before or during download.

2.4.1 Summary of Improvements

The new system will give inspectors access to more information about past inspections regardless of the location of those inspections.

Access to both textual and graphical reference materials will be greatly improved, not only in terms of the amount of material directly accessible on-site and on-board, but also in terms of the speed of access and the accuracy of the searching process. The comprehensiveness of a search for the reference, regulatory, and policy guidance reference materials applicable to a given situation will no longer be dependent upon the accuracy of the inspector's memory.

Multiple steps of transcription, copying, and re-typing of inspection data will be eliminated between the actual collection of the data on-site and the final permanent records of the inspection including coding the information for the Marine Safety database. Once on-site data is entered into the

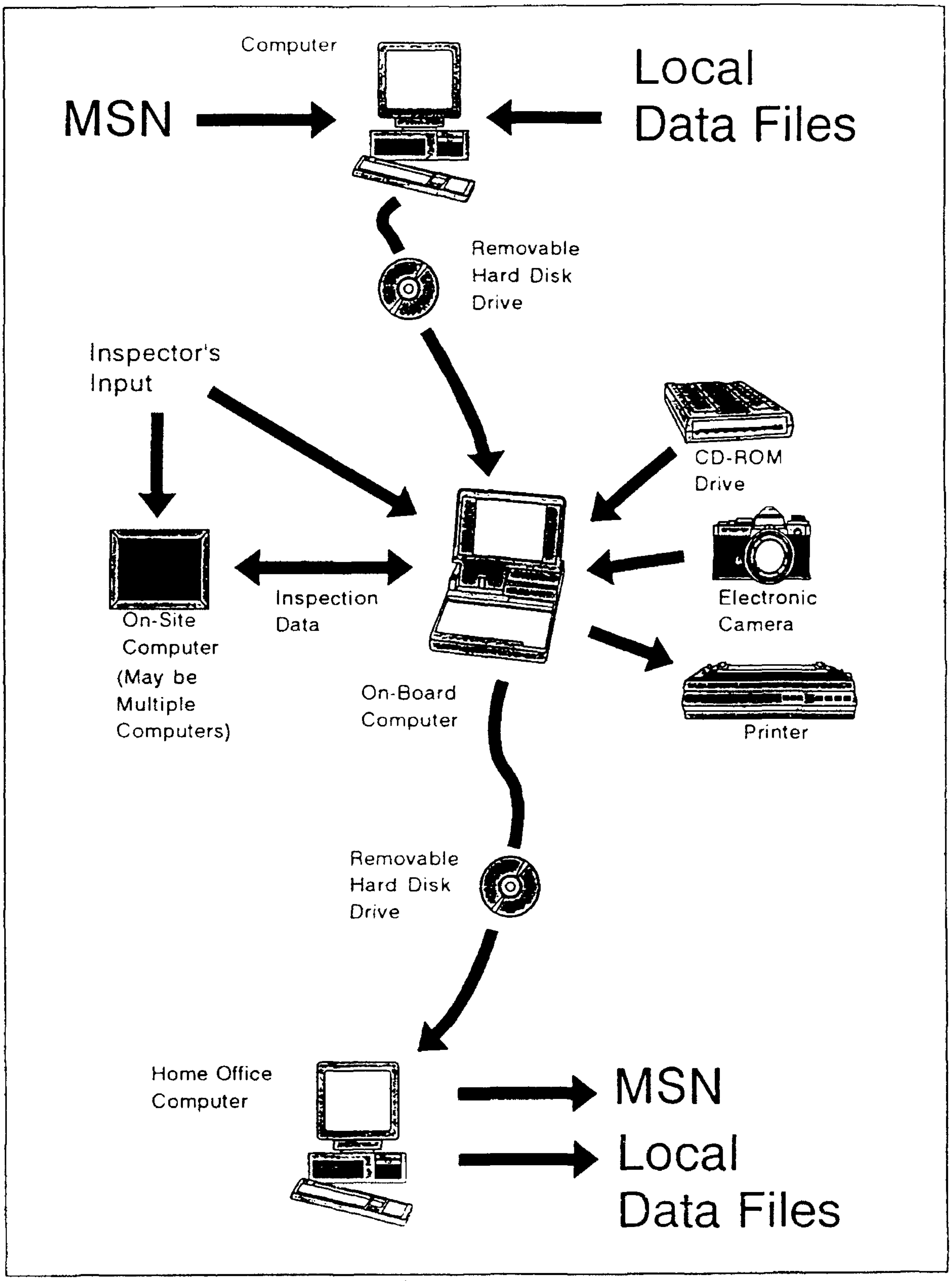


Figure 2 Proposed Inspection System

on-site pen-based computer, all data manipulation other than editing will be eliminated.

Functional improvements will include the availability of graphical reference materials to the inspector on-site and the availability of graphical inspection data such as on-scene sketches or digitally stored photographs in a form which can be incorporated directly into the inspection record.

2.4.2 Summary of Impacts

Impacts will include initial training of users and maintenance personnel, the establishment of maintenance responsibilities in inspection offices, and ongoing training of new users and maintenance personnel. A continuing program to provide comprehensive and up to date reference material will be required.

2.4.2.1 User Organizational Impacts

a. Training of Users Inspectors and administrative personnel will have to be trained in the use of the new system. This training is expected to take from two days to one week per person. The training of the initial users will need to be done either at a central location or by a travelling training unit. It is anticipated that, after the system is operational and the initial training of the first users is completed, training of new users can be accomplished in-house at each inspection office.

In addition to formal training time, it is expected that new users will function at less than full efficiency during their first few weeks using the new system.

b. Maintenance and Training of Maintenance Personnel The inspection computer system will replace an essentially manual system. Therefore, maintenance of portable computer hardware and software will be a new function for many inspection offices.

At least one person in each office will have to be given responsibility for physical maintenance of the hardware, replacement of defective units, acquisition of new and replacement equipment, and inventory control. Additional responsibilities will include system software installation, maintenance, and upgrading. In a busy office (15 or more inspectors) these responsibilities would be expected to translate into a half-time job for one person. In very busy offices, the proposed system will require that one person be occupied full-time in computer system support. Since it is anticipated that primarily off-the-shelf hardware will be utilized, no electronic skills will be required.

Training for maintenance personnel will take approximately one week per person and at least two persons from each inspection location will need this training. While training will most likely be done in large groups when the system first becomes operational, a continuing centralized training capability for maintenance personnel will have to be maintained.

2.4.2.2 User Operational Impacts

An inspection computer system will fundamentally change the way inspectors perform their duties. Most of the information which inspectors need will be available through the system, and virtually all of the inspection data they generate will be entered into and processed by the system.

a. Quantity of Background Information Available

The computer system will make the reference, regulatory, and policy guidance materials which inspectors use available to them on-site. Inspectors are currently only able to carry a few of the most frequently referenced documents with them in hard-copy form. In addition, the computer system will provide enhanced access to these materials by linking them to appropriate sections of the electronic inspection booklet, and providing key-word searching capabilities. Maintenance of the reference database to keep it current is a significant new task imposed by adoption of the Inspection System.

Additional vessel information will also be available. More detailed records of previous inspections will be available on the computer system. This information will allow inspectors to budget their inspection time more effectively, concentrating on areas in which deficiencies are more likely to occur based upon past experience.

b. Quantity of Inspection Data Handled

The computerized inspection system will allow a much larger amount of inspection data to be handled efficiently than the present system allows. Besides the inspectors' responses to the electronic inspection book program, sketches and digital photographs can be collected as needed and will be available for direct incorporation into the official inspection record. Digital storage of expanded inspection documentation will provide inspectors with quick and efficient access to the larger amount of information about past inspections which they would like.

2.4.2.3 User Development Impacts

Because this is a major change in the way inspectors now perform their jobs, a pilot program is recommended before full scale implementation. This pilot program should provide data to improve the final implementation.

All hardware recommended for this system is available off-the-shelf now or will be in the next year. Most of the software is also available. A few of the major programs will need to be developed for this application. The most important of these is the program which implements the electronic inspection book. This program must maintain and update the on-site computer inspection database based on inputs from the inspector during the inspection. Also required are programs for coding and transfer of data to and from the MSN. A program to assist with the context sensitive help function may need some programming effort but software for this type of function is available off-the-shelf. Very little modification should be needed. The complex Computer-Aided Drafting (CAD) and picture manipulation programs are now available for pen-based computers.

2.5 Assumptions and Constraints

The Marine Safety Network is being developed at the same time as this work. The database requirements for the MSN have not been finalized. While this functional description assumes that all desired data storage will be incorporated, this may not be the case once the MSN database is finalized. Thus, some information from the MSN may not be available for the inspector's computer system.

It is also assumed that inspectors will have access to data on the MSN prior to validation. Validation imposes a significant delay. A separate file of inspection data awaiting validation may be needed on the MSN for this purpose. This feature may not be incorporated on the MSN.

3 DETAILED CHARACTERISTICS

3.1 Specific Performance Requirements

a. Office Terminal to MSN

The office terminal for the Marine Safety Network provides the link between MSN and the Inspection System. Though not a part of this study, the functions this computer must perform are summarized below. A standard desktop PC is assumed as the terminal.

- From the MSN the terminal must retrieve the vessel specific inspection books, past inspection data, an equivalent to the MIPIP, waiver information, and ship inspection status.

- Files may also be retrieved from local storage as required. The split between what is stored on MSN and what is stored at the inspection office is the subject of other studies.

- The terminal must convert data between the format used on MSN and the format used on the Inspection System. Conversion is required in both directions.

- The terminal must interface with a removable hard disk drive used to transfer data between the terminal and the on-board computer. Data will be transferred to the on-board computer and inspection results will be delivered using this hard drive. Data for multiple ship inspections may be included on the hard drive. This allows the inspector to visit many ships before returning to the home office. Multiple hard drives may be used to cover all data needed for a large number of inspections.

b. On-Board Computer

A laptop or notebook computer will be used as the base station for inspections on the ship. This computer must have the following performance features:

- Input inspection database from the office terminal via a removable hard disk drive and output inspection results to the office terminal in the same manner.

- A high level word processing program must be included to allow the inspector to prepare the inspection diary, add comments, and complete forms.

- A small reference database containing the most frequently used references (Category 1 in 3.4) must be included along with a search program permitting context sensitive help to be implemented.

- Standard forms must be provided as templates for use with the word processor software.

- Applications to download and upload data from the on-site, pen-based computer are required. These programs must have the ability to merge data from multiple on-site computers into a common database.

- CD-ROM query utilities must be included for all CD-ROMs used.

- A printer driver for the on-board printer is needed.

- A program to input and process electronic photographs is required if this feature is implemented.

- Expert system software can be added as required.

c. <u>On-Site Computer</u>

One or more pen-based computers will be used by inspectors as they make their inspection rounds. An on-site computer is needed for each inspector in the inspection party but only one on-board computer is required. All on-site computers download the inspection database for the current ship from the on-board computer and return information to this computer. The on-site computer must have the following performance features:

- Utilities to download and upload files to the on-board computer must be included.

- A small reference database containing the most frequently used references (Category 1 in 3.4) must be included along with a search program permitting context sensitive help to be implemented.

- The principal program on the on-site computer will be an application to implement the electronic inspection book. This will take data from the inspection database and present it to the inspector for additional input or correction. The inspection database will then be updated.

- A Computer Aided Design (CAD) program is required which allows the inspector to input sketches, display drawings, and overlay drawings with notes. This program must be specifically designed for use with a pen-based computer.

3.1.1 Accuracy and Validity

The applications proposed are mostly database management and word processing type applications. The system must accurately retain and transfer data but a high level of math processing is not required. The CAD programs do require a good deal of math processing but usually allow the user to set the accuracy required.

3.1.2 Timing

Response time is not a critical issue. Most current programs respond without significant perceptible delay. Application programs that must be developed for this system should exhibit this feature, as well.

Download and upload of information to MSN is done at the home office using data delivered from the Inspection System on a removable hard disk. The data will be delayed until the inspectors return to the home office. The size of inspection data files are not large (100 KB or less) so transfer time to MSN should be short. The ability of MSN to respond to data requests is beyond the scope of this study.

3.1.3 Capacity Limits

Details on the inspection database and storage requirements for reference materials are discussed in more detail in 3.4. The minimum installed storage capacity requirements are summarized below. Many of the program sizes have been estimated based on comparisons to comparable PC-DOS applications.

a. On-Board Computer (All storage on internal hard drive unless otherwise noted)

- Storage for Category 1 reference materials - 8 MB
- Storage for Category 2 reference materials on CD-ROM - 77 MB
- Storage for Category 3 reference materials on CD-ROM - 58 MB
- Search program for Category 1 references - 300 KB
- Active inspection database - 100 KB (Additional databases can be stored on the removable hard drive)

- Word Processor - 5 MB
- Standard Forms - 300 KB
- Download and upload utilities - 50 KB
- Operating system - 2.5 MB
- Drawing files - 2 MB
- Text files - 2 MB
- CD-ROM query programs - 300 KB
- Printer driver - 20 KB
- Program for electronic photograph processing - 1 MB

The minimum total internal storage is 25 MB. In addition, the removable hard drive should hold 20 MB minimum to permit access to multiple data files, text, drawings and photographs for multiple inspections. A larger internal hard drive could be used to store some or all of the Category 2 and 3 reference material.

b. <u>On-Site Computer</u> (All storage is on one or two Personal Computer Memory Card International Association (PCMCIA) cards)

- Storage for Category 1 reference materials - 8 MB
- Search program for Category 1 references - 300 KB
- Active inspection database - 100 KB (Additional databases can be stored on the removable hard drive)
- Download and upload utilities - 50 KB
- Electronic inspection book application program - 1 MB
- Operating system - 2.5 MB
- CAD Program - 4 MB
- Drawing files - 2 MB

The total memory required is 20 MB, minimum.

3.2 Functional Area System Functions

The Inspection System functions have been subdivided into five steps discussed below. The steps involving the office computer are interface functions with MSN and are included for a better understanding of the on-board and on-site functions.

a. <u>Office Computer Terminal</u>

A computer operator, who may be the inspector, retrieves information from the MSN. This includes database information, and attached text, drawing, and photo files. The computer formats the database information, as needed, into the format of the Inspection System database for use on the on-board and on-site computers.

Any locally stored inspection information is also retrieved and formatted, if necessary. All of the information is then stored on the removable hard disk drive for the inspector to take to the job site. Multiple ships may be included on the hard drive.

b. <u>On-Board Computer</u>

The inspector(s) take the on-board computer and its associated hardware, including a printer, CD-ROM drive, removable hard drive, to the ship. Also taken to the ship are one or more pen-based, on-site computers, one for each inspector on the trip. CD-ROM(s) with reference materials are also taken along. On the ship, if not before, the inspector downloads the applicable inspection database and drawings to the on-site computer(s).

c. <u>On-Site Computer(s)</u>

One or more inspectors will use the on-site computers to collect inspection data using the electronic inspection book application on the computer. The CAD program installed may be called up for input of sketches or to review and annotate drawings of the ship or ship systems. The operating system should contain a simple word processor to allow the inspector to make notes for later reference.

The electronic inspection book shall have a context sensitive help capability allowing the inspector access to reference materials stored on the computer. The inspection book software should also maintain a listing of Category 2 and 3 reference materials which the inspector needs to consult but which are not available on the on-site computer. These must be available for display on the notebook computer for use in queries of the CD-ROM references.

d. On-Board Computer

At the end of the inspection, or daily during a large inspection, the updated database on the on-site computer(s) are transferred to the on-board computer. If necessary, data from more than one on-site computer will be merged to form a common database. The inspector's sketches and notes must also be transferred. A list of needed queries of Category 2 and 3 reference materials will also be transferred to the on-board notebook machine.

The inspector uses the on-board computer to type up an inspection diary and attach files to the inspection database. These files may include the diary and other text files, drawing and sketch files, and pictures taken with an electronic camera. When complete, this data will be stored on the removable hard drive.

A digital camera is an optional part of the inspection system. The camera should be self contained with internal storage for photographs. An interface between the computer and camera should be included with the camera as should picture processing software. The inspector can use this software to view and choose selected photographs for attachment to the inspection record.

As needed, the inspector can query the reference material stored in internal storage or on CD-ROMs. Ideally this will be done using memory resident software which can be used while in the word processor. The on-board printer can be used to obtain hardcopy of selected reference material.

The inspector will also use the word processing software, together with form templates, to prepare and print necessary forms on board. Forms should be designed so that data from the inspection database is automatically merged into the form, limiting the amount of data entry the inspector must do.

If installed, the inspector can use expert system software on repair severity assessment to help decide about repair requirements.

e. Office Computer

Once the removable hard disk is returned to the home office, the data can be formatted and uploaded to the MSN or local storage. Reports on the inspection may also be printed for use by supervisory personnel at the home office.

3.3 Inputs and Outputs

The minimum database requirements for the Inspection System are included in section 3.4. The interface with MSN will be through the office computer terminal which can reformat data during transfer between the Inspection System and the MSN. Since the database on the MSN has not been finalized, the interface requirements can not be specified at this time.

An interface program is also required between the on-board and on-site computer. For the most part, the only requirement is to transfer files between the two machines. However, the on-board computer must have the ability to merge the inspection database information from multiple on-site computers into a common database on the on-board computer.

3.4 Data Base/Data Bank Characteristics

There are two principal databases on the on-site and on-board computers. The databases are the same on both machines. One database is the inspection database for the ship being inspected. The other is a database of reference material. These two databases are discussed below.

a. Inspection Database

This database will contain the following fields as a minimum. Alternatives may be used to implement the tag and link fields if the same functions are accomplished. Each record in the database will contain these fields. A discussion of the number of records required follows the field descriptions.

Fields	Discussion
Inspection Type	Corresponds to inspection book title. A set of individual databases, one for each inspection book, could be substituted leaving out this field. In either case this field would be on the office commuter or MSN only. Initial sort would produce a file of those items for the vessel being inspected. Thus, this field is not needed on the inspector's computer.
Part	Corresponds to the part of the inspection book. Some parts are applicable only to U.S. vessels, some to foreign, and some to both. This field would be used only for the initial sort of records for copying to

	the field computer and would be included only on the office computer.
Not Applicable Check	On the initial inspection, the entire inspection type data base would be downloaded to the inspector's computer and this field would be added. The inspector would check those records that are not applicable for the vessel for deletion from the vessel specific database. At the end of the initial inspection, a utility program would be run to delete these records from the file and also delete this field from all records, producing a database for use on all future inspections. It is better to use a field like this that the inspector has to check rather than rely on blank records as an indication that they are not applicable.
Major Category	Corresponds to the inspection book categories starting with capital letters, e.g., Emergency Equipment. This field is not essential to the workings of the database but is a useful category for sorting data.
Minor Category	Corresponds to the numbered inspection book categories, e.g., Emergency Lighting. This field is the primary selection field used by the inspector.
Sub Category	Corresponds to bulletized items in inspection book. Only those sub categories which require data entry need be included. Those without data requirements can be implemented as a help file using a pull down menu or automatic display when the item appears. Data required will be stored in miscellaneous field.
Location Fields (3)	Compartment Number or Deck. Three fields is a compromise number. Some records such as navigation equipment will be located in one location only. Others, like fire extinguishers, may be in many locations. The operating program must have the capability to duplicate a record in the database with additional blank location

fields for those categories with more than three locations. This can be done repetitively. Since each duplicate record repeats all the fields, more storage is required. Therefore, having a single location field should take up more storage on average. These fields are used if the inspector elects to display all minor and sub category fields for a single compartment. A search of all location fields would be made to find those that apply. This should provide more efficiency than repeatedly visiting compartments to collect data on different categories.

Tag Fields (2) — These fields are used for links to attached text, electronic photographs, or electronically generated sketches. These would be amplifying comments produced by the inspector. Again, two fields is a compromise. The operating program should have the ability to duplicate records requiring more than two tag fields.

Help Link Fields (2) — These fields associate the index record in the help file and the tickler list that corresponds to the minor category under consideration. The index record link can be to an index such as LCDR Eric Nicolaus's marine inspection reference database. The tickler list corresponds to the bullet items under each minor category that do not require data entry. The operating program should present the inspector with a choice of displaying these for every minor category displayed or only on demand. Context sensitive help can easily be implemented in this manner through a pull down menu.

Comment/Misc. — This field is used to hold data of various types associated with minor or sub categories requiring data entry. This field can hold such information as a name, license number, quantity on board, date, or yes/no. The operating program must be able to use the data in this field in an appropriate manner depending on the form type field in the database.

