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Results of a Field Study of the Performance Enhancement System: A Support System for Aviation Safety Inspectors

Charles F. Layton
Galaxy Scientific Corporation
Atlanta, Georgia 30345

William T. Shepherd
Office of Aviation Medicine
Federal Aviation Administration
Washington, DC 20591

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16. Abstract

The Performance Enhancement System (PENS) is a prototype electronic performance support system for Aviation Safety Inspectors (ASIs). PENS facilitates field data collection, information management, and on-line references, thus eliminating paperwork, redundant data-entry tasks, data errors, slow data-entry and turnaround times, and bulky paper references. PENS allows ASIs to collect field data in the format used by national FAA databases and it allows them to verify data at the time of inspection. A national field study of PENS was conducted. The study consisted of fielding four different computers to four ASIs in each of nine FAA Flight Standards District Offices across the country from November 1993 through March 1994. Study results indicate that the complex information management difficulties encountered by ASIs will not be solved by purchasing computer hardware alone. Rather, appropriate field software applications must be developed that will work in combination with field computer hardware to provide ASIs with a system of tools that supports their daily responsibilities. The ASIs must be closely involved in the continued development of these tools to ensure that they are designed to meet the inspectors' needs.

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The authors also thank all of the inspectors in the Flight Standards Service who participated in this study. Without their support this study would not have been possible. We look forward to continuing this work on their behalf.

EXECUTIVE SUMMARY

The Performance ENhancement System (PENS) is a prototype pen computer-based electronic performance support system for Aviation Safety Inspectors. Several issues related to the efficacy of computers for field use have been identified and study results are discussed. These results have broad implications for implementation of field computer applications.

The Performance ENhancement System (PENS) is a prototype pen computer-based electronic performance support system. PENS is an outgrowth of the Federal Aviation Administration's Flight Standards Service Information System Strategy, which has the goal of improving efficiency by taking a user-centered approach to matching automation capabilities to personnel needs. PENS is designed to support Federal Aviation Administration (FAA) Aviation Safety Inspectors (ASIs) in their daily inspection tasks. ASIs make up the inspection team for the Flight Standards Service within the FAA. ASIs are responsible for ensuring that aviation industry organizations comply with federal safety regulations. ASIs inspect maintenance, training, and operational facilities across the country. Whereas inspectors previously carried two briefcases full of books and forms into the field, PENS allows them to replace these materials with a lightweight notebook computer.

PENS facilitates field data collection, information management, and on-line documentation, thus eliminating paperwork, redundant data-entry tasks, data errors, slow data-entry turnaround times, and bulky paper references. PENS allows ASIs to collect field data in the format used by national FAA databases and it allows them to verify data at the time of inspection. Inspectors currently complete paper forms (up to 400,000 PTRS forms annually) and give them to data-entry clerks who often make transcription errors. There is often a two-week interval between data collection and entry into the national databases.

The PENS field study consisted of fielding three different models of pen computers and one standard notebook computer to four ASIs in each of nine FAA offices across the country from November, 1993 through March, 1994. Thus, 36 computers in all were put into the field. Each inspector used one of the computers for a week and then rated it on such factors as weight, ease of use, speed, preference, etc. The inspectors then rotated to another computer; the rotation was counter-balanced to eliminate order effects. At the end of four weeks, the inspectors compared the four computers and evaluated the PENS software (which was consistent across the computers). The study sites ranged from as far north as Fairbanks, AK, to as far south as San Juan, PR. Questions of interest included: Was a pen computer necessary, or would a notebook computer suffice? Would a computer be used in the field? What factors affect preference for one field computer over another? What environmental conditions preclude use of a field computer? As increasing marketing emphasis is placed on mobile computing, the answers to these types of questions will gain interest among human factors practitioners.

Inspector Characteristics

Four airworthiness (maintenance) aviation safety inspectors at each of nine sites (for a total of 36 inspectors) participated in the study. The inspectors averaged 49 years in age, had been inspectors for five and a half years (thus, it was their second job; most airworthiness inspectors are former aircraft mechanics), and had five and a half years of computer experience. Sixty-five percent of the inspectors use the current data entry system and sixty percent own computers.