Form Type	This field is used by the operating program to display the appropriate form on the pen-based computer's screen. The type of information displayed is determined by the category. For example, if a date is required, a date box will be shown and the date will be stored in the Comment/Miscellaneous field. In the case of a category requiring a count of items, the Comment/Miscellaneous field can hold the current total. This total will be displayed on the form and updated by the inspector for each new location on the vessel. The major, minor, and sub category fields will be shown on every form. Location information will also be displayed automatically. Tag field information can be displayed on demand.
Item Completed Field	This field is a check field entered by the inspector when all information on a category has been completed. The operating program must have an option to display uncompleted items. This field is used to determine which have been completed.

The number of records in the inspection database will depend on the type of inspection book involved. Some inspection may require multiple databases. For example, a tankship inspection might also involve a machinery, hull or drydock inspection book. Tables 1, 2, and 3 below show the number of categories of information from selected versions of the current CG-840 series paper inspection booklets. Figure 3 shows how the categories are designated. The electronic inspection book is expected to have at least the same number of categories as the current inspection books. The minimum number of records in the database is the sum of the total number of minor and subcategory records that are applicable to the inspection being conducted. For example, in Table 1 for tankship inspections, a U.S. tanker carrying hazardous liquids would have records for all minor and subcategories in parts I, II, and IV. This totals to 302 records. Section 4.4 discusses database size further.

Part	PART I – U.S. TANK VESSELS ONLY
Major Category	A. LIFESAVING EQUIPMENT
	Lifeboats and Equipment
Minor Category	1. ☐ Lifeboats and life rafts stripped, cleaned and overhauled.
Sub Category	Last previous date *(If other than this inspection)* ________
Minor Category	2. ☐ Lifeboats and work boats
	• Hull and fittings
	• Tanks and fittings
	• Equipment and stowage
	• Cradles
	• Markings
	• Gripes
	• Compressed air cylinders
Minor Category	3. ☐ Life rafts
	• Launching instructions posted
	• Releasing gear
	• Structure and tanks
	• Equipment and stowage
	• Sea painter/cleat
Sub Category	• Date serviced ________
Sub Category	• Hydro release date ________
	• Weak link
	• Float free
	• Illumination
	• Markings
	• Capacities
Minor Category	4. ☐ Life floats
	• Equipment
	• Stowage
	• Markings

Figure 3 Example Inspection Book Page

Table 1 Tankship Hull Inspection Book

Tankship Hull Inspection Book								
Part	I		II		III		IV	
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	22	11	16		1	28	6	
B	6	9	7	1	4		3	
C	7	1	5		5		11	6
D	4		1	2	5		8	6
E	5		13		1		5	5
F	2		7	3	3		2	
G	13				3		12	2
H	2				3		5	1
I	5	4			1		6	6
J	8				1		4	2
K	8	2					3	1
L	11	3					6	2
M							3	1
N							3	
O							2	4
P							8	
Q							1	
Total	93	30	49	6	27	28	88	36

Note: Part I is U.S. Tank Vessels Only.
Part II is U.S. and Foreign (As applicable).
Part III is Foreign Tank Vessels Safety Examination Only.
Part IV is Vessels Carrying Hazardous Liquids (U.S. and Foreign).

Table 2 Foreign Vessel and Small Passenger Vessel Inspection Books

Foreign Vessel							Small Pass. Vessel	
Part	SOLAS 60		SOLAS 74		U.S. Reg.			
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	9	5	13	6			3	2
B	3		45				3	
C	45	15	17	4			5	31
D	5	5	10				5	48
E	3	1					7	48
F	5	10					9	20
G	5	1					2	
H					25	2	3	5
I							3	
J							4	1
K							9	5
L							13	3
TOTAL	75	37	85	12	25	2	66	163

SOLAS - United Nations Safety of Life at Sea Conventions

Table 3 Miscellaneous Inspection Books

Inspection Books								
Book	Barge		Hull		Machinery		Drydock	
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	5	11	22	13	1		22	15
B	7	52	8	10	9	131		
C	2		6	1	1			
D	1		4		2	50		
E	2		7		9			
F	3	3	2		11			
G	4	2	14		7			
H	3		3		1			
I	2	74	5	5	8			
J	3	12	11		7			
K	9		10	2	7	1		
L	11	15	8	2	5	3		
M	31	2	10	2				
N	12	6						
TOTAL	95	177	110	35	68	185	22	15

b. Reference and Regulatory Materials

Three categories of reference and regulatory materials, based on frequency of need, are apparent from analysis of the information requirement section of the survey questionnaires. This categorization is corroborated by analysis of LCDR Nicolaus's marine inspection reference material database.

Category 1 materials are those which were requested by virtually all questionnaire respondents, were mentioned frequently during interviews, and constitute 66% of the citations in LCDR Nicolaus's database.

Category 2 materials are those which were requested by a significant fraction of questionnaire respondents.

Category 3 materials are infrequently used, but are important in the rare situations when they are needed.

Category 1 includes:

Title 46, Code of Federal Regulations (CFR), Subchapters D, F, H, I, J, T

Category 2 includes:

Parts of Title 46, CFR, other than those in Category 1
Parts of Title 33, CFR
Title 49, CFR
USCG Navigation and Vessel Inspection Circulars (NVICs)
United Nations Safety of Life at Sea Conventions (SOLAS)
American Bureau of Shipping Rules for Building and Classing Steel Vessels
USCG Marine Safety Manual (MSM), Vol. II
USCG Marine Vessel Inspection (MVI) Policy Letters
Local Officer in Charge of Marine Inspection (OCMI) Policy and Inspection Guidance Memos
International Maritime Organization (IMO) Mobile Offshore Drilling Unit (MODU) Code

Category 3:

IMO Gas and Chemical Tanker Codes
USCG MSM Vols. III and IV.
IEEE Shipboard Electrical Code
American Boat and Yacht Council (ABYC) Standards and Recommended Practices
National Fire Protection Association (NFPA) Codes and Publications
ANSI/NFPA National Electrical Code (NEC)

Selected American Society for Testing and Materials
(ASTM) Specifications
Other ABS Rules

Tables 4, 5, and 6 quantify the storage requirements for the textual and graphical content of the documents in Categories 1, 2, and 3, respectively.

The total estimated number of bytes required to store Category 1 information, with the few graphical drawings which are incorporated into the text, is 8 megabytes. This is based upon one page of text requiring 3 kilobytes of storage, and a small graphical drawing, with incorporated text, requiring 50 kilobytes of storage in a common word processing tool.

Table 4 Category 1 Reference Materials

Text	Pgs	kbytes (pgs*3k)	pgs of graphics	kbytes (graphics*100k)	kbytes (total)
Tank Vessels	170	510	5	500	1000
Marine Engineering	230	690	25	2500	3200
Passenger Vessels	170	510	5	500	1000
Cargo & Misc. Vessels	160	480	5	500	1000
Electrical Engineering	70	210	5	500	700
Small Passenger Vessels	90	270	5	500	800
Total	890	2670	50	5000	7700

Table 5 Category 2 Reference Materials

Text	pgs	kbytes (pgs*3k)	pgs of graphics	kbytes (graphics* 100k)	kbytes (total)
Title 46 Code of Federal Regulations					
Procedures Applicable to the Public	70	210	5	500	710
Merchant Marine Officers and Seamen	120	360	5	500	860
Uninspected Vessels	20	60	5	500	560
Load Lines	90	270	5	500	770
Documentation and Measurement of Vessels	40	120	5	500	620
Mobile Offshore Drilling Units	60	180	5	500	680
Dangerous Cargoes	10	30	5	500	530
Certain Bulk Dangerous Cargoes	250	750	5	500	1,250
Equip., Const., & Material Specs and Approval	400	1,200	10	1,000	2,200
Nautical Schools	40	120	5	500	620
Subdivision and Stability	90	270	5	500	770
Ocean Research Vessels	100	300	5	500	800
Marine Occupational Safety and Health Standards	20	60	5	500	560
Title 33 Code of Federal Regulations					
Waivers of Nav. and Vessel Inspection Laws....	10	30	5	500	530
Navigation Rules	40	120	5	500	620
North Atlantic Passenger Routes	10	30	5	500	530
OCS Activities	30	90	5	500	590
Pollution	150	450	5	500	950
Port and Waterway Safety	130	390	5	500	890
Title 49 Code of Federal Regulations	1500	4,500	25	2,500	7,000
Title 33 Code of Federal Regulations (other parts)	2000	6,000	5	500	6,500
USCG NVICs:					
26 NVICs most commonly cited	1400	4200	75	7500	11,700
SOLAS Publications (48, 60, 74, 83)	550	1,650	5	500	2,150

Table 5 (continued) Category 2 Reference Materials

Text	pgs	kbytes (pgs*3k)	pgs of graphics	kbytes (graphics*100k)	kbytes (total)
American Bureau of Shipping Rules:					
Rules for Building & Classing Steel Vessels	5,280	15,837	140	13,900	33,040
USCG Marine Safety Manual Volume II	400	1,200	5	500	1,700
USCG NVI Policy Letters	300	900	0	0	900
Local OCMI Policy Instructions (estimated)	150	450	0	0	450
IMO Codes:					
Code for the Const. & Equip. of MODU	100	300	10	1,000	1,300
Total	13,360	40,080	365	36,500	76,580

Table 6 Category 3 Reference Materials

Text	pgs	kbytes (pgs*3k)	pgs of graphics	kbytes (graphics*100k)	kbytes (total)
Marine Safety Manual Volume III	130	390	5	500	890
Marine Safety Manual Volume IV	250	750	5	500	1,250
NFPA Codes and Publications	200	600	20	2,000	2,600
ASTM Specifications	230	690	25	2,500	3,190
National Electrical Code	1075	3,225	50	5,000	8,225
ABYC Standards	400	1,200	100	10,000	11,200
IEEE Code	180	540	10	1,000	1,540
USCG NVICs:					
127 NVICs less commonly cited	1,905	5,715	200	20,000	25,715
American Bureau of Shipping Rules:					
Guide for R, W, Cladding... of Tail Shafts	20	60	5	500	560
Rules for Building & Classing Aluminum Vessels	125	375	5	500	875
Rules for B & C Mobile Offshore Drilling Units	75	225	5	500	725
Rules for B & C Reinforced Plastic Vessels	75	225	5	500	725
Rules for B & C Steels Vessels Under 61 Meters	70	210	5	500	710
Total	4,735	14,205	440	44,000	58,205

The information storage requirements presented in Tables 4, 5, and 6 are conservative estimates, based, in most cases, upon entire documents cr upon entire sections of documents. If necessary, a reduced database size could be produced by selective editing.

3.5 Failure Contingencies

a. Backup

The on-site computer should be backed up to the on-board computer daily. The inspection record on the on-board computer can be kept on both the internal hard drive and the removable hard drive until entered on the MSN. Local and MSN copies of the database could be maintained as a means of backing up data on the MSN.

b. Fallback

The fallback position for an on-site computer failure is to use a spare on-site computer or use the current paper-based inspection books and record the data later using a pen-based computer.

The fallback position for the on-board computer is to retain the data on the pen-based system until a working on-board computer is available.

c. Degraded Modes of Operation

The system can operate if the inspection data collection portion of the system is operational even if the context sensitive help or CAD programs are not operational.

4 DESIGN CONSIDERATIONS

4.1 System Description

a. <u>Office Computer Terminal Hardware</u>

This hardware is not part of this study. However, this computer must be able to store data in files on the removable hard drive which are compatible with the on-board computer.

b. <u>On-Board Computer Hardware</u>

The on-board computer is expected to be used in the protected environment of an air-conditioned compartment. A commercially available laptop computer with an attached CD-ROM drive and removable hard disk drive will satisfy the requirement provided the physical requirements given below are met.

Physical Requirements

Maximum Size:	13"W x 12"D x 4"H
Minimum Active Display Size:	8.5" diagonal
Minimum Display Resolution:	600 x 400 pixels
Maximum Weight:	13 lbs including batteries

Shock Resistance: Must withstand the rough handling associated with airplane travel, while closed or while inside a carrying case if one is provided.

Moisture Resistance: The device must be able to withstand exposure, while operating, to the high humidities often found near ships.

Temperature Resistance: The computer must operate normally in an ambient temperature range from 60°F to 90°F.

The computer must withstand temperatures of -20°F to 170°F for 8 hour periods, while not operating, without loss of information in non-volatile memory or any permanent physical or electronic damage.

Resistance to Electrical and Magnetic Interference: While operating, the device must be resistant to data loss and permanent or temporary circuit damage due to interference from operating shipboard equipment such as generators, alternators, motor-generator sets, switchboards, and electronic navigation equipment, in close proximity.

While being shipped, the device must be resistant to circuit damage or loss of data in non-volatile memory due to x-ray emissions from airport security systems.

Environmental Factors: The device, screen, and any exposed connectors must be resistant to damage from dusts commonly encountered in the shipyard environment or aboard bulk carriers, such as sandblasting grit, wheat and other grains, and ores of various metals.

Memory

Nonvolatile Memory Type:	Conventional Internal Hard Disk
Minimum Nonvolatile Memory:	20 MB
Preferred Nonvolatile Memory:	120 MB
Minimum RAM Capacity:	8 MB

Processing Capabilities

Maximum Text Screen Rewrite:	1.5 sec.
Maximum Graphics Screen Rewrite (100K graphic):	2.5 sec.
Minimum Data Transfer Rate:	9600 Baud

Batteries

Rechargeable batteries, with easily replaceable battery pack giving at least 3 hrs. operating time with the display on. The computer must also be able to operate from an A/C power line. One spare set of rechargeable batteries shall be provided.

Power Supply

The laptop computer must have a adaptable power supply for 110/120/220/240 VAC 50/60 Hz power, with a power cord and international power supply plug adapters.

Accessories:

The computer shall be equipped with a 101-key enhanced keyboard.

A hard-shell case with handle, latches, and lock which can travel as carry-on baggage on commercial aircraft must be provided.

A battery charger to charge one set of batteries in 1 hr is required.

A mouse or trackball must be provided with necessary hardware and software.

A cable and connector to connect the pen-computer to the on-board computer is required unless some other means of passing data between the computers, such as infrared or radio modem, is provided.

The computer shall have a 5.25" CD-ROM Drive either internal or rigidly attached to the computer case. If an external drive is provided, the carrying case shall protect both the computer and any attached drives.

One 3.5" 2.88 MB Extra High-Density (EHD) Floppy disk drive shall be provided.

A parallel printer adapter and connector for the printer used is required.

A lightweight inkjet printer capable of 300 dpi graphics and which can print on plain paper in 8-1/2" x 11" cut sheets in landscape or portrait orientation is required.

Storage for extra printer ink cartridges, floppy disks, CD-ROMS, and paper are required within the carrying case.

c. <u>On-Site Computer</u>

The size of a portable device directly impacts its functionality; thus size and weight are considered to be performance-related factors. The size limits are established by the minimum allowable display size and the maximum allowable overall size.

The computer shall be designed for pen-based computing and shall have a backlit display visible in a dark room, bright sunlight, and all lighting conditions in between. The microprocessor used shall have adequate speed and capacity to be used as a CAD processor.

The computer shall be provided with a cushioned external case to provide buoyancy and shock resistance. This external case shall remain on while the computer is in use and not interfere with the use of any computer controls or communications ports.

The computer must be battery operated. External communications ports shall be provided to allow communications with the on-board computer.

Hardware Requirements

Physical

Maximum Size:	9" x 12" x 1.5" thick
Minimum Active Display Size:	6" diagonal
Minimum Display Resolution:	600 x 400 pixels
Maximum Weight:	6 lbs including batteries

Shock Resistance: Must withstand occasional drops from 4 ft. onto a hard flat surface without the external case, while operating (this requires about 300g shock resistance).

Must withstand repeated drops from 8 ft. onto a hard flat surface while in the external case, while operating.

The ability to withstand a terminal-velocity drop onto a hard, flat surface while in the protective case is desirable but may not be possible.

Moisture Resistance: The device must be able to withstand exposure, while operating, to salt water spray and short term submergence in salt water to a depth of 1 foot, without immediate or long-term damage which would affect operating capability.

The device must be capable of being washed off frequently with a low-pressure fresh water hose without damage.

The display screen must be able to withstand frequent cleaning with water and soap to remove oil and dust residues without significant degradation of usability or visibility.

Buoyancy: Must float in liquids having a specific gravity of 0.8 (similar to kerosene) when in the external protective case.

Chemical Resistance: The device must be able to withstand crude oil frequently smeared on the case and screen.

Temperature Resistance: The computer must operate normally in an ambient temperature range from 0°F to 140°F (a moderate decrease in display response at low temperatures is acceptable).

The computer must withstand temperatures of -20°F to 170°F for 8 hour periods, while not operating, without loss of information in non-volatile memory or any permanent physical or electronic damage.

Resistance to Electrical and Magnetic Interference: While operating, the device must be resistant to data loss and permanent or temporary circuit damage due to interference from operating shipboard equipment such as generators, alternators, motor-generator sets, switchboards, and electronic navigation equipment, in close proximity.

While operating, the device must be resistant to data loss or damage due to interference from on-board or shoreside shipyard operations such as welding and NDT x-rays, in close proximity.

While being shipped, the device must be resistant to circuit damage or loss of data in non-volatile memory due to x-ray emissions from airport security systems.

Environmental Factors: The device, screen, and any exposed connectors must be resistant to damage from dusts commonly encountered in the shipyard environment or aboard bulk carriers, such as sandblasting grit, wheat and other grains, and ores of various metals.

Memory

Nonvolatile Memory Type:
Solid State Memory Card meeting PCMCIA Standards

Minimum Nonvolatile Memory:	20 MB
Preferred Nonvolatile Memory:	40 MB
Minimum RAM Capacity:	8 MB

Processing Capabilities

Maximum Text Screen Rewrite:	1.5 sec.
Maximum Graphics Screen Rewrite (100K graphic):	2.5 sec.
Minimum Data Transfer Rate:	9600 Baud

Batteries

Rechargeable batteries, with easily replaceable battery pack giving at least 3 hrs. operating time in backlit display mode.

4.2 System Functions

All system functions are described in sections 3.1 and 3.2. In addition, the pen-based, on-site computer shall have a pull down/pop up menu with at least the following menu items:

Major Item	Submenu Items
Help	
	Regulation Reference - Context Sensitive
	Regulation Reference - By Number
	Regulation Reference - By Name/Topic
	Automatic Display of Tickler Info
	On Demand Context Sensitive Tickler Info
	Items yet to be completed
Next Item	
	Choose by Location
	Deck (enter designation)
	Compartment (enter designation)
	Choose by Category
	Major Category (Display list)
	Minor Category (Display list)(Scroll through sub categories on form)
Attach Item	
	Attach text file
	Attach picture
	Attach sketch or drawing

4.3 Flexibility

Flexibility has been assured by specifying off-the-shelf hardware and software wherever possible. Certain capabilities of the system, such as memory, are likely to increase rapidly. It is conceivable that available internal memory will supplant the need for using CD-ROM drives in a few years. All reference materials could be stored in nonvolatile system memory.

Flexibility can be enhanced by choosing operating systems for the on-board and on-site computers which are industry standards. Operating systems proprietary to one company should be avoided.

4.4 System Data

System data has been described in section 3.4. The size of the inspection system database was estimated based on a combination of requirements for a U.S. tank vessel carrying hazardous liquids together with the machinery, hull, and drydock inspection books. This requires a minimum of 737 database records. The size of fields used for each record are given below:

Fields	Field Size (bytes)
Inspection Type	20
Part	2
Not Applicable Check	1
Major Category	20
Minor Category	20
Sub Category	20
Location Fields (3)	12
Tag Fields (2)	4
Help Link Fields (2)	4
Comment/Misc.	20
Form Type	4
Item Completed Field	2
Total	129 bytes

The database must be at least 737 x 129 ≈ 95 KB. With header information this might grow so 100 KB was used for data file size.

5 ENVIRONMENT

5.1 Equipment Environment

The interface with MSN can only be specified after the requirements for MSN are final. The office computer will most likely be a IBM PC compatible with a DOS operating system.

5.2 Support Software Environment

Software for formatting the data transfer between the Inspection System and the MSN must be developed once the databases for both systems are finalized.

5.3 Communications Requirements

There are no requirements for communications between the Inspection System and MSN. Data transfer is by removable hard disk drive. Modem transfer is an option that could be added with little extra cost. This would permit remote transfer of data but could introduce errors or permit transmissions to be intercepted.

5.4 Interfaces

The only interface required between the Inspection System and the MSN is a removable hard disk drive that is readable by both systems.

5.5 Summary of Impacts

The existing ADP system is expected to be replaced entirely by the MSN and Inspection System. The use of existing data from the MSIS is a subject of the MSN development studies.

5.6 Failure Contingencies

All failure contingencies are discussed in section 3.5.

5.7 Assumptions and Constraints

Interface requirements assume that a home office computer will be used as an interface device between the MSN and the Inspection System. This has yet to be finalized.

6 SECURITY OF DATA

Data security was not considered as part of this study.

7 SYSTEM DEVELOPMENT PLAN

The following comments represent MAR's recommendations for implementing the system. The final System Development Plan will have to be written by the Coast Guard.

It is recommended that a pilot program be initiated in the near future. This pilot program would purchase a limited number of each type of hardware and software needed for a full scale system. Several competing products should be tested to determine the best features for the Coast Guard system. This is particularly true of the competing operating systems for pen-based computers. Software that needs to be developed would be written and field tested under this pilot program. Any changes needed to the system to better adapt it for use in the field would also be made and field tested.

The pilot program should be limited to no more than two years duration so that the inspection system can be implemented Coast Guard wide as soon as possible. Two years is a reasonable time frame for purchase, development, and testing of the needed hardware and software.

During the pilot program, refinements can be made to the functional description for a full scale buy of hardware and software. Full implementation will be dependent on the parallel development of the Marine Safety Network with which the inspection system interfaces. However, much improvement is possible through use of the inspection system alone, even if the output data must be coded by hand for the existing MSIS database.

Full scale implementation can be completed Coast Guard wide or on an inspection zone by inspection zone basis. The choice is dependent on delivery of hardware and software and on inspector training in use of the new equipment.

PART 3 - SURVEY OF NONDEVELOPMENTAL ITEMS (NDI)

1 GENERAL DISCUSSION

The NDI survey focused on identifying hardware and software items which would fulfill the requirements for a computerized inspection system presented in Parts 1 and 2 of this report.

1.1 Scope of the NDI Survey

The NDI survey covered both hardware and software. The hardware categories surveyed were:

Pen-Based Computers
Notebook Computers
External Storage Devices (hard drives and CD-ROM units)
Peripheral Equipment (printers and digital cameras)

The software categories surveyed were:

Pen-Computer Operating Environments
Existing Pen-Computer Applications (Searching, CAD, file-transfer, note-taking)
Pen-Computer Application Development Packages
Notebook Computer Operating Environments
Existing Notebook Computer Applications
Notebook Computer Application Development Packages

1.2 Information Sources

Most of the information upon which this survey was based, particularly with respect to pen-based computers and software for them, was provided by manufacturers. In many cases, the items mentioned are only recently or not yet commercially available, so very little objective information such as magazine test reports, etc., is available.

The order in which various hardware and software items are listed in the following presentation of Nondevelopmental items has no relation to relative suitabilities of those items for the tasks. In those cases where particular items do appear to be more suitable than others, this is pointed out explicitly.

1.3 Maintainability

Since all the hardware recommended is available off-the-shelf, the first level of maintainability is simplicity of replacement. Any computer which can use the operating environment under which the application programs will run can serve as a replacement for a malfunctioning unit. This feature applies to both pen-computers and notebook computers.

Repairs to notebook computers are generally made by swapping out motherboards, storage devices, or other modular components, and are within the capability of computer repair facilities in most locations. These repairs are also well within the capability of most electronic technicians and of many experienced computer users.

The pen-computer industry is still in its infancy, and repair facilities for pen-computers, other than returns to the manufacturer, are not yet widely available. However, manufacturers project a large volume of sales for pen-based machines, and it is likely that repair availability for pen-computers will soon match that for notebook computers.

1.4 Interoperability

This report recommends that pen-computers used for the inspection system operate under either the PenPoint™ or PenWindows™ operating environments, and that notebook computers use MS-DOS™, with the Windows™ graphical interface optional.

Virtually all current notebook computers will run the latest versions of MS-DOS™ and Windows™. Procedures for interfacing notebook computers with external storage devices such as the removable hard drive and CD-ROM drive specified for the inspection system, however, vary from one machine to another.

The latest generation of 80386-based pen-computers, a few of which are available now, and many of which are slated for availability in the near future, all support both the PenPoint™ and PenWindows™. Any application written under either of these environments will run on any 80386-based pen-computer.

Both the on-site pen-computers and the on-board notebook computers will retain all of their capabilities as general-purpose portable computers capable of using all standard commercial software and could thus be used in emergencies to perform tasks not related to marine inspection.

2 PEN-BASED COMPUTERS

The on-site computer specified in this report is a pen-based computer to be used by inspectors as they make their inspection rounds. Pen-based computing provides the user with a more comfortable and natural way of interacting with a computer, writing directly on the screen with a stylus, or pen. Users can operate a pen-based computer while they are standing or walking. Users who are new to computers often find keyboards intimidating; the pen-interface is much less intimidating to these users.

Interaction with the pen-based computer is by printing, sketching, or making special marks, referred to as gestures, directly on the screen with the pen. The trace of the pen is immediately shown on the screen. The trace is referred to as ink. Ink may be retained in its original form as a rough sketch, or it may be recognized by the system and transformed to another data type such as ASCII coded text. Simple shapes such as circles, rectangles, etc, can be displayed in smooth form just as a CAD program would display shapes. Gestures are recognized as identifying marks or executable commands.

2.1 Existing Applications of Pen-Based Computers

The American Bureau of Shipping (ABS) has a pilot ship inspection program based in New Orleans that uses pen-based computers. ABS is presently using several GRIDPADSL pen computers in the Portable Computer Pilot Project (PCPP). The ABS offices involved are New Orleans, Mobile, and Houma. Mr. Joseph Fortin of ABS stated that the time needed to generate survey reports has been reduced from 21 to 5 days.

Pipeline workers of Southern California Gas Co. (SCG) presently carry three thick, three-ring binders of reference material describing the elaborate structure of the gas utility. The pen-based computer is being used to compress this reference material and provides the workers with work orders and graphical instructions on-line.

Marion Merrell Dow, a pharmaceutical company, gave the pen-based computer to their sales representatives two years ago. It allows the company's sales representatives to get drug samples to doctors up to a week faster than the competition. They are using the GRiDPad and claim 2% of the GRiDPad computers fail each month, when you drop it.

Kellogg Sales Company deployed 300 GRiDPad computers across America to tally inventory in the field. The workers go into supermarkets to record inventory changes and the application instantly calculates Kellogg's percentage of shelf space. The worker's fill out electronic forms on the computer screen and transmit data each day to a host computer via a modem link.

Conrail has outfitted its locomotives with 300 GRiDPad computers, Mobidem (wireless) modems, and printers. The engineers communicate to the station yard on the Mobidex radio network. The benefits of using the pen-based computer are timeliness of data, customer service and improved fleet management. In the past, work orders came to engineers at the beginning of each shift via a fax from the station yard, telling them to either pick up or drop off railroad cars at customer sites. If the engineers did something unexpected, they would fax the station yard at the end of the shift, and changes would be keyed into the database, after eight to 16 hours. The old system was error-prone and slow. Now, engineers receive new orders during a shift, and transmit their changes directly to the host system. Communication is now close to real-time, within minutes after the actual work is done.

ITT Hartford is an insurance company which requires many forms to be filled out by insurance adjusters. The company is in the pilot stage of a project using NCR 3125 pen-based tablets running Microsoft™ Windows™ for Pens. The pen-based computers reduce the amount of transcription in the reporting phase. The data gathered in the field can be fed directly to the network at the home office, and the company saves time and money now spent on transcription. ITT Hartford is planning to implement a wireless network to automate the transmission of field reports.

Other pen-based applications developed by companies include the following: Southern Pacific Railroad (Conductor work order automation), City and County of San Francisco, Contra Costa County (Building inspection), Pacific Gas and Electric (Line inspection from helicopter), Chevron (vessel turnaround system for Marine terminals) and International Medical Instrument (Pen-based medical instrument).

2.2 Full-size Pen-Computers

There are four full-sized pen-based computers currently available on the market and four more will be available within a year. Tables 1 to 3 illustrate the important characteristics. The following discusses the full-sized pen-based computers in general terms. Apple computers are not included here because they have proprietary hardware and software. Their systems are not compatible with the hardware and software discussed here. Apple is discussed in another section of this report. Of the available pen-based computers

GRiD's GRiDPAD SL and MicroSlate's Datellite 300L are built to meet the requirements for the On-site computer. The International Business Machine Corp (IBM™) ThinkPad™, which is available on a limited basis, will also meet the requirements.

Full-size pen-based computers average 13" x 10" x 2.5" with an average weight of 5 to 6 pounds. Many of the full-size computers have an Intel 80386SX or 80386SL microprocessor.

They are powered by internal rechargeable Nickel-Cadmium (NiCad) batteries and have a backup AC power supply. The minimum battery duration is 3 hours; some will last up to 8 hours depending on the usage.

The 80386SL processor has advanced power management built into it, this feature allows the computer to shut down when not in use to conserve power. Most pen-computers offer RAM sizes of 2MB, 4MB, or 8MB.

The storage media available for the full-sized computers include hard-disk drives and solid state memory cards. Hard disk drives used have capacities between 20MB and 62MB. Solid state cards meet the Personal Computer Memory Card International Association (PCMCIA) standard.

All of the screens are backlit, CGA or VGA Monochrome Liquid Crystal Displays (LCDs). They have a resolution of 640 x 480 dots (pixels) and have a screen size of approximately 10" in diagonal.

Most have an internal modem with a data transfer rate of at least 2400 bits per second. Interface connectors are generally available for standard serial and parallel devices, external keyboards and external VGA monitors. Some have optional ports such as a Small Computer System Interface (SCSI) connection, an external floppy drive connector or a docking station for direct data transfer to another computer. All have an Industry Standard Architecture (ISA) standard 80386 with an XT bus or AT bus. Most of the 80386-equipped pen-based full sized computers support both of the primary operating environments, PenPoint™ and Windows™ for Pens. Some manufacturers also offer proprietary operating environments, especially for computers with pre-80386 processors.

Certain full-size pen-based computers are designed for harsh environments. GRiD's GRiDPAD SL has a plastic case with rubber flaps over its external connectors. IBM™'s computer has a magnesium case with rubber seals over all connectors and IBM™ claims the system is water-resistant. IBM™'s computer is durable because of it's removable solid-state storage cards. It can survive a 3 foot drop onto a carpeted floor and was undamaged. TriGem's case is polycarbonate/ABS. Most of the computers will withstand a minimum shock of 5G when operating.

The following full sized pen-based computers using 80386 or higher processors are currently available:

GRiD Systems Corporation

The GRiDPAD SL uses the 386SL processor, the size is 1.5" x 9.3" x 11.5" and weighs 5.4 pounds with the battery. It comes with a 60MB hard drive and one PCMCIA industry-standard card slot. As an option their is an external floppy disk drive available. GRiDPAD offers many interfaces such as: an RS-232 serial port, floppy disk drive and two RJ-11 connector as an option. The display is a backlit, VGA-compatible, 10-inch with a transmissive LCD screen. Special features include rubber flaps over the interface ports and the GRiDPAD is encased in rugged plastic. Other options include several configurations of internal data/fax modem. Table 1 illustrates other features not mentioned above.

NCR™ Corporation

NCR™ manufactures their model 3125 with a 386SL processor, the size is 1.2" x 9.8" x 11.7" and weighs 3.95 pounds with the battery. The RAM available is 4MB expandable to 8MB. The mass storage devices available include: 2MB or 8MB of onboard Flash EPROM and an optional 1C-card slot for 2MB or 4MB Flash EPROM and 20MB hard disk. An extension unit is available which includes an ISA compatible expansion slot and flexible/hard disk mass storage. The NCR™ 3125 was not designed to be rugged and is not water resistant, it was designed for the office environment. Table 1 mentions other features.

MicroSlate, Inc.

MicroSlate produces the Datellite 300L, 386SX processor, the size is 2.625" x 12.625" x 10" and weighs 6.6 pounds. This is one of the heaviest and largest pen-based computers available. The storage capacity consists of 128KB of FLASH EPROM and an internal 60 to 120MB formatted hard disk. Power is supplied by 1 or 2 removable 12 volt batteries, an external DC power supply is offered as an option. The battery duration is 6 to 8 hours depending on the application with the suspend/sleep power management modes to conserve power. The 300L survives a 3 foot drop and has sealed end caps to prevent moisture from entering the computer. Interface options available include SCSI connections to connect an external hard drive or CD-ROM drive. Table 2 mentions other features.

NEC Technologies, Inc.

NEC manufactures the Ultralite SL/20P with the 386SL processor, a size of 2.2" x 11.5" x 9.06" with a weight of 6.8 pounds with the battery. This is a notebook computer with a pen as an interface. It does not meet the requirements for the on-site computer. The SL/20P has 2.5" 80MB hard disk drive. An optional portable docking station allows you to interface other peripherals. The docking station includes one full-size AT or two half-size 16-bit slots, 5.25" internal half height bay and external floppy disk drive port. Table 3 mentions other features.

IBM™ Corporation

The IBM™ ThinkPAD™ is only available on a limited basis. It has a 386SX processor, a size of 12.25" x 9.4" x 1.375" with a weight of 6 pounds. It has a removable 20MB internal solid state file storage. The case is made out of magnesium. The backlit display is transflective. An optional expansion unit is available for file and data communication transfer. Table 3 mentions other features.

Dauphin Technology, Inc.

Dauphin manufactures their model 5000, a 386SL, a size of 1.75" x 9.6" x 11" and a weight of 5.5 pounds with the battery. Dauphin is in the process of manufacturing the 5000 and hope to start shipping in December of 1992. This computer has unique features, the screen flips up and a notebook computer is available; the keyboard is detachable. It has 32MB of memory available and a 120MB hard drive. A special interface is available that includes an external 100-pin 16-bit AT expansion bus port. Table 1 mentions other features.

TelePad Corporation

Telepad is currently manufacturing their TelePad SL, a 386SL, size of 1.3" x 11" x 11" and weighs 4.5 pounds. The SL has a unique adjustable handle for setting up onto a desktop. A choice of system memory up to 20MB is available. 2.5" Hard drives from 40MB to 130MB are available. The expansion interface is an 180 pin mass termination connection. The TelePad SL has a tough polymer case. Table 2 mentions other features.

TriGem Corporation

Trigem's pen-based computer is not yet available, it has a 80386SL processor, size of 1.1" x 10.6" x 13.4" and weighs 4.9 pounds with batteries. An interface option includes 2 PCMCIA card slots. The case is polycarbonate/ABS. Table 2 mentions other features.

Tusk, Incorporated

Tusk's pen-based computer is called the All-Terrain SuperTABLET™. It has a 25 MHz 80386SL processor with a maximum RAM capacity of 20 MB. It has an internal SuperVGA display adapter capable of driving an external monitor to 1280x1024 resolution. Nonvolatile storage is either an 85MB or 180 MB shock-resistant hard drive. The machine has an external bus connector which gives external devices access to all 200 lines of the computer's ISA bus.

Tusk offers a docking station with a keyboard and a floppy disk drive, which holds the SuperTABLET™ in an upright position to serve as the display. The case is primarily a reinforced plastic composite, with aluminum and stainless steel components.

Table 1 Full-Sized Pen Computers

Hardware Requirement	Vendors		
	Grid Systems Corp.	Dauphin Technology, Inc.	NCR Corp.
Product Name	Pen-Based GridPAD SL	Dauphin 5000	NCR 3125
Base System Price	$7,000	$3,000 - 3,500	$4,500
Processor Chip	386SL	386SL	386SL
Clock Rate	20 Mhz	25 Mhz	20 Mhz
Standard RAM	4MB with 16 KB Cache	4MB with 64 KB Cache	8MB(max.) with 16KB Cache
Maximum System Memory	20 MB	32 MB	8 MB
Non-Volatile Storage	60 MB Hard drive. 1 PCMCIA slot.	60,80 or 120 MB Hard Drive Int. 3.5" Floppy Drive	Int. 2MB or 8MB Flash EPROM 2MB or 4MB Flash EPROM card slot 20MB Hard disk
Ports	Serial,Parallel,Monitor,Floppy Disk, Keyboard, and Speaker.	Serial,Parallel,Monitor,Floppy Disk, Keyboard, and AT Expansion Bus.	Serial, Parallel,Monitor
Bus Type	ISA	ISA	ISA
Display	10"/Transmissive/Adj. Edgelight	Backlit Pagewhite	Backlit/reflective
Screen	640 x 480 LCD/VGA	640 X 480 LCD/VGA	640 x 480 LCD/VGA
Operating System	PenRight,PenWindows,PenPoint, PenDOS,MS-DOS	MS-DOS,OS/2,MS-PenWindows	PenOS,PenWindows,PenPoint
System Powered By	100-250V AC, 47-63 Hz NiCad Recharg./Removable Battery	120-240V AC,NiCAD Rechargeable Battery	120-240V AC, 50-60 Hz Recharg./Removable Battery
Battery Duration	Int. or Ext. Battery Recharge. 2 Hour Quick-Charge	3 Hours	4 to 6 Hours with 1 hour charge time
Power Management	Standard Advanced Power Management	25% Extended Battery Life using Sleep,Suspend, and Resume Modes.	Standard Advanced Power Management
Height (in.)	1.5	1.75	1.2
Width (in.)	9.3	9.6	9.8
Depth (in.)	11.5	11	11.7
Weight (lb)	5.4 with Battery	5.5 with Battery	3.95 with Battery

Table 1 (Cont) Full-Sized Pen Computers

Hardware Requirement	Vendors		
	Grid Systems Corp.	Dauphin Technology, Inc.	NCR Corp.
Product Name	Pen-Based GridPAD SL	Dauphin 5000	NCR 3125
Operating Temperature	0C (32F) to 40C (104F)	5C (41F) to 54C (130F)	5C (41F) to 40C (104F)
Storage Temperature	-20C (-4F) to 60C (140F)	-29C (-20F) to 55C (131F)	20C (-4F) to 70C (158F)
Humidity	10% to 80%	20% to 90%	Not Available
Drop (ft.)	Not Available	Not Available	3
Shock	(Operating) 5G (Storage) 50G	(Operating) 5G (Storage) 50G	Not Available
Vibration	(Operating) 5-100 Hz at .5G (Storage) 5-100 Hz at 1G	Not Available	Not Available
Altitude (ft.)	(Operating) 10,000 (Storage) 40,000	Not Available	Not Available
Durability	Plastic casing	Not Available	Not designed to be rugged
Water Resistance	Rubber flaps over ports	Not Available	Not water resistant/Leather Case
External Interface Options	Floppy disk drive	100-pin 16 bit AT expansion bus	ISA Expansion slot
Availability	Currently	12/92	Currently
Additional Components Available	(Int.)2400 bps modem,9600 bps Fax	Screen Flips Up/Down. Int. Fax/Modem (2400/9600 Baud)	2400/9600 bps Data/Fax modem

Table 2 Full-Sized Pen Computers (Additional)

Hardware Requirement	Vendors		
	MicroSlate, Inc.	TelePad Corp.	TriGem Corp.
Computer Type	Datellite 300L	TelePad SL	Pen 386SXL
Base System Price	$6,000	$3,300	$4,000
Processor Chip	386SX	386SL	386SXL
Clock Rate	20 Mhz	25 Mhz	20 Mhz
Standard RAM	4Mb up to 16Mb	2Mb	4Mb
Maximum System Memory	16Mb	20Mb	4Mb
Non-Volatile Storage	Int. 128Kb Flash EPROM/60 to 120 Mb Hard Disk	40Mb to 130Mb, 2.5" Hard Drive	Up to 4MB Int. Flash EPROM.
Ports	Serial,Parallel,Monitor,Hard Disk or CD-ROM,Keyboard,Mouse, and Printer	Serial,Parallel, Monitor,Floppy Drive,Keyboard, and 180 pin connection	Serial, Parallel,Keyboard, and Pen
Bus Type	ISA	ISA	ISA
Display	9.5"/Backlit/Transmissive and transflective	10"/Backlit/Transflective	Backlit
Screen	640 x 480 Touch LCD/VGA	LCD/VGA	640 x 480 LCD/VGA
Operating System	Pen-Windows,PenPoint,Pen-DOS	Pen-Windows, PenPoint,PenDOS,PenRight	PenWindows,PenDOS,PenPoint, MS-DOS
System Powered By	Int. 1 or 2 Removable 12 V Batteries, Ext. DC Power Supply/AC to DC Power Supply Adaptor.	Battery,110/250V AC,50/60 Hz, Adaptor and charger	115/230V AC or 12V DC Ext., NiCad Battery
Battery Duration	6 to 8 hours	4 with 2 hour recharge	5
Power Management	suspend/sleep mode	Standard Advanced Power Management	Standard Advanced Power Management
Height (in.)	2.625	1.3	1.1
Width (in.)	12.625	11	10.6
Depth (in.)	10	11	13.4
Weight (lb)	6.6	4.5	4.9 with Batteries