Note that the inspectors' computer experience corresponds with their experience as ASIs. The current computer systems installed at the field evaluation sites run a very limited set of DOS applications, as opposed to Microsoft Windows applications; PENS runs in Microsoft Windows for Pen Computing.

Training was given according to time, rather than to criterion. Inspectors were trained for two days. The first day of training consisted of an explanation of file storage conventions, DOS, Windows, and handwriting recognition (including training the computer to the inspectors' handwriting). The second day consisted of training on the PENS software.

Much more time was spent covering basics in Windows than was originally thought necessary. Even though each office had Windows installed on its workstations, inspectors were generally inexperienced with respect to that operating environment. The most likely reason for their inexperience was that few of the inspectors had a need to run Windows software. The extra Windows training did not significantly affect the amount of training devoted to PENS, as there was time left at the end of the second day of training.

Materials

Three different models of pen computers and one standard notebook computer were fielded at each office. Thus, 36 computers in all were put into the field. These computers were selected based on their particular combination of features and differentiating characteristics. That is, the computers were selected because they had certain features in common, but they also had a particular feature that made them unique compared to the others. These three computers allowed the inspectors to evaluate the tradeoffs between weight, versatility, and speed. These features are summarized below.

GRiD Convertible	NEC VersaPad	TelePad SL	Toshiba Satellite T1900
486/25 MHz CPU	486/25 MHz CPU	386/25 MHz CPU	486/25 MHz CPU
200 Mb Hard Drive	80 Mb Hard Drive	200 Mb Hard Drive	120 Mb Hard Drive
Built-in Keyboard	Separate Keyboard	Separate Keyboard	Built-in Keyboard
Pen Stylus	Pen Stylus	Pen Stylus	Trackball

Features common to all four computers:

- 8 Mb RAM
- Backlit LCD Monochrome display
- PCMCIA Data Storage Card
- DOS 6.0
- Windows
- Microsoft Word 2.0 (except the NEC VersaPad)
- PENS Prototype Software

Results--Computer Platforms

The inspectors were asked to rate a number of usability characteristics of the computers. Such characteristics included weight, ease of use, screen characteristics, environments in which the computer was used, and the like. In comparing the particular characteristics of the pen computers, the only significant difference was that the GRiD Convertible was judged to be more comfortable than the NEC VersaPad. This result is consistent with inspector comments that the case made using the VersaPad difficult and cumbersome, whereas the Convertible was much more compact and easy to use.

When the ratings for the pen computers are compared against the notebook computer (Toshiba Satellite T1900), both the GRiD Convertible and the TelePad SL were judged to be faster. The VersaPad was generally disliked by the inspectors, and that dislike may have biased the inspectors when evaluating it. The VersaPad originally was thought to be a good computer to examine the tradeoffs between computer characteristics: it had a smaller hard disk, but was also much lighter in weight.

Finally, the inspectors addressed the tradeoff between weight and capability: many of the inspectors complained that the VersaPad did not have enough hard disk capacity because it was too small to contain the on-line versions of both the FARs and the Airworthiness Inspectors' Handbook.

Perhaps the most telling data collected on the computers was in response to the question: "Would you use this computer in the field as part of your job?" The GRiD Convertible and the TelePad SL were generally preferred over the NEC VersaPad and the Toshiba Satellite. One must note, however, that none of these computers are currently in production. The GRiD Convertible and the NEC VersaPad have been removed from the market. The TelePad SL is due to be replaced this Fall with the TelePad 3, and the Toshiba Satellite T1900 has been replaced by another model.

Because the notebook computer was comparatively heavy and cumbersome, it was extremely difficult to use while actually performing an inspection. While a pen computer could be easily operated with two hands, the notebook computer really needed a flat surface to rest it on. Inspectors indicated that they definitely would not be able to use a standard notebook computer as part of their daily routine, whereas a pen computer was feasible.

Interviews with the inspectors indicated that immediate recording of field data may not always be required, but immediate access to previous data or regulatory materials is required. Thus, the computer is a better information management and retrieval tool than a data collection vehicle for many inspection activities.