Table 2 (Cont) Full-Sized Pen Computers (Additional)

Hardware Requirement	Vendors		
	MicroSlate Inc.	TelePad Corp.	TriGem Corp.
Product Name	Datellite 300L	TelePad SL	Pen 386SXL
Operating Temperature	0C(32F) to 50C(41F)	Not Available	Not Available
Storage Temperature	-40C(-40F) to 70C (158F)	Not Available	Not Available
Humidity	Not Available	Not Available	Not Available
Drop (ft.)	3	Not Available	Not Available
Shock	31G	Not Available	(operating) 10G
Vibration	Not Available	Not Available	Not Available
Altitude (ft.)	Not Available	Not Available	Not Available
Durability		Polymer Case	Polycarbonate/ABS casing
Water Resistance	Seal end caps	Not Available	Not Available
Interface Options	SCSI connection for hard disk / CD-ROM	180 pin mass termination connector	2 PCMCIA card slots
Availability	Currently	Currently in manufacturing stage	Currently in manufacturing stage
Additional Components Available			

Table 3 Full-Sized Pen Computers (Additional)

Hardware Requirement	Vendors		
	NEC Technologies,Inc.	IBM Corp.	Tusk, Incorporated
Computer Type	Ultralite SL/20P	ThinkPad	All-Terrain SuperTABLET
Base System Price	$2,800	$5,000	$5,995/6495
Processor Chip	386SL	386SL	386SL
Clock Rate	20 Mhz	20 Mhz	25 MHz
Standard RAM	4MB with 16KB Cache	4MB	8 MB
Maximum System Memory	8 MB	8MB	20 MB
Non-Volatile Storage	80 MB Hard Drive, 1.44 MB 3.5" Disk Drive	20 MB Removable Int. Solid State	85/180 MB Hard Drive
Ports	Serial,Parallel,Monitor,Floppy Disk Keyboard, and Mouse	Serial,Parallel,Floppy Disk, Keyboard	Serial, Parallel, VGA, Phone, ISA Bus
Bus Type	ISA	ISA	ISA
Display	9.4" /Sidelit backlight	10"/Transflective Backlit	10" Refl./backlit
Screen	640 x 480 Touch LCD/VGA	LCD/VGA	640x480 VGA
Operating System	MS-DOS, MS-PenWindows	OS/2,PC-DOS,PenPoint	Pen-Windows, PenPoint, others
System Powered By	100-240V AC, 50/60 Hz Int. Battery	AC/Recharg. NiCad Battery	110/220 AC, NMH Battery
Battery Duration	3-7 Hours. 2.2 Quick Charge Hours	3 Hours	3-8 Hrs. 1 Hr. charge
Power Management	Standard Advanced Power Management	Standard Advanced Power Management	Standard Advanced Power Management
Height (in.)	2.2	1.375	2.0
Width (in.)	11.5	12.25	12.5
Depth (in.)	9.06	9.4	10.1
Weight (lb)	6.8 With Battery	6 With Battery	6.0 With Battery

Table 3 (Cont) Full-sized Pen Computers (Additional)

Hardware Requirement	Vendors		
	NEC Technologies, Inc.	IBM Corp.	
Product Name	Ultralite SL/20P	ThinkPad	All-Terrain SuperTABLET
Operating Temperature	5C (41F) to 35C (95F)	5C (41F) to 35C (95F)	Not Available
Storage Temperature	-20C (-4F) to 50C (122F)	-20C (-4F) to 60C (140F)	Not Available
Humidity	Not Available	8 % to 80 %	Not Available
Drop (ft.)	Not Available	3	Not Available
Shock	Not Available	Not Available	Not Available
Vibration	Not Available	Not Available	Not Available
Altitude (ft.)	Not Available	Not Available	Not Available
Durability	Not Available	Magnesium Case	Composite/Alum. Case
Water Resistance	Not Available	Not Available	Currently
Interface Options	1 Memory expansion slot 1 modem slot, 1 docking station port	Expansion unit for network communications	Docking unit w/keyboard and 3.5" floppy
Availability	Currently	On a limited basis	Currently
Additional Components Available	2400/9600 bps data/Fax modem, Portable docking station: 1 16-bit slot, 1/2 height 5.25" bay, keyboard and floppy disk port.	9600/2400 bps Fax/modem, AC/DC adaptor.	9600/2400 Fax/modem standard 14400 Fax/modem opt.

2.3 Palm-size Pen-based Computers

Two vendors currently manufacture Palm-sized pen-based computers, GRiD Systems and Fujitsu. Neither of these is presently capable of operating under PenPoint™ or PenWindows™. However, GRiD™ expects to upgrade their palm-size machine to a 80386 processor in 1993. Refer to Table 4 for their characteristics.

GRiD PalmPAD

The GRiD Systems product is called the PalmPAD. It is 9.0" x 6.2" x 1.9" and weighs 2.9 pounds with the batteries. It can be strapped to the user's palm or wrist. The processor is a NEC V20 operating at 9.54MHz. GRiD Systems expects to release a PalmPAD with a 386-based processor in 1993. Internal rechargeable NiCad batteries power the computer with a backup AC power adaptor. Battery power is conserved by either standby, suspend/resume mode or sleep mode. Currently, 2MB of RAM memory is available. The two options for media storage available are: one SunDisk high capacity storage card (up to 20MB) or one PCMCIA industry-standard RAM storage card. The screen has an adjustable backlight, black and white CGA transflective LCD, 640 x 400, and a 6.5" diagonal display. The present PalmPAD supports MS-DOS™ based PenRight operating environment. The 80386 version will support PenPoint™ and PenWindows™.

Standard I/O ports included are serial port and an external keyboard port. Special optional features include: Nickel-metal hydride rechargeable/removable batteries, a spread spectrum radio communication's module for wireless communications up to 800 ft (19,200 bps) and various internal modems up to 14400 bps. The PalmPAD is cushioned by a rubberized plastic case, and the manufacturer claims it can withstand an operating shock of 273G.

Fujitsu PoqetPad

Fujitsu Personal Systems manufactures the PoqetPad, a 9.65" x 4.59" x 1.26", 1.2 pound, palm-sized pen-based computer. The processor is an NEC V20HL operating at 7MHz. It is powered by two AA alkaline batteries with an optional AC power adaptor. The battery life is 16 to 48 hours depending on the application. It also incorporates a standby/resume mode for conserving the battery power. The RAM memory available is 640KB. System memory is 1MB and option for Non-volatile storage consisting of two 4MB PCMCIA cards for a total of 8MB. The screen is a non-glare, reflective supertwist CGA LCD, 640 x 200 resolution, and a size of 7.25" diagonal. PoqetPAD supports the PenRight operating environment and NestorWriter's handwriting recognition software.

There is an optional 2400 baud external modem available. Optional I/O ports available include the standard serial and parallel ports. Also included is an optional 80-pin expansion port. Other key features include: Operating shock of 100G's (about a 3 foot drop to concrete) and it passed a 48 hour salt spray test.

Table 4 Palm-Sized Pen Computers

Hardware Requirement	Vendors		
	Grid Systems Corp.	Fujitsu Personal Systems, Inc.	
Product Name	Pen-Based PalmPAD	PoqetPad	
Base System Price	$2,900	$2,000	
Processor Chip	NEC V20	NEC V20HL	
Clock Rate	9.54 MHz	10 Mhz	
Standard RAM	2 MB	640 KB	
Maximum RAM	20 MB	1 MB	
Non-Volatile Storage	SunDisk or PCMCIA	2 PCMCIA card slots	
Ports	Serial/Keyboard	Serial,Parallel	
Bus Type	ISA	Proprietary	
Display	6.5"/Transflective/Adj. Backlight	7.25"/Reflective Supertwist	
Screen	640x400 LCD/CGA	640 x 200 LCD/CGA	
Operating System	MS-DOS,PenRight	PenRight	
System Powered By	110-240V AC,47-63,400 HZ NiCD Recharg./Removable Battery (opt.) NiMH Battery	2 AA alkaline batteries/ (opt.) AC adaptor	
Battery Duration	8 Hours/Int. or Ext. Charging Internal 1.5 Hour Fast Charge	16 to 48 hours application dependent	
Power Management	Standby, Suspend/Resume Sleep mode	Standy and Resume mode	
Height (in.)	1.9	1.26	
Width (in.)	9.0	9.65	
Depth (in.)	6.2	4.59	
Weight (lb)	2.9 with Battery. 2.3 without Battery	1.2 with battery	

Table 4 (Cont) Palm-sized Pen Computers

Hardware Requirement	Vendors		
	Grid Systems Corp.	Fujitsu Personal Systems, Inc.	
Product Name	Pen-Based PalmPAD	PoqetPad	
Operating Temperature	0C (32F) to 50C (122F)	0C (32F) to 40C (104F)	
Storage Temperature	-20C (-5F) to 60C (140F)	-20C (-4F) to 60C (140F)	
Humidity	5% to 95%	10 % to 90 %	
Drop (ft.)	3	3	
Shock	273 G at 2 ms	(Operating) 100G (Storage) 750G	
Vibration	(Operating) 3-200-3 Hz at .5 G (Storage) 3-200-3 Hz at 1.5 G	(Operating) 3-200 Hz at 1G (Storage) 3-200 Hz at 1.5G	
Altitude (ft.)	(Operating) 10,000 (Storage) 40,000	(Operating) 10,000 (Storage) 40,000	
Durability	Rubberized plastic casing		
Water Resistance	Not Available	Moisture Resistant	
External Interface Options	Communication module for radio transmission/RS-232 port	2 PCMCIA card slots, 80-pin bus connector.	
Availability	Currently	Currently	
Additional Components Available	2400/14400 bps Data Modem. 9600 bps Fax Modem. 19.2 kbps Spread Spectrum Radio up to 800 ft range.	AC adaptor/2400 external modem	

2.4 Pen-Based Computers Under Development

Apple Computer, Inc.

Apple is developing a palm-size pen-based computer named the "Newton", which Apple refers to as a "Personal Digital Assistant" (PDA). This computer will run under Apple's proprietary operating environment. The Apple operating environment is not compatible with any of the other pen-based operating environments. The PDA is designed for tasks such as writing memos, sending faxes, and planning appointment. Apple is the sole source of the computer and of the operating environment.

PI Systems Corp. and Sigma Information Systems, Inc.

These companies are developing a 2 x 10 x 9 inch, 2.9 pound pen-based computer with a MC68331 microprocessor. The product name is PI-Infolio.

Digital Equipment Corp. (DEC)

DEC is developing two pen-based computers. The "Pocket-PC" is a pen-based, checkbook sized computer. The other, "Convertible PC", is a slim pen-based computer whose screen slides back to reveal a full QWERTY keyboard. DEC expects these computers to hit the market in 8-14 months.

Sony Corp.

Sony has developed two pen-based palmtop computers, the "PTC 300" and the "PTC 500". These computers are not presently available in this country.

Scenario, Inc.

Scenario is developing a pen-based computer, no release date is available.

Microslate

Microslate is working on a smaller version of their notebook sized pen-based computer. Their is no release date available.

Norand Corp.

Norand is developing "Penview", a notebook sized pen-based computer. It is still in the R & D stages.

Hewlett-Packard Corp.

HP is working on a pen-based version of their HP95LX notebook computer. The release date is not available.

2.5 Solid State Memory Cards

Most of the latest generation of pen-computers can use solid state memory cards for non-volatile storage. Most of these cards conform to the PCMCIA interface standard. These cards are approximately the size of a credit card, but thicker. The actual size is 3.5 mm x 69.2 mm x 51.5 mm. At one end of the card is either an 68-pin or 88-pin female connector used for either memory interfacing or input/output (I/O). Intel™ produces Flash Memory Cards conforming to the PCMCIA interface standard. Memory cards with 10 MB per card are currently available, with 20 MB per card expected by the end of 1992 and 40 MB per card by the end of 1993. Most pen-computers can take two cards if they have no other storage devices i.e., hard or floppy disk drives. The memory on these cards is nonvolatile (data isn't lost when power is turned off). The Flash Cards permit safe, convenient storage and data transport, with much less weight and power consumption than either floppy or hard disk drives. The shock resistance of the entire computer system, which is often generally limited by the shock resistance of rotating magnetic/mechanical storage devices, improves greatly when solid state memory is used. The disadvantage of these cards is that the cost of a 20MB card, bought in large quantities, is presently $600.

2.6 Pen-Computer Displays

Virtually all pen-computers use monochrome Liquid Crystal Display (LCD) screens overlaid by a digitizer which senses pen input. An etched glass surface is generally used to provide a realistic pen-on-paper feeling when the pen is used on the screen.

LCD displays fall into three categories: reflective, transmissive (backlit), and a hybrid of these called transflective.

Reflective displays use ambient light and the reflectivity can generally be adjusted to suit varying lighting conditions or viewing angles. Viewing in near or total darkness requires an external light source, and the use of reflective displays with non-uniform light sources such as flashlight beams is difficult. Reflective displays work well in bright sunlight. The power consumption of reflective displays is low, making them practical for battery-powered devices. Reflective displays have been produced which are intrinsically safe for use in explosive atmospheres.

Transmissive LCD displays use a light source behind the screen, generally adjustable in intensity, and are suited for use in low-light conditions. However, transmissive displays have poor contrast in bright light. Transmissive displays use considerably more power than do reflective displays, and a backlit LCD display is often the largest power-using component of a battery powered computer system. Transmissive displays cannot currently be made intrinsically safe.

Transflective LCD displays combine the features of the transmissive and reflective displays. In transmissive mode, with backlighting, these offer good visibility in low-light conditions. In reflective mode, with backlighting turned off, they offer good contrast in bright light and low power consumption. Like transmissive displays, transflective displays cannot currently be made intrinsically safe, and industry sources indicate that this may never be possible.

Most of the latest generation of pen-computers offer transflective displays as standard equipment.

3 NOTEBOOK COMPUTERS

There are at least 50 notebook computers on the market and available that will fulfill the on-board notebook computer requirement. Notebook computers are keyboard-input devices with average sizes of approximately 12" x 9" x 2.5" and generally weighing less than 8 pounds. Many of the notebook computers have either Intel 80386SX or 80386SL processors with 20MHz or 25Mz clock speeds. The SLs have an advanced power management built into the chip to conserve battery power. Most have internal rechargeable NiCad batteries. Some have internal rechargeable NiMH batteries. The battery duration for most of these notebook computers are approximately 3 hours depending on the application. The RAM available ranges from 2MB to 8MB. The media storage used for notebook computers are either 3 1/2" 1.44MB floppy disk drive and hard drives with a memory range of 20MB to 80MB with a few to 120MB. The screens are generally monochrome backlit VGA LCD, 640 x 480 resolution, and screen sizes range from 8.5" to 10" diagonal. Both standard and extended keyboards are available. Options include 2400 baud data/fax modems. I/O ports include: serial, parallel, monitor, keyboard, and mouse.

The two notebook computers described in detail below are particularly suited to the role of the on-board computer for the inspection system because they are available with factory-designed portable expansion units which attach to the computer and which facilitate physical and electronic connection to external storage devices, such as the external removable hard drive and the CD-ROM unit specified for the on-board computer. A large number of other notebook computers have expansion connectors or SCSI ports which are intended to allow connection to external devices.

GRiD Systems Corporation

GRiD Systems produces the GRiDCASE 1550CD notebook computer. It has the 386SX processor and a detachable CD-ROM drive built into the back of the notebook. The CD-ROM attaches to the notebook through a SCSI interface. A unique mouse feature, Isopoint, is built into the notebook. The 1550 is 4.75" x 11.5" x 16" and weighs 17.3 pounds without the battery. Available memory of 4MB RAM and an option of 8MB RAM is available. A 10", backlit LCD, VGA display is included. The detachable CD-ROM drive stores 635MB and other available storage includes a 3.5" 1.44MB floppy disk drive and a 120MB hard disk drive. It supports MS-DOS™ 5.0, Microsoft™ Windows™ 3.0, and Microsoft™ CD-ROM extensions. The 1550 is powered by a battery and internal/external AC power. The operating environment that it can run under includes: a temperature of 10C to 40C, humidity of 10% to 80%, a shock of 5G, vibration level of 5-200-5 Hz at .4G and an altitude of 10,000 feet.

NCR™ Corporation

The NCR™ 3170 has an Intel 80386SL processor with a clock speed of 25MHz. The choice memory available is 2 or 4MB with an upgrade to 20MB. It has a VGA, LCD screen with 640 x 480 resolution. A slot is available which supports the PCMCIA standard 2.0. There is a choice of 80MB or 120MB capacity, 2.5" internal hard disk drive and a 3.5" 1.44MB external flex disk drive available. Ports available include: two serial, parallel, mouse or keyboard, external 200 pin AT bus and two RJ11 modem ports which support a wide variety of modem configurations. It has a FingerPoint mouse and is powered by a NiCad battery with a life of 3 hours. One of the unique features NCR™ offers is the expansion unit (3170 Expansion Manager) that the NCR™ 3170 notebook computer slides into. The expansion unit provides the notebook with a wide variety of peripherals.

3.1 Data Transfer Capabilities

Some of the notebook computers have either an expansion port or bus, docking stations or SCSI interface. Any of these external connections can be used to connect external hard drives or CD-ROM units. Many of the notebooks have an internal data/fax modem or Personal Computer Memory Card International Association (PCMCIA) slot which could be used to transfer data between the on-site and on-board computers. The IBM™ PS/2 N51 SX notebook has an optional communications cartridge for Local Area Network (LAN) connectivity. The Micro Express NB913 notebook has a SCSI interface pack.

Other methods of communicating between pen-based and notebook computers are wireless connections such as radio links and infrared light. Phototonics Corp.'s Infrared Transceiver uses an infrared light source to transmit data between computers at a rate of 1Mbps. O'Neill Communications and Cardinal Technologies are working together to produce the Wavecomm which is a portable communications device that relies on a radio link to transmit information. Wavecomm can support as many as 100 users who can transmit information from as far way as 10,000 feet.

3.2 External and Removable Hard Drives

External hard drives can be connected to the notebooks by using expansion bus connectors or docking stations. Many notebooks incorporate these connections. Librex is in the process of manufacturing a notebook with a removable hard drive. MiniStor Peripherals Corporation manufactures two types of removable hard drives. One type is 1.8", 32MB or 64MB hard disk which connects to an AT computer interface. The other type is a 1.8", 32MB or 64MB hard drive which connects into an ejector socket connected to the computer through a PCMCIA interface.

Hewlett-Packard (HP) has developed a 1.3" hard disk drive, named Kittyhawk, conforming to either the PCMCIA or IDE interface. It has two platters and can write 7MB on each of three sides, for a total of 21MB. It weighs less than one ounce and has an average power consumption of slightly more than 2 watts. It can withstand a 3-foot drop onto concrete during a read/write operation (100G) and a 7-foot fall onto concrete when not operating (225G). The solid state memory cards that Intel is producing costs about $30 per megabyte while HP is pricing the Kittyhawk at $10 to $12 a megabyte or $250 for the unit.

3.3 External CD-ROM Units

GRiD Systems Corporation has provided a CD-ROM drive attached to the rear of its notebook via a SCSI interface. Other notebook computers with SCSI interfaces or interface cards can access external CD-ROM drives. The MS-DOS™ CD-ROM Extensions allow DOS and Windows™ applications to interface with CD-ROM units.

3.4 Expansion Units

An expansion unit is a portable self-powered unit which connects to the system bus of a notebook computer and which includes bays for storage devices, communications devices, and allows connection of PC-type expansion cards to the notebook computer. NCR™ manufactures a unit with three bays for peripherals and two expansion slots. An choice of an AT card slot that supports either a full size AT card or an optional battery pack and a half length XT card slot for a SCSI controller is needed for a CD-ROM kit. Also included with NCR™'s unit is an option for a floppy drive or a Radio Fax (RF) Modem.

4 PORTABLE PRINTERS

Portable printers are widely available on the market. Below is a typical representation of some of the ink jet portable printers available:

Canon U.S.A

Canon U.S.A. manufactures an ink-jet printer with the following characteristics: a print speed of 110 cps, a resolution of 360 dpi, emulates IBM™ and EPSON printers, a tray capacity of 50 sheets, a maximum form width of 8 inches and is powered by a battery. The size of the printer is 2" x 12" x 9" and weighs 4 pounds.

Eastman Kodak Co.

Eastman Kodak manufacturers a Diconix 701 mobile inkjet printer. The print speed is 3 ppm with a resolution of 300 dpi. It emulates the IBM™ Proprinter X24E and the Hewlett-Packard Deskjet. The tray holds 30 sheets. It is powered by a battery and is 7" x 12" and weighs 6 pounds.

Hewlett-Packard Co.

QuietJet Plus Model 2228A is manufactured by Hewlett-Packard. It has a print speed of 40 cps and a resolution of 96 x 96 dpi. It emulates an Epson printer and accepts a 10 inch wide form. The dimensions are 5" x 16" x 8" and weighs 9 pounds.

Hewlett-Packard also manufactures a ThinkJet Model 2225 ink jet printer. The print speed is 150 cps and it has a resolution of 96 x 96 dpi. It emulates an Epson printer. It accepts an 11 inch wide form. The dimensions are 4" x 12" x 8" and weighs 7 pounds.

Brother International Corp.

Brother manufactures an ink jet printer, HJ-100i. Print speed is 48 seconds a page and it has a resolution of 360 x 360 dpi. It emulates the IBM™ Proprinter and Epson printers. It accepts an 8 inch wide form. It is powered by a battery, is 2" x 12" x 9" and weighs 5 pounds.

Star Micronics America, Inc.

Star Micronics manufactures a StarJet SJ-48 ink jet printer. The print speed is 83 cps with a 360 x 360 dpi resolution. It emulates an IBM™ Proprinter and Epson printers.

It accepts an 8 inch wide form. The dimensions are 2" x 12" x 9" and weighs 4 pounds.

5 DIGITAL CAMERAS

Two digital cameras are currently available on the market.

Logitech, Inc.

Logitech manufactures the Fotoman™, a portable, digital still camera which stores up to 32 images on an internal RAM chip and then transfers images through a serial port of a computer.

Canon

Canon manufactures two still video cameras, the RC-250 and the RC-570. These cameras capture images, store them, and transfer them to a computer which displays them on the monitor through the use of a special digitizer board.

6 SOFTWARE FOR PEN-BASED COMPUTERS

The software recommended for the on-site pen-based computer includes an operating environment, application software such as a searching program, download and upload utilities, CAD program, and programs for the electronic inspection book application. These pen-based computer software programs are discussed as follows:

6.1 Operating Environments

Operating environments for pen-based computers were either developed from the ground up for the pen interface (pencentric), or they evolved from existing operating systems developed for keyboard-based desktop PCs. Two operating environments that are pencentric are Go Corporation's PenPoint™ and GRiD System Corporation's PenRight™. Microsoft Windows for Pen Computing™ was developed from the familiar PC-based Windows™. Communication Intelligence Corporation's PenDOS™ was developed from the DOS operating system. These operating environments are discussed below.

<u>PenPoint™</u> (GO Corporation)

PenPoint™ Version 1.0 was designed to be used on pen-based computers. It was designed to be easy to use, even for people who have never worked with computers before. PenPoint™ treats the computer as a clipboard with multiple pages. Application development programming for PenPoint™ is based on an object-oriented C++-based development environment. The PenPoint™ environment is compatible with any of the 386-based pen computers, including those from IBM, NCR, Samsung, and GRiD Systems. PenPoint™ Version 1.0 supports only Intel 80386 and higher microprocessors.

Included with PenPoint™ are two applications: MiniText™ and MiniNote™. MiniText™ is a text-editing and word-processing application. MiniNote™ is a notetaking application which allows the user to sketch and jot notes on the screen with handwriting recognition.

PenPoint™ supports five standard fonts, a wide range of printers, and a wide variety of networks. Included with PenPoint™ is the PenTOPS™ software for file and printer sharing and for installing applications. PenTOPS™ also allows access to networks.

PenPoint™ uses GOWrite™ as a handwriting recognition translator. GOWrite™ translates upper and lower case printed letters, numbers, and punctuation. Other handwriting engines can be installed to replace GOWrite™. GOWrite™ provides handwriting and gesture training which allows users to practice their handwriting accuracy.

PenPoint™'s recommended minimum memory size is 4 MB of RAM. Up to 256 MB of RAM is supported; the actual maximum amount which can be present depends upon the hardware configuration. The operating system can address up to 256 MB of physical memory, and up to 4 gigabytes of virtual memory.

PenPoint™ supports IDE-based hard disks and solid state memory cards. The operating system requires 3.5 MB of disk space and 4 to 5 MB of additional virtual memory space, but the minimum recommended disk space is 5 MB.

PenPoint™ version 1 uses the MS-DOS™ file format. Under the PenPoint™ system, a number of documents (files) can be opened simultaneously. The size of a file and its volume, and the files per volume are unlimited, restricted only by memory and disk space.

PenPoint™ can read/write to MS-DOS™ 720K, 1.44 MB, and 2.88 MB 3 1/2" floppy disks.

<u>Windows for Pen Computing™</u> (Microsoft Corporation)

Windows for Pen Computing™ (also referred to as "Windows for Pens™" and "PenWindows™") was developed by Microsoft, and uses the same desktop metaphor and pull down menu structure as Windows™ for PCs. Many existing Windows™-based applications are compatible with Windows for Pens™.

Windows for Pens™ applications programming supports features that include ink and gesture management, printed handwriting recognition, and integrated edit controls. The pen can be used to gesture, write, point, and tap. Windows for Pens™ will support third-party handwriting recognition translators.

Windows for Pens™ supports a variety of development tools, hardware platforms, networks and wireless connections, and printers. It also supports graphical, 32 bit architecture, object-oriented technologies, and multimedia.

<u>PenDOS™</u> (CIC Corporation)

Communication Intelligence Corporation (CIC) developed the operating environment, PenDOS™. It was designed to work with new and existing DOS applications on pen-based computers. PenDOS™ transforms mouse-aware DOS applications into pen-aware applications. It recognizes gesture commands and provides a window for handwritten entries on top of graphics or text DOS applications. CIC's handwriting recognition translator, Handwriter™, is included with PenDOS™.

PenDOS™ provides the user with a keyboard and mouse emulation, pop-up keyboard, and multilingual support.

The minimum requirements for PenDOS™ are: the 386 or higher microprocessors, standard PC-AT ROM BIOS, DOS 3.0 or higher, standard VGA display, 50K of conventional memory and 309K of extended memory, and 1 MB of hard disk storage.

<u>PenRight™</u> Version 3.1 (GRiD Systems)

PenRight™ was developed by GRiD Systems Corp. to support major pen hardware systems on the market. It is a pen-based environment for pencentric graphical applications built on the MS-DOS™ operating system.

PenRight™ features include upper and lower case character recognition and gestures while utilizing the windowing environment. It contains application programming interfaces (APIs) with more than 230 functions and a handwriting engine designed to support the execution of mission-specific applications including data collection.

Older versions of PenRight™ were hardware specific, PenRight™ 3.1 has eliminated that problem by customizing the digitizer interface during run time installation.

6.2 Existing Application Software for Pen-based Systems

The pen-based software applications discussed are those which are available off-the-shelf or under development and which fulfill part of the software requirements for the on-site pen-based computer. This pen-based application software includes: searching programs, download and upload utilities and CAD programs. The primary application to be run on the on-site inspection computer, the electronic inspection book application software, will be a custom-developed application.

6.2.1 Searching Software

The searching program would aid the inspector, by providing him access to a small reference database that he could search using key words and utilize the context sensitive help feature. The following search programs will accomplish this task:

<u>Slate Penbook™</u> (Slate Corporation)

Slate Penbook™ is an electronic book software designed to provide reference materials to pen-based computer users. It is compatible with both the Windows for Pens™ and PenPoint™ operating environment.

Slate Penbook™ consists of two programs, PenBook Author™ and PenBook Reader™. Penbook Author™ converts existing source file and compresses it to 60% of its original size into PenBook's Bookfile™ format. Documents are indexed during this process. Source files can be generated from IBM PC and compatibles, or Macintosh desktop computers using many word processing programs. PenBook Reader™ allows the user to read the PenBook's Bookfile™ files like a book. Pages can be turned by flicking the pen across the page. A "paper clip" feature allows the user to save a page for future reference. An annotation layer allows the user to highlight, underline, illustrate, comment, and mark up a page. Using gestures, a user can search for specific words or phrases. Any page can be printed or faxed with or without annotation.

The minimum requirements for PenBook Reader™ are PenPoint™ 1.0 or Windows for Pens™ and 100KB of RAM.

<u>PenLiner™</u> (Notable Technologies, Inc.)

PenLiner™ is designed for pen-based users to create notes, outlines, and sketches on a notebook page. The notes in PenLiner™ can be in either digital ink format, translated into text, or a combination of both. The sketching feature allows users to annotate outlines, maps, diagrams, doodles or other personal markings on the page. Mathematical calculations can be created by entering formulas on the page. A nice feature includes the indexing and search, which allows the user to visually browse the pages and search all documents in the notebook using key words. PenLiner™ also offers integrated searching, sorting and linking of topics. Topics linked may be on a single page, other PenLiner™ pages or other PenPoint™ documents.

6.2.2 Download and Upload Utility Software

Download and upload utility software is necessary to allow inspectors to transfer files to and from the on-board computer. Programs which implement these functions are:

<u>Slate Laplink Pro™</u> for PenPoint™ (Slate Corporation)

Slate Laplink Pro™ is used with the PenPoint™ operating environment as a document transfer utility. It enables the user to move documents between mobile PenPoint™ computers and desktop MS-DOS™ systems. The transfer of documents is made by either a direct cable connection or by a modem, using standard phone lines.

Laplink Pro™ will access files on any desktop PC and any disk drives connected or networked to a remote desktop computer. Documents can be transferred by selecting "drag and drop", moving it to a destination window. Multiple destination windows can be defined to designate different locations, transfer schedules, and other communication options. Transfers can be scheduled for any time of the day, week, or month either in advance or on a regular basis.

The minimum requirements to run Laplink Pro™ are 400KB of RAM.

PenComm™ (Notable Technologies, Inc.)

PenComm™ is a telecommunications package designed for the PenPoint™ operating environment. It allows users to transfer documents from various host environments to your PC or mainframe. PenComm™ fully supports the PenPoint™ interface, gestures, handwriting input, and the "drag and drop" feature of sending or receiving documents. The protocols for document transfer include the following: Text/ASCII, XMODEM, YMODEM, YMODEM-G, ZMODEM, and Kermit.

PenTOPS™ (Sitka Corporation)

PenTOPS™ is a mobile networking software used with PenPoint™. It allows users to create network connections to Pcs, Macintoshes and Sun workstations for access to remote drives and printers. PenTOPS™ works with PenCentral™, DosTOPS™, MacTOPS™, or SunTOPS™. Physical and wireless networking media works with PenTOPS™.

The memory required for PenTOPS™ is 70 KB of RAM.

6.2.3 Computer-Aided Design (CAD) Software

A CAD program will allow the inspector to enter sketches, display drawings, and overlay drawings with notes. The following CAD programs are available for pen-based computers:

Stylos/Markup™ (Stylos Development Corporation)

Stylos/Markup™ allows mobile pen-based users to import industry-standard CAD and graphics files onto a pen-based computer and to create names for the marked up layers. Once the user is finished marking the layers, all the notes and revision information can be saved back to the origina file.

Some of its features include reading and writing to many industry standard CAD drawing file formats, zoom capability, and a utility for transferring images from digital scanners and cameras.

Additional features of Stylos/Markup™ are the ability for multiple users to markup CAD drawings, integrate with data collection (forms) and graphic referencing, providing a link to third party developers. The program also has a communication utility for sending binary files or FAX.

Stylos/Markup™ supports any pen-based computer with the PenPoint™ or Windows for Pens™ operating environments. The system requirements are: an 80386/80486 microprocessor, a minimum available memory of 4 MB, application disk size of 200KB of non-volatile storage, and a display resolution of a VGA (640 x 480).

PortaCad™ (Consortech Incorporated)

PortaCad™ is a portable graphics tool designed for the mobile pen-based computer user. Its features include: integration of graphic information with descriptive data, field data with office-based CAD drawings, graphic functions, handwriting recognition, layering capability, freehand sketching, and zoom functions.

PortaCad's™ software requirements are DOS 3.X or higher and GRiD's PenRight™ operating environment. Hardware requirements are PC-XT or higher with a mouse or pen and VGA screen. A pen-based computer with a minimum of 1MB RAM and disk space of 520KB.

FieldNotes™ (PenMetrics)

FieldNotes™ is designed for pen-based computer users. It allows the user to go into the field and capture information onto a graphical database. FieldNotes™ is written for the Microsoft Windows™ environment. Commands are entered using the pen via menus or gestures.

Four main components of FieldNotes™ are: image data, vector drawings, database data, and annotations. The software displays raster images with overlays of vector DXF files. Users can read or create databases and enter information into the database. Database information can be linked to vector objects. Users can also add annotations to the drawings.

FieldNotes™ users can take complex drawings into the field, modify, then add drawing vectors and annotate the drawings with gestures.

FieldNotes™ supports the following file formats: DXF, PCX, TIFF, ASCII and DBF. It can magnify, scan, scroll drawings and images, and do a database search. Drawing shapes such as a rectangles, lines, points, circles, arcs, ellipses, and polygons can be created, as well as text.

The computer requirements include: 386 or 486 based pen computer with a backlit or plasma VGA display, or a PC compatible desktop or laptop with a pointing device. The operating environment is Microsoft Windows™ 3.0, or 3.1 with Windows for Pen Computing™ enhancements. A 40 MB or greater hard drive and 4 MB or more RAM are recommended.

The following pen-based CAD applications are under development.

Delrina Technology

Delrina is developing a pen-based CAD program, Perform™. It uses digital ink to add annotations and freehand sketching to forms. There is no release date available.

WNDX Corporation

WNDX is working on a pen-based program used for graphical applications. There is no release date available.

6.2.4 File Compression Utilities

Because the nonvolatile storage of pen-computers using solid state memory is quite limited, efficient use of that memory is important. File compression utilities enable more effective use of available memory by eliminating "empty space" in files when they are saved, then restoring them to their original configuration when retrieved.

PenCrush™ (Notable Technologies)

PenCrush™ is a utility for the PenPoint™ operating environment that compresses and decompresses files to about half of their original size. When a page is turned in a document, decompression occurs automatically. The user can control the documents to compress by using gestures.

PenBook™ (Slate Corporation)

The PenBook™ electronic book software has a utility for file compressing. The utility is PenBook Author™, it accepts standard PostScript format files as input and compresses the file into a PenBook Bookfile™. The PenBook Bookfile™ is another utility within the PenBook™ electronic book software.

6.3 Electronic Inspection Book Application Software

The electronic inspection book application program will allow the inspector to implement CG-840 series inspection booklets on the pen-based computer. In addition, the electronic inspection book software will manage access to a reference and regulatory material database which will be stored in the memory of the pen-computer and which will be linked to appropriate sections of the inspection book. This software will be a custom application which must be developed. Development can be done more easily using an application development package specifically designed for the operating environment selected. Application development packages which might be used to develop the inspection book software are discussed in the next section.

6.4 Application-Development Packages for Pen-Computers

Some of the packages discussed below are Computer-Aided Software Engineering (CASE) tools, which are based on object oriented versions of the C language, but which do not require any actual programming on the part of the developer. Other packages require a main program to be written in C which calls on pre-written subroutines and procedures.

<u>Slate PenApps™</u> (Slate Corporation)

Slate PenApps™ application builder is a development software for industry specific pen computer applications. It is compatible with PenPoint™ and Windows for Pens™ operating environments. Included with PenApps™ is a forms designer, Slate PenBasic™, which is an object oriented programming language and a database engine. PenApps™ provides a design, test and compile environment. Programming in PenApps™ is an open development where a developer can substitute their own database engine. PenApps™ can be integrated into an existing data architecture or store and access data locally, using its database engine. It supports a variety of data types including bit mapped images. Data can be imported and exported to .DBF,.WKS,.DB and ASCII formats.

PenApps™ pencentric capabilities include input targeting, markup, deferred translation, revert to ink, and sketch fields. Input targeting allows users to write outside of field boundaries. Markup lets users add handwritten annotations to forms. Deferred translation allows users to delay input translation until a convenient time. Revert to ink converts translated text back to its original ink. Sketch fields allow free form sketches to be stored as a part of the form.

The minimum system requirements for development: 80386 processor or higher, 6 MB of RAM, DOS 3.3 or higher, Microsoft C™ 6.0 or higher, and a digitizing tablet.

PenPoint 1.0 Software Development Kit™ (Go Corporation)

PenPoint 1.0 Software Development Kit™ (SDK) is an object oriented program used in conjunction with 3rd party development tools using the C programming language. The PenPoint SDK includes the PenPoint™ operating environment, development tools, sample programs, and documentation.

The PenPoint SDK allows users to develop PenPoint™ header files, libraries and debug version of the Dynamic Link Libraries (DLLS). It also includes a source-level debugger, mini-debugger, bitmap editor, font editor, resource tools and DOS directory tools.

Required for desktop development is an 30386 or 80486 PC with 8MB RAM, 30MB disk, DOS 4.0 or higher, and a digitizer tablet. Programs developed with these systems are run on pen-based computers under PenPoint™.

GRiD PenRight Pro Software Development Kit™ (GRiD Systems Corporation)

PenRight Pro Software Development Kit™ is designed for C programmers with knowledge of MS-DOS™ for pen-based mission-specific applications. The kit contains the following components: PenRight Pro Application Interface™ (API), development tools (PenResource™, CodeStart™, and GRiDForm™), sample code, fonts and clip art, and documentation.

The API is a library that provides over 230 routines that can be called by any C program allowing you to use off-the-shelf MS-DOS™ development tools. Tools like standard compilers, editors, debuggers and other utilities.

Other API features include: upper and lower case handprinted character recognition, multiple window control used for data collection, and data entry through fields, radio buttons, check boxes, and lists. More features include: fields to capture electronic signatures, ability to rotate output to face of any four sides of display, create graphics, design custom control objects and then tie them to PenRight Pro's event processing. Also included are code resource support and resource management facility to isolate user interface from your source code.

The minimum hardware requirements for development: 640 x 400 or VGA display, 3MB storage, 80C86 processor or above, and

2MB system memory. Minimum software requirements for development: MS-DOS™ version 3.3 or higher, Microsoft mouse, C compiler, MS-DOS™ linker or turbo linker, debugger, and a source code editor. Minimum Pen-based system: 640 X 400 or VGA display, 80C86 processor or above, 640KB system memory, 512KB storage, pen input device, and MS-DOS™ version 3.3.

GRiD Pen-Pal™ (GRiD Systems Corporation)

GRiD Pen-Pal™ is a development software for users to design pen-based form applications without prior knowledge of C programming. Features include: database access, data communication, keystroke and menu style programming, graphics and downloading capabilities.

The minimum system requirements for development: 80286 processor or higher, 1MB of memory, 1MB of disk space, VGA display, Microsoft mouse, and MS-DOS™ 3.3 or higher.

Personal Pen Pal™ (PenPal Associates)

PenPal Associates are ex-GRiD employees who developed Personal Pen-Pal™. Because of this relationship, GRiD Pen-Pal™ and Personal Pen-Pal™ are similar.

Personal Pen Pal™ is an application development package designed to build upon DOS-based pen applications. It does not require prior knowledge of C programming. It allows users to design forms, program, compile, and test their mission-specific application.

Personal Pen-Pal's™ features include: a menu-driven interface, pop-up lists of objects and event types, a syntax builder and an on-line help. Other benefits are: database access, data communication, keystroke and menu programming, and graphics capability. It allows users to create objects including handwriting fields, buttons, signature boxes, text, lines, scrolling lists, logos, and graphics.