Inspectors were unanimous in requesting computers that were smaller and lighter. They were particularly interested in devices that would fit in their coat pockets, such as personal digital assistants (e.g. Apple Newton, Tandy/Casio Zoomer, etc.). Currently such devices do not have the storage or processing resources to run the applications necessary for ASIs. Inspectors were also intrigued by the possibility of using speech recognition for data collection so that their hands would remain free.

A number of additional concerns were raised by the inspectors during the study. Many of the inspectors were concerned about liability for the equipment should it be stolen, dropped, or left on an airplane. Some inspectors were concerned with the perceptions of the people they were inspecting; that is, they were worried that they appeared inept or incompetent when using the computers. Others were concerned that the computer lent an air of permanence to notes they made and, as a result, operators would be less cooperative (even though notes made on paper had the same degree of permanence). While there are practical solutions to all of these issues, the issues themselves go well beyond the questions of which computer is better or can a field computer be used for one-time data capture.

With regard to environmental considerations, the inspectors commented that the computers stopped working once the temperature approached freezing. Such cold temperatures also make it more difficult to use computers because of the need to wear gloves, bulky coats, etc. Finally, as might be expected, the inspectors were also reluctant to use the computers in the snow or rain for fear of damaging them.

The accompanying report addresses all of these issues in much greater detail. In addition, insights into what would be required of a completed PENS software application are addressed. The concerns raised by inspectors and potential solutions to those questions are discussed at length. Finally, recommendations for future field studies are made.

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RESULTS OF THE PERFORMANCE ENHANCEMENT SYSTEM FIELD STUDY: A SUPPORT SYSTEM FOR AVIATION SAFETY INSPECTORS

BACKGROUND

The Performance ENhancement System (PENS) represents a series of investigation and implementation phases supporting the goal of matching the needs and responsibilities of Flight Standards Service (FSS) Aviation Safety Inspectors with automation capabilities. This project is a direct result of the FSS Training and Automation Committee's Information Systems Strategy, which recommended that all future automation systems be developed in conjunction with the work force so that the systems are designed to meet their needs and desires. The Training and Automation Committee has been instrumental in supporting PENS and providing project oversight.

One characteristic of ASI activities is field data collection. The data are collected on paper forms and these forms are transcribed by data entry clerks into computer databases. These data are then recorded in a national database and are used to monitor the safety of the aviation industry. Another characteristic of field inspector activities is that they must authoritatively answer questions as they arise. This need requires ASIs to carry voluminous, bulky, cumbersome copies of regulations and guidance in the field.

There are four primary concerns which provided the impetus for PENS. First, data entry clerks represent a significant annual expense for FSS. If it were easy for inspectors to record their data in the computer databases themselves, FSS would save money spent on data entry. Second, there is a significant time delay (up to two weeks) in transcribing forms. By decreasing that time delay, FSS would be more effective at monitoring and ensuring compliance of the aviation industry. Third, many data transcription errors occur from the current process. The Government Accounting Office has repeatedly criticized the FAA for the quality of its data. Fourth, the paper regulations and guidance materials are not used effectively because of their bulk and because they are difficult to maintain. When combined, these factors point toward automation as a potential solution. In particular, field automation at a minimum would allow the ASIs to: 1. store data directly in the proper database format; 2. verify the validity of those data at the time of the inspection; 3. eliminate the time delay associated with transcription; and 4. quickly and easily use on-line guidance materials with minimal maintenance of the documents. Other benefits would accrue as more tools were added to the field computers.

The project started as an investigation into the utility of pen computers for aviation industry inspectors and maintenance technicians sponsored by the Office of Aviation Medicine (AAM). This phase of the project continued from approximate January of 1992 through August of that year. Meanwhile, FAA Administrator Thomas Richards had learned of pen computers and thought they might be a good tool for Aviation Safety Inspectors. He requested briefings from the Flight Standards Service (FSS). The Flight Standards Service learned of the AAM research and requested information in August 1992. After a series of briefings to FAA personnel, including Clyde Jones, FSS Director Thomas Accardi, and Associate Administrator for

Regulation and Certification Anthony Broderick, we briefed Administrator Richards in November, 1992, and Acting Administrator Joseph DelBalzo in January, 1993.

Between January and August 1993, PENS received a lot of publicity within the Flight Standards Services, both in the FSS Headquarters and in the field. Meanwhile, the project was continuing at a low level of funding from the Office of Aviation Medicine. From August 1992 through August 1993, a series of task analyses and prototypes were carried out to determine the basic content of a field computer tool. The Fort Lauderdale Flight Standards District Office (FSDO) was fundamental to these initial analyses and prototypes.

Funding for a national field human factors study of PENS concepts was provided in August and October of 1993. Because of all of the publicity that had occurred over the previous year, FSS Headquarters felt considerable pressure to start the field study quickly once funding was available. After some very rapid prototyping and testing with Atlanta FSDO inspectors, the national field study began on November 15, 1993 and continued until March 1, 1994. The following is a description of the PENS concepts that were evaluated, of the nature of the field study, the important results, lessons learned, recommendations for future study, and considerations for full implementation.

SYSTEM DESCRIPTION

The Performance ENhancement System, PENS, represents a suite of tools to support Flight Standards Service Aviation Safety Inspectors (ASIs) in the field. PENS addresses data quality, data collection, efficient access to regulatory information, decision support, work program management, and a host of other issues.

The general data collection concept is that a pen computer will replace the inspector's clipboard. (Pen computers are approximately the same size as clipboards.) The system presents an enhanced version of the Program Tracking and Reporting Subsystem (PTRS) form, as well as job aids and other forms. In many cases, the inspector does not need to write data on the form; instead, he/she is able to select entries from lists. The error checking procedures that are built into the current PTRS data-entry system are also present in the PENS PTRS. The PENS prototype PTRS form is shown in Figure 1.