The minimum system requirements for development: 80286 processor or higher, 1MB of memory, 1.5MB disk space, VGA display, Microsoft mouse, and DOS 3.3 or higher.

Power Pen Pal™ (PenPal Associates)

Power Pen Pal™ includes the same features as Personal Pen Pal™ except it is a more advanced package aimed at professional developers.

Additional features other than what is included in Personal Pen Pal™ are data communication and downloading to a pen-based computer.

The minimum system requirements for development: 80286 processor or higher, 1MB of memory, 1.5MB disk space, VGA display, Microsoft mouse, and MS-DOS™ 3.3 or higher. Minimum system requirements for pen computing: 8086 processor or higher, and 640 x 200, 640 x 400, or 640 x 480 display.

<u>PenDOS Software Developer Kit (SDK)™</u> (Communication Intelligence Corporation-CIC)

The PenDOS Software Developer Kit™ is a pen-based development system for DOS applications. The software accepts handwritten entries and gestures using the pen as an interface.

The PenDOS SDK's features include: gesture customization, a choice of toolkits such as handwriting recognition, third party graphics, and a language compiler, and CIC's Handwriter Recognition System (HRS) which recognizes upper/lower case characters, punctuation, and gestures.

The minimum system requirements for development are of a 80386 or higher processor, standard PC-AT ROM BIOS, DOS 3.0 or higher, VGA display integrated with a digitizer tablet, 50KB of conventional memory for PenDOS™, 330KB of extended memory for HRS, and a pen with a side button. Minimum software requirements for development are: any language compiler with interrupt invoking capability and a source code editor.

<u>Visual Basic with Professional Toolkit™</u> (Microsoft™ Corporation)

Visual Basic with Professional Toolkit™ is a program used to develop applications for Microsoft Windows™ and other third party add-ons to be used on pen-based computers. The Toolkit includes Multiple Document Interface (MDI)™ child window control, a spreadsheet-type grid and tools for developing charts and graphs. It supports Windows for Pens™ operating environment.

7 SOFTWARE FOR NOTEBOOK COMPUTERS

7.1 Operating Environments

MS-DOS™

The Microsoft Disk Operating System (MS-DOS)™ is the predominant operating environment for desktop and laptop (notebook) personal computers. Version 5 of MS-DOS™ is the latest release.

DR-DOS™

Digital Research Corp.'s DR-DOS™ 6.0 is functionally equivalent to MS-DOS™. Any programs, including Windows™, which run under MS-DOS™ 5 will also run under DR-DOS™ 6.0. Differences between DR-DOS™ and MS-DOS™ are limited to utility programs and a few system command functions.

PC-DOS™

IBM PC-DOS™ is the IBM Corp.'s proprietary version of MS-DOS™; the two are virtually identical from a functional standpoint.

Programs which are written to run under MS-DOS™, PC-DOS™, or DR-DOS™ are generally referred to generically as "DOS" applications, to distinguish them from applications written to run under Windows™, OS/2™, or other operating environments.

Windows™

Microsoft Windows™ is a graphical user interface (GUI) which enhances MS-DOS™. Special versions of programs are required to fully utilize the graphical features of Windows™. Windows™ application development packages are offered for the BASIC and C languages by Microsoft and for the C and Pascal languages by Borland International.

OS/2™

IBM OS/2™ is a 32-bit operating system and GUI intended for high-level desktop systems. Its memory requirements (both RAM and hard disk space) are high and it is not considered suitable for notebook computers.

The performance requirements for the on-board notebook computer in Part 2 have provided for sufficient RAM and hard-disk storage capacity for any of the operating environments mentioned above except OS/2™.

7.2 Existing Application Software

7.2.1 Word-Processing

A large number of DOS and Windows™ word-processing programs are available. The performance requirements for the notebook computer allow sufficient storage capacity for any of the popular word-processing programs. The Windows™ 3.1 interface includes a simple word-processing program called Windows-Write™, which would likely serve the needs of marine inspectors for word-processing. Many inspectors are already familiar with WordPerfect™ 5.1, the most popular DOS word-processing application.

7.2.2 File Transfer Utilities

Programs which manage file transfer between pen-computers and other machines, including notebook computers are discussed in section 6.2.2, which covers file-transfer utilities for pen-computers.

7.2.3 Database Searching Software

The on-board notebook computer must have the ability to search a large CD-ROM database. Some components of this database, such as the ABS Steel Vessel Rules, include their own searching routines, which can be called by any program running on the notebook computer.

Non-commercial CD-ROM databases, such as many of Category 2 and 3 marine inspection references, can be searched by generic programs which eliminate the need to include custom-written searching routines in developed applications such as the inspection booklet software.

Discussed below are a sample of the CD-ROM database searching software available on the market. All of the programs will retrieve and search CD-ROM databases using word and text searching. They support either MS-DOS™ or Microsoft Windows™.

<u>DIS Professional Search™</u> (Data Information Services, Inc.)

This database searching software uses an index and search technology to collect and retrieve information. It supports magnetic media and CD-ROM. It can search words within words and same paragraphs, bi-directional and preceding proximity, phrase and field search, full boolean and wild card connectors and special characters. It can also capture, edit and merge text. It maintains a history of prior searches. It is compatible with MS-DOS™ and requires 640KB of RAM.

InnerView (Version 2.11)™ (TMS, Inc.)

This database searching software is a text retrieval package supporting CD-ROM, floppy and hard disk media. Utilities include searching and browsing techniques, drop-down menus, key word search and backward/forward scanning through series of pages and images. It is compatible with Microsoft Windows™ and uses the C source language.

Knowledge Retrieval System (KRS) for Windows™ (KnowledgeSet Corporation)

KRS is a searching software that searches, retrieves, and displays text and graphic information from CD-ROM, magnetic or optical media databases. It is designed for technical documentation and reference manuals. It supports Microsoft Windows™ and uses the C source language.

ZyIndex for Windows™ (Version 5.0) (ZyLAB)

This searching software is a text search and retrieval product that allows users to find information regardless of whether it is stored on hard disk, CD-ROM, network drives or removable media. It performs search requests of single words, true phrases, logical statements, proximity, synonym, numeric and date ranges, quorum, concepts, defined fields wildcards and nested searching. It supports Microsoft Windows™ and uses the C source language. It requires 2MB of RAM and takes up 3MB of disk space. It supports the Novell, 3Com, NetBIOS, Banyan, PC-LAN and LAN Manager networks.

7.2.4 Digital Photography Support Software

The digital photography support software is included with the still image cameras. Other software that is available includes the following:

InkWare Photo 1.0™ (Ink Development Corp.)

InkWare Photo™ allows users to edit and display digitally recorded photographs on a pen computer. It supports the Logitech Fotoman™ digital camera. With InkWare Photo™ the user can mark-up, process, and edit to annotate and customize each picture. The pictures can be stored in the PenPoint™ notebook on photo album pages. Added features include: printing, faxing, and using the modem to place the pictures in other documents or forms.

The minimum requirements for application: 386-based computer running PenPoint™, 300 KB of RAM, one active 8-level gray-scale photo, and 50 KB for each additional 8-level gray-scale photo. The disk storage required is 200 KB for application plus less than 30 KB for each 8-level gray-scale, compressed photo. The camera required is the Logitech Fotoman™ FM-1. A standard serial port is required for camera connection to computer.

Stylos/Markup™ (Stylos Development Corporation)

Included with Stylos/Markup™ (discussed in section 6.2.3) is a utility for transferring photographic images from digital cameras, named Stylos/Pix™. This utility runs only on pen-based computers but could be used to import drawings to the on-site computer for transfer to the on-board computer.

7.3 Discussion of Software to Be Developed

A primary function of the on-board notebook computer will be merging and formatting the inspection data collected by one or more inspectors on the pen-computers. This application must be developed.

7.4 Application Development Software

A number of software development tools are available for both the DOS and Windows™ environments. These range from collections of subroutines which can be called by main programs written in a programming language to Computer-Assisted Software Engineering (CASE) applications often referred to as integrated development environments in which the writing of the main program and the subroutine calls are done by the program itself. Some of the many software packages that will satisfy the application development requirements for the on-board notebook are discussed below.

Professional Developer™ Version 3.0 (Clarion Software, Inc.)

Professional Developer™ is a programming language and 14 utilities including a compiler, editor, designer, reporter, helper, processor translator, cross-reference, filer, sorter, scanner and converter. It generates source code from the designer. Also included is a utility, RT-Link™ used for creating executable programs and Report Writer™ used for query and reporting. Professional Developer™ is compatible with MS-DOS™, requires a minimum of 512KB of RAM and takes up 6.5MB of disk space. It is compatible with networks such as Novell, Banyan, 3Com, NetBIOS, LANtastic and Alloy. The source programming language is C and Assembler.

C4 Object-Oriented Programming Environment™ (Axon Development Corporation)

This application development software is based on the object-oriented programming environment. It develops applications by assembling application building blocks. Included in this development package are utilities such as alerts and dialogues, browser, hypertext, full screen editor, menu builder, RDBMS functions, SQL, report generation, accounting tools, portability, windows, built-in functions, built-in objects and application libraries. It is compatible with MS-DOS™, requires a minimum of 640KB of RAM and takes up 1MB of disk storage. The source programming language is C.

Probuild™ (Argo Data Resources Corporation)

Probuild™ builds transaction-oriented applications requiring data entry, data analysis, decision support, data management and retrieval, mathematical computations, on-line host application interface and report/document printing. Also included is Probuild Application Development Environment™, Probuild Compiler™, Probuild Run-Time™ and Probuild OS/2 Server™ components. It is compatible with MS-DOS™ and OS/2™, requires 640KB of RAM and takes up 2MB of disk space. It supports the token-ring network.

Microsoft C Professional Development System™ (Version 6.0) (Microsoft™ Corporation)

This programming package contains many tools. One tool is the Source Browser™ which enables programmers to interactively browse through project database. It also includes a Programmer's Workbench™, it provides an extensible foundation for all of the tools to run on. It supports MS-DOS™ and OS/2™, requires a minimum of 640KB of RAM in DOS and 3MB of RAM in OS/2™. It takes up 5MB of disk space.

Toolbox™ (Faircom Corporation)

Toolbox™ is an application development system which includes: a development environment, file management and report generation. Other utilities are provided such as: prototype generation, data dictionary, screen management, overlapped windows, file restructuring, variable length records, key compression, dynamic space reclamation, multi-file access, layout control, conditional page breaks, nested headers and footers. It is compatible with MS-DOS™.

8 VOICE RECOGNITION UNITS

Vocollect, Inc. has developed the Talkman™, hands-free, eyes-free data collection terminal designed for the mobile users. The Talkman™ recognizes and records your speech and then communicates with a remote computer. Vocollect's voice recognition engine produces ASCII files compatible with industry standard hardware and software for PC-based computers. The software is compatible with Microsoft Windows™. Programming is accomplished using flow charts using questions and answers. The Talkman will recognize over 1000 words. The three modes of operation are: speaking to the Talkman™ by using a radio link, speaking to the Talkman™ and storing the collected data in memory, and then uploading it to a host computer, and the last mode is speaking to a Talkman™ network, Talknet™ where 16 voices can be recognized and data is transferred directly to a PC-based computer.

References

1. "Assessment of the Coast Guard Marine Safety, Security, and Environmental Protection (M) Program," NKF Engineering, Inc., Coast Guard Report No. CG-D-11-89, March 1990.

APPENDIX A SURVEY QUESTIONNAIRE

The survey questionnaire used in the field survey of marine inspectors is presented in full in this appendix. This questionnaire includes the tabulation of the responses to each question entered into the response area for each question. Thirty-three completed full questionnaires were returned by inspectors. However, not every respondent answered every question. The average number of responses to any one question was 20. Where the choices for a given question are mutually exclusive, responses are also presented as percentages of the total number of responses to that question.

On Site Marine Inspection Data Capture

The purpose of this questionnaire is to collect information needed to establish requirements for a field data collection system to be used by Coast Guard marine inspectors. This system is expected to replace the inspection books now used.

Some type of portable computer system is the most likely candidate, with voice recording and photography being possible alternatives or additions to a computer-based system. If computers are used they will have the capability of providing reference material needed by the inspectors as well as allowing the inspectors to enter observations about the condition of the vessel being inspected.

Several data recording devices are possible. They include:

<u>Computers</u>:

Computers can store and display textual and graphic reference materials, and can record inspection results in various forms, including text, sketches, digitally stored photographs, and voice recordings.

o **Notebook or Notebook computers.** These have folding screens, typewriter-type keyboards, and hard and/or floppy disk drives for data storage. They can display both text and graphics of reference materials and can record text or menu choices. A reasonable level of proficiency with the operating system and with programs is required. Weights range from 5 to 15 lbs.

o **Pen-Based computers.** These are like a clipboard, are designed for use without a keyboard (although most are compatible with standard keyboards), and generally have solid state memory for data storage (no moving parts). Text and sketch entry and menu selection are accomplished by writing or drawing directly on the display screen with a pen-like stylus. Neat printing is recognized and converted into text. Both stored reference materials and entered sketches and photographs can be annotated on-screen. Cross-referencing of text, sketches, photographs, voice recordings, and other data is possible. Operating systems and programs are designed for those with little computer experience. Weights range up to 3 to 8 lbs.

Data Loggers:

- **Digital Data-loggers.** These resemble large calculators. Keyboards, if present, are of the calculator "chicklet" type. Entry is restricted to menu selections and limited text entry. Display capabilities are limited to a few lines of text. Weights range from 1 to 4 lbs.

- **Voice Recorders.** These record comments either by simple tape recording or by voice recognition and storage as a computerized text file . They are generally configured as a headset and a belt-worn unit for hands-free operation. Weights are in the 3-5 lb. range.

****

Of the options presented above, which do you think would provide the greatest improvement over present methods of recording inspection data?

Notebook Computer	___2 (17%)
Pen-based Computer	___7 (58%)
Data Logger	___2 (17%)
Voice Recorder	___1 (8%)
None of these	___
Other	______________________________

Would you carry the device you chose above into a restricted space?

Yes	___4 (36%)
No	___7 (64%)

Inspection Information

Roughly, what percentage of your work is:

Structural Inspections of Cargo Spaces in:		
	Tank Vessels	___33 (29%)
	Other Vessels	___23 (20%)
Structural Inspections other than Cargo Spaces in:		
	Tank Vessels	___31 (27%)
	Other Vessels	___26 (23%)
Inspections other than Structural (specify)		

Are multiple inspectors frequently assigned to an individual vessel or facility?

Yes ___15 (83%)
No ___ 3 (17%)

Environmental Conditions

These questions are intended to establish a worst-case operating environment for any data collection system selected.

What is the most severe moisture condition the computer must be designed to?

Submergence in more than 3 feet of water	3 (12%)
Submergence in less than 3 feet of water	5 (19%)
Occasional water splashes	11 (42%)
High humidity atmosphere	7 (27%)

What type of grease or oil resistance must the computer be designed for?

Submergence in more than 3 feet of oil	2 (10%)
Submergence in less than 3 feet of oil	5 (25%)
Occasional oil or grease contact	13 (65%)

What other chemicals are likely to contact the computer in service?

Must the computer be intrinsically safe for use in explosive atmospheres?

Yes ___17 (89%)
No ___ 2 (11%)

What is the highest temperature the computer will be subjected to in service?

________132°F

What is the lowest temperature?

________20°F

What is the most severe physical impact the computer must be designed for?

Occasional bumps against steel structures	___2 (11%)
Frequent bumps against steel structures	___4 (21%)
Drops of less than 1 foot onto steel	___1 (5%)
Drops of 1 to 6 feet onto steel	___9 (47%)
Drops of more than 6 feet	___3 (16%)
Maximum drop height ______________	

<u>Human Factors</u>

The ideal computer for a marine inspection job weighs almost nothing, is very small, but has a large, well lighted screen and an easy means of data entry. Unfortunately, these requirements conflict with one another and such a computer is impractical to build. Some of the following questions ask for your judgement about the <u>upper</u> limits on size and weight that are practical from an inspection standpoint. The computer chosen will be as small and light weight as possible given current technology, but definitely below the size and weigh considered practical for marine inspection purposes.

What is the maximum weight that the inspector could carry?

Less than 2 pounds	___5 (25%)
2-4 pounds	___6 (30%)
4-6 pounds	___5 (25%)
6-10 pounds	___4 (20%)
More than 10 pounds	___0
Upper weight limit? ________________	

What are the upper limits on the size of a device which would be carried during inspections?

Clipboard size (8-1/2 x 11 paper)	___11 (69%)
Textbook size (~9-1/2 x 7)	___2 (13%)
Pocket Book size(~7 x 5)	___3 (19%)
Other size constraints ______________________________	

What is the best method for the inspector to carry a computer while moving about?

In a backpack	___2 (15%)
In a pack on the chest or stomach	___2 (15%)
Strapped to the wrist	___0
Strapped to thigh	___0
In a pack attached to the belt	___2 (15%)
In a coveralls pocket	___7 (54%)
Other (Specify)	______________________

What is the fewest number of lines of text that must be displayed at one time?

One	___1 (5%)
2-5	___7 (35%)
6-10	___4 (20%)
10-16	___5 (25%)
16-25	___2 (10%)
More than 25	___1 (5%)

What is the minimum number of characters in each line of text?

Less than 40	___2 (10%)
40	___17 (85%)
80	___1 (5%)

Choose the minimum display character size from those shown below.

This is 6 point ___0
This is 8 point ___1 (5%)
This is 10 point ___11 (55%)
This is 12 point ___6 (30%)
This is 14 point ___2 (10%)
This is 16 point ___0
This is 20 point ___0

If you had to choose between the text constraints chosen above or the overall size constraints on the computer, which would you choose as the limit on computer size?

Text constraints	___3 (19%)
Overall size constraints	___13 (81%)

Will the computer be used in near or total darkness?

Yes ___12 (60%)
No ___8 (40%)

Will the computer be used in bright sunlight?

Yes ___18 (90%)
No ___2 (10%)

If a keyboard is used for data entry, does the keyboard have to be lighted for use in low light or no light conditions?

Yes ___12 (60%)
No ___ 8 (40%)

Will an inspector be wearing gloves while using a keyboard?

Yes ___12 (60%)
No ___ 8 (40%)

An alternative to using a keyboard for data entry is to use a <u>pen based</u> data entry system. If one of these is chosen, should the pen or stylus be attached to the computer to prevent it from being dropped and lost?

Yes ___19 (95%)
No ___ 1 (5%)

Is a better alternative to supply extra pens or styluses?

Yes ___ 5 (25%)
No ___15 (75%

With current pen based systems, all writing must be printed neatly for the computer to recognize it. Is this a serious problem for inspectors?

Yes ___13 (65%)
No ___ 7 (30%)

Voice data entry is another alternative. Would a simple voice recording system (with later transcription and entry into MSN), a voice recognition system (direct conversion of voice to computer text), or neither, be an improvement over present methods?

Voice Recording ___3 (21%)
Voice Recognition ___3 (21%)
Neither ___8 (57%)

Would either of these methods be preferable to a computer-based system?

Voice Recording ___0
Voice Recognition ___3 (23%)
Neither ___10 (77%)

If voice data entry were used, would shipboard noise present problems?

Yes ___16 (80%)
No ___ 4 (20%)

If voice data entry were used, is there a need to keep the inspectors comments from being overheard by the operators of the ship or facility?

Yes ___11 (55%)
No ___ 9 (45%)

What is the minimum time any data collection device (a computer or other device) must operate between battery changes?

Less than 1 hour ___ 0
1-2 hours ___ 2 (10%)
2-3 hours ___ 5 (25%)
3-4 hours ___ 2 (10%)
More than 4 hours ___11 (55%)
Minimum Operating time ____________

Would rechargeable batteries (with a 120 V charger) or disposable batteries be more practical?

Rechargeable ___12 (92%)
Disposable ___ 1 (8%)

Is it practical to carry a number of charged batteries to the vessel in order to make battery changes when needed?

Yes ___ 5 (38%)
No ___ 8 (62%)

Is it practical for the inspector to have multiple diskettes of information (CD Roms, Floppy Disks, solid state memory modules) and change them in the field to find the information needed?

Yes ___14 (74%)
No ___ 5 (26%)

Is a printer needed for use in the field?

Yes ___ 9 (45%)
No ___11 (55%)

If a printer is needed, what are the minimum requirements for such a printer.

Communications Capability

Would the ability to share and transfer information between computers used by inspectors at different locations on the same vessel be desirable?

Yes ___10 (50%)
No ___10 (50%)

Should an inspector's computer be able to communicate with a computer at the home office or the MSN computer?

Yes ___12 (60%)
No ___ 8 (40%)

If so, is wireless communication necessary or would a standard telephone modem be sufficient?

Wireless ___ 3 (17%)
Modem ___15 (83%)

What is the maximum time that could be spared for training an inspector to use a new system?

Less than 1 day	____	0
1-2 days	____	9 (50%)
2-5 days	____	8 (44%)
6-10 days	____	1 (6%)
More than 10 days	____	0

Maximum training time ______________

Would you be willing to take this much time to learn to use a new data collection system?

Yes	____	12 (100%)
No	____	0

Inspector's Information Needs

A computer system would have the capability of displaying both the text and illustrations of documents which apply to inspection procedures.

The following questions cover the information that an inspector needs to have available in the field, that is, on the computer, to properly conduct an inspection.

Textual Information

Does the inspector need the text of at least some parts of the Code of Federal Regulations (CFRs) during an inspection?

Yes ___
No ___

If CFRs are needed on the inspector's computer, which of the following are needed?

Title 46 CFR	Subchapters and Parts	
A, 1-9	Procedures Applicable to the Public	___
B, 10-16	Merchant Marine Officers and Seamen	___
C, 24-29	Uninspected Vessels	___
D, 30-40	Tank Vessels	___
E, 42-46	Load Lines	___
F, 50-64	Marine Engineering	___
G, 66-69	Documentation and Measurement of Vessels	___
H, 70-89	Passenger Vessels	___
I, 90-106	Cargo and Miscellaneous Vessels	___
I-A, 107-109	Mobile Offshore Drilling Units	___
J, 110-113	Electrical Engineering	___
N, 146-149	Dangerous Cargoes	___
O, 150-155	Certain Bulk Dangerous Cargoes	___
Q, 159-165	Equip., Const., & Material Specs & Approval	___
R, 166-168	Nautical Schools	___
S, 170-174	Subdivision and Stability	___
T, 175-187	Small Passenger Vessels	___
U, 188-196	Oceanographic Research Vessels	___
V, 197-199	Marine Occupational Safety and Health Standards	___

Title 33 CFR	Subchapters and Parts	
A, 19	Waivers of Navigation and Vessel Inspection Laws and Regulations	___
D, 80	Navigation Rules	___
H, 105	North Atlantic Passenger Routes	___
, 126-127		
N, 140-147	Outer Continental Shelf (OCS) Activities	___

O, 151-159	Pollution	___
P, 160	Ports and Waterways Safety	___

<u>Title 49 CFR</u>	<u>Subchapters and Parts</u>	
C, 171-179	Hazardous Materials Regulations	___

Others (List)____

____

____

Does the inspector need the full text of the following documents during an inspection?

American Bureau of Shipping Rules
- Rules for Building and Classing Steel Vessels ___
- Approved Welding Electrodes ___
- Shipboard Elevator Construction Guide ___
- Guide for Inert Gas Installations on Vessels Carrying Oil in Bulk ___
- Guide for Repair, Welding, Cladding and Straightening of Tail Shafts ___
- Guide for Shipboard Centralized Control and Automation ___
- Guide for Underwater Inspection in Lieu of Drydock Survey___
- Provisional Rules for the Approval of Filler Metals for Welding Higher Strength Steels ___
- Requirements for Radiographic Inspection of Hull Welds ___
- Requirements for the Certification of Cargo Gear ___
- Rules for Building and Classing Aluminum Vessels ___
- Rules for Building and Classing Bulk Carriers for Service on the Great Lakes ___
- Rules for Building and Classing Mobile Offshore Drilling Units ___
- Rules for Building and Classing Reinforce Plastic Vessels___
- Rules for Building and Classing Steel Barges for Offshore Service ___
- Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways ___
- Rules for Building and Classing Steel Vessels Under 61 Meters ___
- Rules for Building Wooden Hulls ___
- Rules for Nondestructive Inspection of Hull Welds ___

Other Standards Included by Reference

ASME Boiler and Pressure Vessel Code ___
NFPA Codes and Publications (including NEC) ___
Guide for Steel Hull Welding (American Welding Society) ___
ANSI Standards (Selected) ___
ASTM Standards (Selected) ___
ABYC Standards ___
IEEE Code ___

NVICs

___

Text of Federal laws or the U.S. Code

___

IMO codes or publications:

Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code) ___
Code of Safety for Dynamically Supported Craft ___
Code of Safety for Special Purpose Ships ___
Code of Safety for Diving Systems ___
Inert Gas Systems ___
SOLAS publications (48, 60 and 74) ___

Marine Safety Manual, Volume II, Materiel Inspection

___

Other volumes of the MSM?
Which ones? ____

Other Commandant Instructions

___

Marine Inspection Field Instructions

___

MVI Policy Letters

___

Graphical Information

Portable computers have the capability of displaying graphical reference materials. Some systems will allow direct annotation of this material on the screen with sketches or text for purposes of identifying the nature of, the location of, and recommended remedies to structural or other problems. Photographs taken with a digital camera can be downloaded immediately into a computer and annotated as well.

Would it be useful to have available for display and annotation on the computer screen:

Typical arrangement plans for the type of vessel being inspected?	___20
Typical structural plans for the type of vessel?	___17
Detailed plans of the specific vessel?	___ 8
Photographs taken and during the inspection and stored digitally in the computer?	___15

Would a simple sketch of the vessel or a photograph of the General Arrangement drawings be adequate in most cases to provide the information needed by an inspector?

Yes ___28 (85%)
No ___ 5 (15%)

Please comment on the need for vessel or facility drawings during an inspection and the detail that must be available to the inspector.

____
____
____
____
____
____
____

<u>Inspection Records</u>

Does the inspector need the vessel's status from the last inspection during the current inspection?

Yes ___17 (71%)
No ___ 7 (29%)

If it were available, would the electronic equivalent of the last inspection booklet be useful to the inspector during the current inspection?

Yes ___28 (90%)
No ___ 3 (10%)

Is the ship inspection history reviewed at the office or should this be provided on an inspector's computer?

Reviewed at the office ____24 (69%)
Needed on computer ____11 (31%)

Does the inspector need a listing of the MSN vessel profile data (Vessel File & Marine Inspection file) while doing an inspection?

Yes ___24 (73%)
No ___ 9 (27%)
Comments____

____

Is it necessary to have reports on the vessel from other OCMI zones while conducting an inspection or are these reviewed at the office before an inspection?

Reviewed at the office ____27 (83%)
Needed on the computer ____ 6 (6%)

Is a copy of the old Certificate of Inspection needed on the computer?

Yes ___25 (78%)
No ___ 7 (22%)

Should the Marine Inspection Preinspection Package (MIPIP) be loaded onto the inspector's computer and updated during the inspection?

Yes ___26 (79%)
No ___ 7 (21%)

If portable computers are used in marine inspection, the Vessel Inspection Booklets will be replaced by a record of the inspection on electronic media. This will become the official and legal record of the inspection. Do you foresee any problems with maintaining inspection records in this manner?

Yes ___ 5 (15%)
No ___28 (85%)
Comments

____

____

Should the Merchant Marine Inspection Requirement form be made a part of the electronic record of the inspection?

Yes ___30 (91%)
No ___ 3 (9%)

Should the inspector be able to print out Merchant Marine Inspection Requirement, Form CG-835, on site?

Yes ___18 (55%)
No ___15 (45%)

Should the inspector's computer be able to download outstanding CG-835 forms into the MSN Mailbox for use by inspectors in another OCMI zone?

Yes ___22 (67%)
No ___11 (33%)

Does the inspector have the authority and need to print out Temporary Certificates of Inspection, Form CG-854?

Yes ___19 (58%)
No ___14 (42%)

If the inspector is permitted to give the owner of the vessel a copy of the MIPIP, is this a case where a printer must be supplied with the computer?

Yes ___10 (30%)
No ___23 (70%)

Should the Vessel's Construction Log (Inspection Diary) be kept electronically, as well?

Yes ___29 (88%)
No ___ 4 (12%)

Inspection Aids

Are you happy with the current format of the Vessel Inspection Booklets which are arranged by equipment category or would a booklet arranged by location on the ship (more like a compartment check-off list) be preferred?

Keep current system ___19 (68%)
Arrange by location on ship ___ 9 (32%)
Other (Specify)______________________________

Would a more detailed list of items to look for (memory joggers) be of assistance?

Yes ___18 (55%)
No ___15 (45%)

Do you think that a list of multiple choice questions should be developed for each area of the inspection rather than the current method of having the inspector write out comments?

Yes ___17 (52%)
No ___16 (48%)

Is a list of Coast Guard approved equipment needed by the inspector during an inspection?

Yes ___17 (52%)
No ___16 (48%)

Should a phone number directory be included on an inspector's computer?

Yes ___23 (70%)
No ___10 (30%)

Should a computerized inspection system include context related help? That is, if the inspector has a question in a particular area, the help command would bring up related text or graphical reference material for the inspector to consult.

Yes ___18 (90%)
No ___ 2 (10%)

In certain fields (medical diagnostics and automobile troubleshooting, for example) so-called "Expert System" computer software has been developed. These programs are a distillation of the diagnostic procedures used by a number of very experienced people in a given field. They incorporate both a process-of-elimination multiple choice approach and also provide warnings about the location and nature of additional problems which have a high probability of occurring in conjunction with the discrepancies already noted. Suggestions for correcting problems which are found would also be incorporated into such a system.

Do you think that an expert system option in an inspection computer would be beneficial?

Yes ___ 8 (40%)
No ___12 (60%)
Comments ______________________________

Data to be Collected and Stored in an Electronic Data File

Which of the following features of the existing Vessel Inspection Booklets do you feel are essential to maintain in the electronic substitute?

Inspector's initials in check list boxes	____ 9
Inspector's written comments on vessel condition	____ 14
Inspector's signature certifying fit for service	____ 12
Memory joggers to aid the inspector	____ 17

Should the electronic record include selected vessel or facility plans or the photographic image of the plans?

Yes ___ 8 (40%)
No ___ 12 (60%)

Should the electronic record include photographs of the vessel or facility?

Yes ___ 5 (25%)
No ___ 15 (75%)

Should specific vessel deficiencies, such as a crack or an excessively corroded area, be documented by photographs in the electronic file?

Yes ___ 5 (25%)
No ___ 15 (75%)

Should sketches of the vessel or of discrepancies made during the inspection be made a permanent part of the inspection record?

Yes ___ 15 (75%)
No ___ 5 (25%)

Should the current MSIS computer record for the vessel or facility be loaded into the inspector's computer so that the inspector can fill in any gaps in the record and correct any errors while on site?

Yes ___18 (90%)
No ___ 2 (10%)

Should the inspector be able to download the corrected MSIS computer record from the inspector's computer to the MSIS system or is an auditing step required?

Inspector can correct MSIS directly ___8 (57%)
Data entry clerk should correct MSIS ___6 (43%)
Other (Specify)

____

____

If multiple inspectors are assigned, what is the preferred method for combining the separate inspections into one database?

Assign each inspector a computer and merge the records electronically 10 (50%)___
Assign only one computer to the senior inspector with other inspectors using Vessel Inspection Booklets which are later entered into the computer 7 (35%)___
Have all inspectors use Vessel Inspection Booklets and enter the data on the computer after a meeting of all the inspectors 1 (5%)___
Assign each inspector a computer and have a data entry clerk sort out the data needed for MSIS 2 (10%)___
Other (Specify)

____

____

____

Does the inspector need to provide standard forms to vessel owners or operators?

Yes ___12 (60%)
No ___ 8 (40%)

If the inspector does need to provide standard forms, should these be printed out by a printer on site or will hard copy forms be carried by the inspector?

Print out the forms ___ 3 (18%)
Provide hard copy forms ___14 (82%)

Are there any other forms that the inspector would have to print on site?

Yes ___ 6 (30%)
No ___14 (70%)
Specify if yes

APPENDIX B REPORT FROM PEN-BASED COMPUTING CONFERENCE

The contractor was represented at the Conference on Pen-Based Computing held May 5-6, 1992 in Boston Mass.

The Principles of Pen-based computers

Pen-based computers are a relatively new development in personal computing, and are the first true multi-purpose computers to abandon the desktop environment by their fundamental design philosophy. While based on similar processors, and retaining the capability of using similar software to desktop and notebook computers, these machines use a clipboard environment with a pen being the primary input device, and are intended to equally usable to either a standing or sitting person.

Manufacturers envision heavy usage by inspectors, appraisers, order takers, law enforcement officials, the transportation and shipping industries and others in mobile professions to whom computers have previously inaccessible due to the encumbrance of using a keyboard, the necessity to operate them from a desktop, and, in some cases, the operator's lack of typing ability. Accordingly, prototypes and the few stock models currently available are clearly designed with the intention of making them able to withstand rough treatment and hostile environments.

Operating systems and software also show the influence of this "clipboard" design philosophy. Data entry is accomplished with a pen-like device which is used in the same manner as a mouse for selecting menu choices. The pen can also be used to enter information on the screen in the form of "ink", which is a visible trace of the pen's track across the screen. Ink can be stored and manipulated as a bit-mapped image in its original form, or the system can recognize printed letters or numbers and store the resulting data in standard a computer text or numerical data format so the data can later be manipulated by standard word-processing, database, spreadsheet, and other programs. Ink sketches and figures can be recognized and stored as vector-based graphic images for manipulation by graphics or CAD programs.

Basic Hardware

Most available or prototype pen machines are built around a monochrome LCD display measuring 7 to 10.5 inches diagonally, with the computer being slightly larger than the screen dimensions and approximately 1.5 - 2.5 inches deep. The screen is permanently attached to and forms one of the faces of the computer and does not fold out as in a notebook computer. Most machines are ruggedly constructed and most manufacturers offer a separate padded fabric shock-absorbing case which protects all but the screen itself. Protection of the screens, most of which are glass, is not generally possible as the pen input device must make direct contact.

While several existing machines use Intel 8086, 8088, or equivalent 16-bit processors, most of the most recent group of pen-based computers, a few of which were available at this writing (summer 1992), and the rest slated for availability before Jan. 1993, are based on 32-bit processors like the Intel 80386 SL or 80486. Maximum RAM capabilities are similar to those of current notebook computers, with 8 to 16 megabytes generally being the upper limit. Some machines have 3.5" floppy disk drives and hard disks up to 240 MB. However, machines designed for hostile environments are using solid state non-volatile memory cards. Most machines will accept two of these cards, which about the size of a credit card, but a bit thicker. Current storage capabilities are 10 MB per card, expected to go to 20 MB per card by the end of 1992 and to 40 MB per card by the end of 1993.

Operating Systems

Two fully-featured pen-computer operating systems, both released for the consumer market in the spring of 1992, have emerged as the likely standards for pen-based machines. Windows™ for Pen Computing, by the Microsoft™ Corp., is an extension of the desktop Windows™ environment with added pen input, handwriting and graphics recognition capabilities. This system allows the use of existing Windows™ software on pen-computers, moving the desktop onto the clipboard. Windows™ allows the immediate use of a large existing base of software; however, much of that software is intimately linked to keyboard input and is likely to be of marginal use on a hand-held machine. Those pen computers which are designed for use in the most demanding of conditions will use card memory and will be limited in non-volatile storage capabilities. Windows™ itself and many Windows™ applications consume large amounts of memory, and this may prevent many Windows™ applications from being useful on pen systems. Application development for pen computers running under Windows™ is implemented with currently available and well-known Windows™ software development kits.

The other full-scale pen operating system is PenPoint™ by the GO Corp. This system was designed from the ground up for the clipboard-based pen-interface environment. Since it was recently released, and since no existing software for other operating systems will run under PenPoint™, there are presently very few PenPoint™ applications. However, it is likely that the majority of software which is written specifically for the pen environment will be written under this system, since it was specifically designed to exploit the clipboard-based, pen-entry environment and to be compatible with the memory limitations which will be inherent in many pen-computer systems. IBM™ has chosen PenPoint™ exclusively for its 80386-based pen computer, due for consumer availability in fall '92. The PenPoint™ software development kit is complex and different, and this will slow the development of applications and increase the expense of small-market PenPoint™ applications.

Several minor pen operating systems predate PenPoint™ and Windows™ for Pens. The best known is PenPal, a proprietary system of the GRiD Corp., an early pen-computer manufacturer. CIC Corp.'s Pen-DOS provides a pen interface extension for non-Windows™ DOS applications, allowing them to run on pen-computers.

Both Windows™ for Pens and PenPoint™ require an 80386 or higher processor for fully functional operation.

- The inspectors interviewed were senior personnel, none of whom were presently in active field inspection billets. The group included one member whose primary inspection experience was with safety inspections rather than structural inspections. It was pointed out that a hand-held computer might be more valuable as a direct data collection device to a safety inspector than to a structural inspector who is severely limited in equipment by the requirements of climbing and crawling through tight spaces and by extremely hostile environments. However, the information needs of safety inspectors will be somewhat different than those for structural inspectors.

- Inspectors present, when asked to summarize their personal inspection experience, indicated that in terms of numbers, deep-draft vessels were a small fraction of the vessels they had inspected, but that, due to the large amount of time required for such inspections, deep-draft vessels accounted for nearly half of their total inspection time.

- Shipyard personnel and other CG inspectors, in order to perform repairs or reinspections, must often return to structural defects noted by an inspector. The terminology used by inspectors is not always standardized, and this sometimes leads to confusion about the location of a problem. A GIS-type location system in which location information would automatically be attached to the description, sketch, or digital photograph of a structural failure in an inspector's clipboard computer would eliminate any ambiguities or uncertainties about positions of failures and additionally would allow computerized tracking of structural failure trends for one vessel or for a class of vessels.

- Inspectors present felt that digital photographs might be valuable in recording failures for which repairs were necessary, both for repair planning and for reinspection.

- Inspectors indicated that a portable computer system might be even more valuable as a source of information than as a recording device. Two primary classes of information were discussed;

  Inspectors need access to a large amount of regulatory and reference materials which are primarily textual but which include a small amount of graphical information as well. They presently carry with them the books they are most likely to use and must often do without immediate access to a large amount of other information cannot be carried. A system which could provide immediate access to this reference material, along with cross-referencing and keyword-searching capabilities, would be a great benefit to inspectors.

  A system which could graphically display facsimiles of a vessel's arrangement, system, and structural plans would also be helpful. The ability to annotate or overlay those plans with an inspector's notes, sketches, or digital photographs and to link this information to descriptive textual material such as entries in the inspector's diary would add to the value of on-screen plans.

- A fairly large number of junior inspectors are at some stage in their training process, most of which occurs on the job. Cross-referencing of inspection reference material to the OJT checklist and training manuals would be helpful.

- If a computer system is developed which gives inspectors optional access to a larger body of information without increasing their workload, such information as construction scantlings, construction inspection logs, vessel repair records, audiogaging reports from past surveys and inspections, and classification society surveys reports would be desirable.

- An inspection computer should be able to exchange and merge data with other portable inspection computers, since many inspections of large vessels are conducted by multiple-inspector teams with each member operating independently, and thus each requiring an individual computer.

APPENDIX D INTERVIEW WITH MIO NEW YORK MARINE INSPECTORS 5/21/92

The group interviewed comprised approximately ten people, and included both civilian and uniformed CG field inspectors and several CG administrative personnel.

Office Workload and Inspection Environment

- Breakdown of the inspection workload for this office:
  - 60% tanker cargo space structural inspections
  - 15% structural other than tanker cargo spaces
  - 15% structural other than tankers
  - 10% safety inspections

- A large proportion of the tankship inspections conducted by this office are done overseas, often in places where it is dangerous or impossible to bring expensive equipment like computers. These items may be stolen or confiscated by foreign customs agents, large bribes may be required, etc.

- The most dangerous (explosive) environments in which inspectors are required to work are aboard MODU's.

- Most major tankship structural inspections are conducted in shipyards. In most cases, cargo spaces are gas-freed and certified for hot work.

Inspection Procedures

- Inspections of large vessels usually involve more than one inspector. If data were collected electronically, it would have to be merged into a single coherent record as a final stage of the inspection.

- In accordance with MVI and local OCMI policy, inspectors do not prescribe or suggest repairs for deficiencies found (there are also legal considerations). Rather, the ship's owners or yard to propose a repair method, and the CG then approves or rejects the proposal.

Inspectors' Opinions on the Use of Computers as Data Collection Devices

- Very few of the NY field inspectors would carry a computer of any kind, no matter how small or rugged, into a cargo tank with them. They are concerned about the device interfering with their movements and tying up their hands. In addition, they are concerned that if the device were damaged the inspector would be held accountable for it and would be required to pay for its replacement.

- Field inspectors were divided on the issue of direct entry of field inspection data into a computer. Some felt that a computer would offer no advantages over a pencil and paper pad for entering descriptions of problems. Others felt that there would be advantages, but they would not be willing to risk bringing such an expensive and fragile device into an inspection environment. Others did not believe that the Coast Guard, which refuses to provide the inspectors with suitable flashlights for inspection (they must buy these themselves) would ever actually adopt such an expensive system. A few inspectors indicated willingness to try a field data entry system to see how it actually worked.

- Concern was expressed that oil or sludge would become smeared on the screen of a portable computer and, even if the screen was resistant to the chemical effects of the oil, the display might become difficult or impossible to see. Inspectors are very limited in the amount of equipment they can carry with them into a tank, and screen cleaning equipment would be out of the question.

Inspection Documentation and MSN Considerations

- Most of the inspectors felt that the elimination of transcription steps between initial recording of inspection data and eventual entry into MSN would cut their administrative workload and allow then more time for field work. Some preferred to use a pencil and paper and enter the information into a computer later, perhaps after consultation with other inspectors or with printed reference materials, others felt that data could be entered directly, then edited or combined with other inspector's information for the same ship, in an intermediate computer step.

  The field inspectors unanimously felt that a system which could offer immediate access, in the field, to the many volumes of reference materials to which they constantly refer would be a major service.

- Inspectors liked the idea of direct and immediate access to the MSN database, feeling that the many levels of administrative review which currently are necessary before inspection information is downloaded are unnecessary and prevent important information from being entered in a timely fashion. Most of the field inspectors felt that the system would be improved if the jobs of the administrative review personnel were eliminated.

Administrative Procedures

- Administrative personnel expressed concern that the normal review process might be circumvented if inspectors could directly download information into the MSN system. Some of these people were clearly concerned that their jobs and the authority they exercise over the field inspectors might be eliminated.

Computer System Requirements

- Inspectors would prefer to carry a computer on a shoulder strap so it could be set down, pulled or pushed through narrow passages, etc., rather than having it in a backpack or chest harness. They felt that such an arrangement would interfere less with climbing and other movements while keeping the computer ready for immediate use.

- Inspectors were concerned that the handwriting (actually printing) recognition function of pen-based computers would have trouble with the large number of specialized nautical and technical terms the inspectors use in locating and describing structural problems.

  Note: [This is a very valid concern. The handwriting recognition function, which is important to the concept of pen-based computers, is an integral part of the operating system. This function is used by, but not easily altered by, the application software. Most of the present handwriting recognition schemes use a two-stage process which includes both character-recognition and word-recognition, with dictionary-based word-recognition being the most important part by far. The ability to add a fairly extensive list of specialized words to the word-recognition dictionary would be an important requirement in specifying an appropriate computer system.]

- Experienced inspectors overwhelmingly felt that expert-system software on an inspection computer would not be a great benefit to them.

  Note: [Interviews for this task were conducted primarily with experienced personnel. The applications of an expert-system approach would primarily focus on more junior and less experienced personnel.]

Training Considerations

- Those field inspectors who were receptive to the idea of an inspection computer system agreed that if they found that a computer system could help them work more efficiently, they would find the time necessary for training. Administrative personnel expressed concern that there was no time available for training inspectors on such a system.

- The majority of the inspectors were quite familiar with computers, both the USCG standard workstations and DOS systems. They unanimously suggested that if an inspection system were adopted it be compatible with DOS systems as well as the present CG system. Many felt that the CG system is so bad that it is bound to be replaced by DOS-compatible desktop computers before long.

Brief Suggestions for computer system:

- Generic forms for recording vessel document information

- Cross-referencing and subject-searching capability for textual reference material. Citations must often be given as part of the deficiency report delivered to the vessel owner, and a quick way of pinpointing the correct citations would help.

APPENDIX E MSO NEW ORLEANS INTERVIEW

This interview was conducted with two contractor representatives and an average of seven inspectors, mostly senior personnel, including the CID.

General. Inspectors were enthusiastic about the communications and information providing ability of computers. Few of them would actually take a computer into a restricted space like a tank during an inspection (because of concerns over inspector safety and damage to the device), but everyone would use one for recording the "smooth" version of field notes, printing out worklists, CG-835 forms and other necessary forms, gaining access to reference materials, communications, and for actual direct data logging during deck and machinery space inspections and safety inspections.

- N.O. inspectors do a considerable amount of overseas inspection work.

- Inspectors often call back to the office for reference information or citations.

- Communication between inspectors in the field and the OCMI and CID is frequent. This is especially true in cases of collisions, fires, groundings, and from overseas. Decisions must often be made at the office to support field operations. Transfer of graphical or digital photographic info would greatly aid this process. A means of communication other than telephone (like long-range radio fax/modem) would be a welcome addition. This communication often involves the OCMI or other senior inspectors at home, so a computer or communication system would have to be taken home in order to fully utilize the possibilities.

- Inspectors would like to have access to MSN at home.

- Inspection book format. The books are very general - most of the information in a book does not apply to a given vessel. A lot of the inspector's time is spent deleting inapplicable sections of the book. A computerized book could be vessel-specific and only present the applicable sections for a particular vessel.

- Repetitive entries take up a lot of an inspector's effort. The vessel's name, etc., should only have to entered once during an inspection.

- MSN entries must be accompanied by codes which facilitate statistical analysis of MSN data by administrative personnel. These codes must be looked up by the inspectors during MSN data entry and take quite a lot of time for something from which the inspectors see no immediate benefit.

- The inspectors considered the MIPIP "the PIP" to be mostly useless information. It contains information from the MSN such as equipment serial numbers and other information which is entered during a vessel's original inspection and which is typically not updated during subsequent inspections. For an older vessel, much of the detailed information is wrong due to replacements of various pieces of equipment.

- Inspectors are burdened by the lack of physical access to the MSN system due to an insufficient number of workstations in inspection offices and the slowness of the system. They would like to see information from field computers downloaded in an unattended fashion, preferably at night, without tying any people up.

- Typical inspection protocol:

  After the first day, the owners are given a worklist of deficiencies. These may be corrected immediately if possible, checked by the inspector while still aboard, and if corrected to the inspector's satisfaction, are not listed as deficiencies. The worklist is not a part of the vessel's permanent file.

  At the completion of the inspection, a form CG-835 is issued, detailing all outstanding deficiencies. This becomes part of the vessel's permanent file.

  The inspector's diary is used to fill out the inspection books, which are the official permanent record. The diary is does not become part of the official permanent record of the inspection or of the vessel's permanent file.

  The inspectors would like to see both the diaries and the worklists become part of the permanent file, since they capture the "flavor" of the inspection. These would both be of great use to the next person inspecting that vessel. The previous diaries would give a valuable subjective impression of the overall condition of the vessel. A history of similar worklist items would indicate that some equipment or systems are only maintained as necessary to pass the inspections, and not as a matter of vessel policy.

- Senior inspectors noted that the level of preparation of the more junior inspectors has recently been decreasing for several reasons. Junior officers are entering inspection billets with college preparation in fields other than engineering or naval architecture; this was uncommon in the past. Because marine inspection is not a good route to promotions, junior inspectors strive to spend as little of their tour of duty as possible actually in the inspection department in favor of jobs offering more opportunity for advancement and leadership development. In addition, inspectors no longer concentrate on a particular area, such as hull, deck, or engineering inspections, but are instead encouraged to acquire a broad base of experience, which limits the expertise of junior people in any given area. As a result, older senior inspectors feel that many junior or mid-level inspectors are deficient in experience.

  The senior inspectors felt that a computer system might be of great value to less experienced personnel, especially if it could help guide them through the maze of regulatory and reference material. While experienced inspectors feel that the more esoteric capabilities of a computer system, like knowledge-based systems, would be of little use to them, these capabilities might be of considerable value as a training aid for more junior inspectors.

APPENDIX F MSO HONOLULU INSPECTOR INTERVIEW

The Honolulu Interview was conducted on Thursday, June 4. A group averaging 10 inspectors was present, all with field inspection experience.

Workload and Inspection Environment

The workload of the Honolulu office consists of the following:

- A significant number of deep-draft vessels, virtually all of which are inspected overseas (MSO Honolulu is responsible for the Western Pacific area).
- Subchapter T small passenger vessels, mostly local.
- Moderate sized inter-island tank and cargo vessels.

Inspectors' Present Experience with Computers

- In general, the inspectors in Honolulu were receptive to the idea of a portable computer system. A number of the inspectors there regularly use notebook computer PC's (which they must purchase themselves) to keep their inspection diaries. These computers are used either in a stateroom on the vessel or back at the office or hotel room.

Inspection Documentation and MSN Considerations

- Inspectors cited the inefficiencies caused by duplication of effort and redundancy in their paperwork and record-keeping (the need to enter the same information several times) and redundancy.
- A majority of those interviewed felt that arrangement of the inspection information by location rather would be an improvement over the present system which is arranged by systems. [Note: Inspectors in other ports have expressed a desire to retain the present system-oriented format. Since both systems seem to have a number of advocates, it may be desirable that the software allow an electronic checklist to be presented in either format].

  Most of the inspectors felt strongly that an electronic form of inspection book would be a great improvement and that it should be vessel-specific to as great a degree as possible. The inspection checklist would be downloaded from a central computer into an inspector's portable computer in much the same manner as the PIP is now printed out, and would contain only information which pertained to the specific vessel, possibly arranged in a manner suitable to that vessel.

- The electronic inspection checklist should incorporate vessel-specific information concerning due dates for inspection of equipment items.

- Honolulu inspectors felt that most of the information provided in the MIPIP is more or less useless to inspectors. A lot of this information is equipment serial numbers and other info that is initially entered in a vessel's file during its new construction inspection and is not subsequently updated when changes are made.

- In most CG inspection ports, vessels are rarely inspected by the same inspector more than once, and often vessels are seen which were last inspected by another port. There is presently no uniform system by which the diaries, worklists and other semi-official but potentially useful information pertaining to past inspections of a given vessel is made available to an inspector. The information which is permanently retained in the MSN system contains very little detail concerning an inspector's subjective overall impression of a vessel or concerning past deficiencies which have been corrected. The information from past CG-835 forms is generally available, but in many cases, inspectors have difficulty interpreting the meaning of some items on the CG-835 forms without access to supporting information such as the diaries.

  Most inspectors would like to have the option of reviewing inspector's diaries, worklists, and repair records of a vessel. Recent changes to the MSN system allow a text file product set to be attached into a vessel's record, but this capability has not been utilized because entry of information into and retrieval from the system is difficult and because of file compatibility problems between MSIS and the DOS-based systems most inspectors use for writing diaries and worklists. Most inspection offices do not have enough MSIS workstations for inspectors to accomplish their present work efficiently, so expanding the amount of work on the system is presently impractical.

- The bridge record card (CG-2832) on all inspected vessels is generally the most current record of outstanding deficiencies, repairs, etc. It is usually more up-to-date than the MSIS. When a vessel enters a port other than its last port of inspection, this card is a primary reference for the inspectors there, but they don't have access to the information until they actually go aboard the vessel.

  During an inspection, a lot of information is generally copied from the bridge record card by the inspector. One suggestion was to have a floppy disk version of the card kept on the ship as well. A simple program in the inspector's computer could download the applicable parts of the record card, and an updated version would be written to replace the present disk at the conclusion of the inspection. The information should also be immediately entered into MSIS as a temporary file attached to the vessel's record to allow immediate system-wide access to the most current inspection information pertaining to the vessel.

- Inspectors cautioned that any new system or modifications to MSIS in order to integrate computer-assisted inspection into the system should avoid certain problems that have made MSIS more of a burden than a help to inspectors. Among these problems are:

  MSIS has shifted an administrative burden directly to field inspectors, who are already overworked. The coding of MSIS entries is time-consuming and difficult, with little effort having been expended to make the system more user-friendly. Inspectors see no immediate benefit from the cumbersome data entry procedure. Although inspectors would like the system to be able to provide more information, they are concerned that any expansion of the information handled by the system will also expand their responsibilities in processing the information.

  Inspectors would be happy if raw data such as drafts of diaries and worklists could be attached directly to a vessels file, without further editing or coding, for the use of future inspectors of that vessel. However, present system administration requires that all entries be coded to allow statistical analysis; this is presently a burden on inspectors, and expanding this procedure to more information would make an already bad situation much worse.

  In several cases, the MSIS system has been used by administrative personnel as a "big brother" device. Statistics derived from MSIS data were used to show that the number of inspections conducted per man-week for several inspectors had dropped from one year to the next. The inspectors involved felt that the system did not contain sufficient information about the level of difficulty of inspections, which greatly affects the required time for inspection.

System Requirements

- Hardware preferences:
  Pen-based system with a screen size similar to a notebook.
  Ability to use a standard PC keyboard, and an appropriate stand to allow use of the pen computer as a screen.
  Printer, ink jet or similar, high quality not necessary, but should be lightweight.
  CD-ROM drive, preferably external.
  External DOS 3-1/2" HD floppy drive.
  Long-distance wireless communication capability.
  Carrying case that incorporates all peripherals.

  Software:
  A standard keyboard-based word-processing program.

- Inspectors need some guidance in selecting the correct regulation in cases where multiple regulations apply to the same situation. A system which provides access to the text of regulations might incorporate such guidance.

- Access to graphical information on a portable inspection computer system:
  General arrangement plans, especially if vessel-specific, would be very helpful.
  Vessel-specific structural detail plans would be somewhat helpful, but should have a low priority.
  Generic structural plans would be of little use.

- Digital photography and the ability to annotate photographs on screen would be useful in inspections of repairs. However, low-resolution 2D gray-scale digital photographs of complicated 3-D structures are not likely to be highly useful to anyone except the person who took the picture. Higher resolution color digital photographs, taken with a more powerful light source than those currently included in digital cameras might be more useful.

- Equipment inspections:
  Software to support deck-safety inspection checklists require counting capability (life preservers, etc.).
  Present inspection lists lack information on location and numbers of boiler valves.
  Inspection checklist items should include the function of equipment. Present lists (the information in the MIPIP) do list equipment by manufacturer, serial number, and rough location. Since many items are replaced by equivalent equipment as a result of maintenance and repairs, and may even be moved to other locations, all without the MSIS listings being updated, information about manufacturer and serial number is often useless in unambiguously identifying a specific piece of equipment. Equipment such as valves, air receivers, etc, should be primarily identified by function.

- A portable printer would be useful for printing:
  worklists
  CG-835 forms
  excerpts from regulations and reference materials

- As a general rule, a computerized system should be designed to make it unnecessary for the inspector to re-enter any information which is already known to the system, such as the vessel's name and documentation number and other such information which is not subject to change. Presently, inspectors spend a considerable amount of time and effort repetitiously writing down names and numbers on various forms and records.

- The amount of regulatory information which inspectors must know and which applies to the vessels they inspect continues to increase. In addition to direct statutory and regulative requirements (U.S. Code and Code of Federal Regulations), there are standards included by reference in CFR regulations (ABYC, NFPA, ASTM, ASME, etc.), NVIC's, International Regulations (SOLAS), Commandant Instructions, MVI Policy letters, and local OCMI directives and policy letters. An accurate and continuously updated cross-referencing system for such information is becoming more and more necessary.

APPENDIX G WORKSHOP WITH MARINE INSPECTORS 7/1/92 AT NEW ROCHELLE, NY

This workshop was conducted with the COTR and one contractor representative, along with 8 marine inspectors who were attending a diesel engine inspection course at New York Maritime College.

The contractor's preliminary proposals for an inspection computer system were presented, a pen-based computer with a simple inspection example was demonstrated, and a demonstration of a pen-based graphical application was demonstrated on a notebook computer.

The inspectors present were positive and enthusiastic about the potential for an inspection computer system. Many of them had considerable experience with computers and all were computer-literate to at least some extent.

Graphical Applications of an Inspection Computer

- A procedure whereby structural defects would be located by noting their location on three one-dimensional views of the vessel's arrangement was demonstrated and discussed. The inspectors felt that, for their own purposes, this would not be any better than the current system of taking notes and sketches with paper and pencil and later reporting defect locations in text form. However, they did feel that a graphical defect location scheme might be more useful when the information needed to be made available to owners and yard personnel for repair proposals and location of the problem areas and to the OCMI and subsequent inspectors for repair authorization and inspection. In addition, it was felt that a graphical display of defects might be an aid to trend identification.

- A graphical display of internal structure, including typical structural joints which frequently fail, would also be very helpful in repair authorization and subsequent deficiency inspections of repaired areas.

  One suggestion was to have a number of typical generic structural details available as icons in a pen-based CAD sketching system. An icon could be selected, zoomed if necessary, and annotated to identify and describe a structural failure. This information would then be available to the owner and yard in planning repairs, to the coast Guard for approving proposed repair strategies, to the shipyard for locating the problem and making the repairs, and to the inspector who must check to see that the repair has been completed as required.

- Inspectors felt that specific vessel plans would be helpful if CAD files of a particular vessel or class were available and if appropriate software were available for zooming and bringing up usable views.

Inspection Documentation and MSIS

- Inspectors would like to have access to MSIS at home.

- It was suggested that if current inspection information could be made available system-wide immediately after an inspection, the bridge record cards would no longer be necessary. AT least, the record cards could become a backup - a record printed on the spot from the inspector's computer; the information now contained on the card would be automatically downloaded onto an inspector's computer and copying information off the bridge record cards would no longer be necessary.

- MSIS should incorporate a help facility for displaying and allowing menu picks for the required entry codes.

- Inspectors are concerned that added overhead work associated with a new system could add to their workload. They point out that MSIS, which was originally touted as a system to streamline the inspectors' work, actually increased their administrative workload.

System Requirements

- Inspectors cautioned that any computer system selected should have sufficient memory and clock speed, or at least upgrade capability to meet future needs and to handle more sophisticated software which might follow the first-generation system.

  Screen scrolling rates and rewrite times should be an important consideration in development of any inspection hardware and software. Inspectors are often pressed for time and waiting for a slow-responding computer display could make matters worse.

- EMI interference is a concern in shipboard environments. Large rotating AC and DC machinery is commonplace. Welding cables carrying high DC currents are also common in the shipyard environments in which most structural inspections of deep-draft vessels take place.

  Radiographic interference is encountered both in the shipyard from weld inspection Xrays and in airports.

- Inspectors' wish-list items:

  Time-management and scheduling software

  An up-to-date vessel-specific telephone directory

APPENDIX H WORKSHOP AT CG HEADQUARTERS 7/23/92

This workshop was conducted on July 23, 1992 at CG Headquarters. G-MVI staff personnel, the project COTR, members of the traveling inspection staff, a representative from MIO New York, and headquarters personnel involved with MSIS and computer systems were present. MAR's preliminary proposals for an inspection computer system were presented and discussed.

- Inspectors would like better access to old records for vessels. An example given was certain Subchapter T small passenger vessels which are 40 or more years old. These vessels have had letters issued from various OCMI's over the years waiving certain regulatory requirements. When such a vessel changes ports or remains in service in the same port for a very long period of time, records such as these waivers are often lost. An electronic data storage system that included all relevant information about the vessel would make that information available system wide, and there would be no question where that information is located.

- Former and present field inspectors, including traveling inspectors, reiterated the opinion expressed previously by many others that very few, if any, inspectors would use a portable computer as a direct data collection device in a hazardous location like a cargo tank of a tank vessel. Some inspectors questioned whether a portable computer would be used in an engineering space inspection, either.

- Two pen-based computers were shown to the group and demonstrated. The possibility was discussed that a keyboard-based notebook computer might serve the inspectors' needs as well as or better than a pen-based machine, if no inspectors were likely to use the device as a portable (i.e. hand-carried) machine in the first place. The notebook computer could incorporate a floppy disk drive, a high-capacity internal hard disk drive, and possibly a CD-ROM drive, while the pen-computer would only have access to high-capacity rotating storage media through an expansion or docking connector. However, the majority of the group felt that the walk around capability was worth retaining, even if access to large storage devices was made a bit more difficult. In addition, other departments of the CG are already more or less assuming that pen-based computers will eventually be used extensively for certain law enforcement, safety, and pollution response functions, and that using a standard machine throughout the service would be advantageous to everyone.