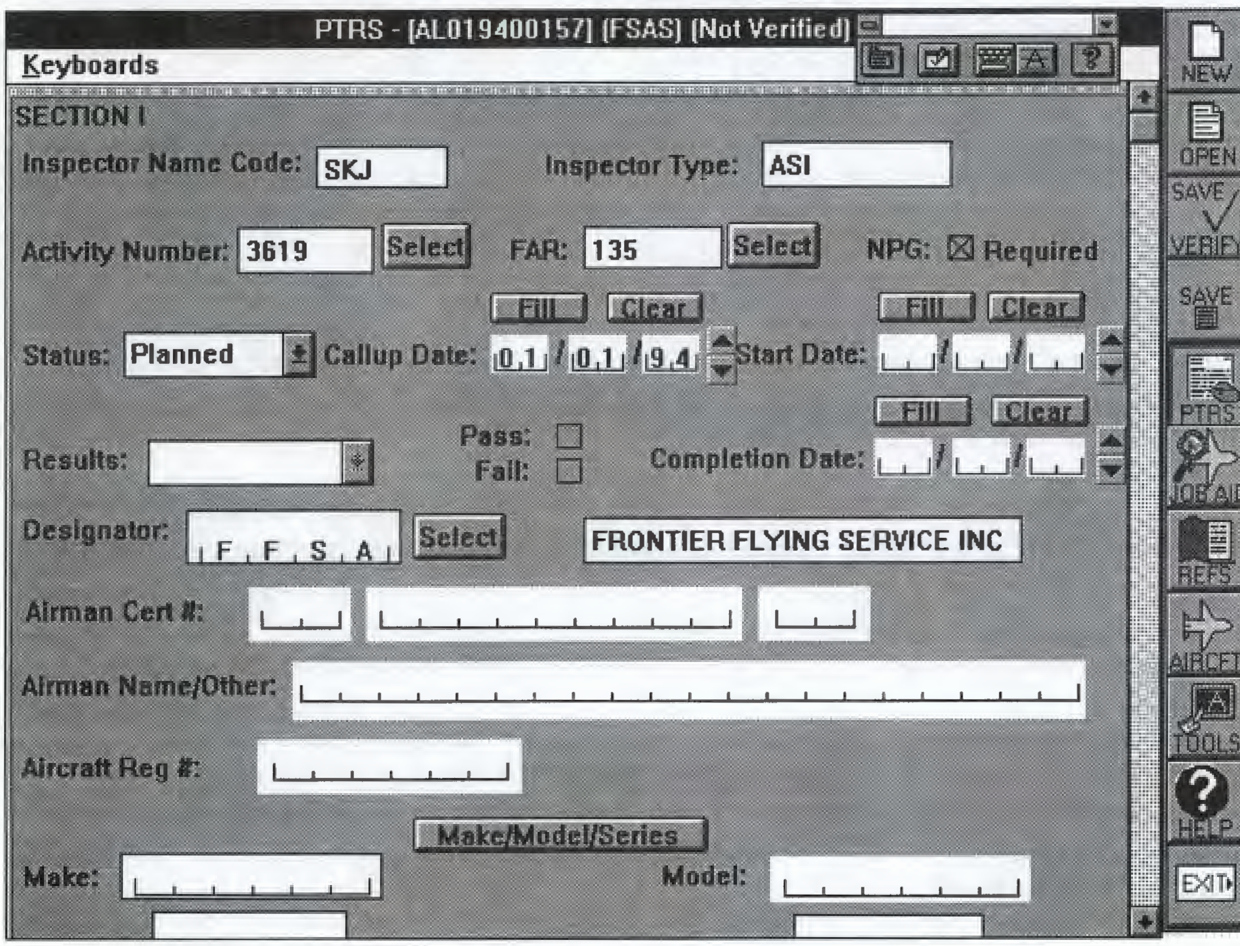


Figure 1: PENS Prototype PTRS Form

The completed PENS software will include additional error prevention mechanisms that are not included in the Flight Standards Automation System (FSAS) PTRS. Such mechanisms will have the additional benefit of speeding data collection. For instance, the forms could be linked to other FAA databases. This will allow the system to fill in default information on the PTRS form. For example, if the inspector were performing an airworthiness ramp inspection on Mythical Airlines and Mythical flew only Boeing 737s, the form would automatically fill in B737 on the PTRS form.

The system allows inspectors to collect field data and store it in the proper database format immediately, thus eliminating the need for data entry clerks. Instead of giving paper PTRS forms to data-entry clerks or sitting down at a data-entry terminal in the office, the inspector connects the pen computer to the office network and starts a software utility that transfers all of the field-collected data into the office database while the inspector takes care of other business. Furthermore, the forms will be linked together so that an entry in one form propagates to the other forms, thus eliminating the redundant data entries required for paper-based forms.

PENS automatically loads all reference materials required to perform a given activity. Inspectors currently carry two briefcases full of books with them on their daily inspections. A regulatory document system will replace these books with information stored on the hard disk of the pen computer or on a CD ROM. All of the Federal Aviation Regulations (FARs), the Inspectors' Handbooks, Airworthiness Directives, Advisory Circulars, FAA Orders, and other regulatory documents and reference material will be available on the computer. These documents will be incorporated into an easy to use system that will allow the inspectors to quickly answer questions in the field. The inspector will be able to browse through the information as if it were in a book, but he/she will also be able to ask the computer to search all of the documents that discuss a particular topic. For instance, if an airline operator asks an inspector "Do I have to file a report if I find corrosion on one of my planes?", the inspector will be able to write or type the word "corrosion" and initiate a computer search of the FARs. The computer will then display FAR Part 121, Subparts V "Mechanical Reliability Reports", with the word "corrosion" highlighted. An example of such a search is shown in Figure 2.

PENS includes work program management utilities that allow an inspector to quickly determine the percentage of her/his work program that is completed, remaining inspections, inspections planned for a given day or time period, the planned inspections for a given operator, and the like. This capability obviates the need to carry large, cumbersome printouts into the field to monitor progress and schedule inspections. A rough prototype of such a utility is shown in Figure 3.

Additional capabilities might include report and letter generators that would automatically produce these documents when required based on inspection outcomes. The data collection system could be tied to on-line documents. For instance, if an inspector is performing a ramp inspection on a given aircraft, PENS could notify her/him of all of the Airworthiness Directives that apply to that aircraft.

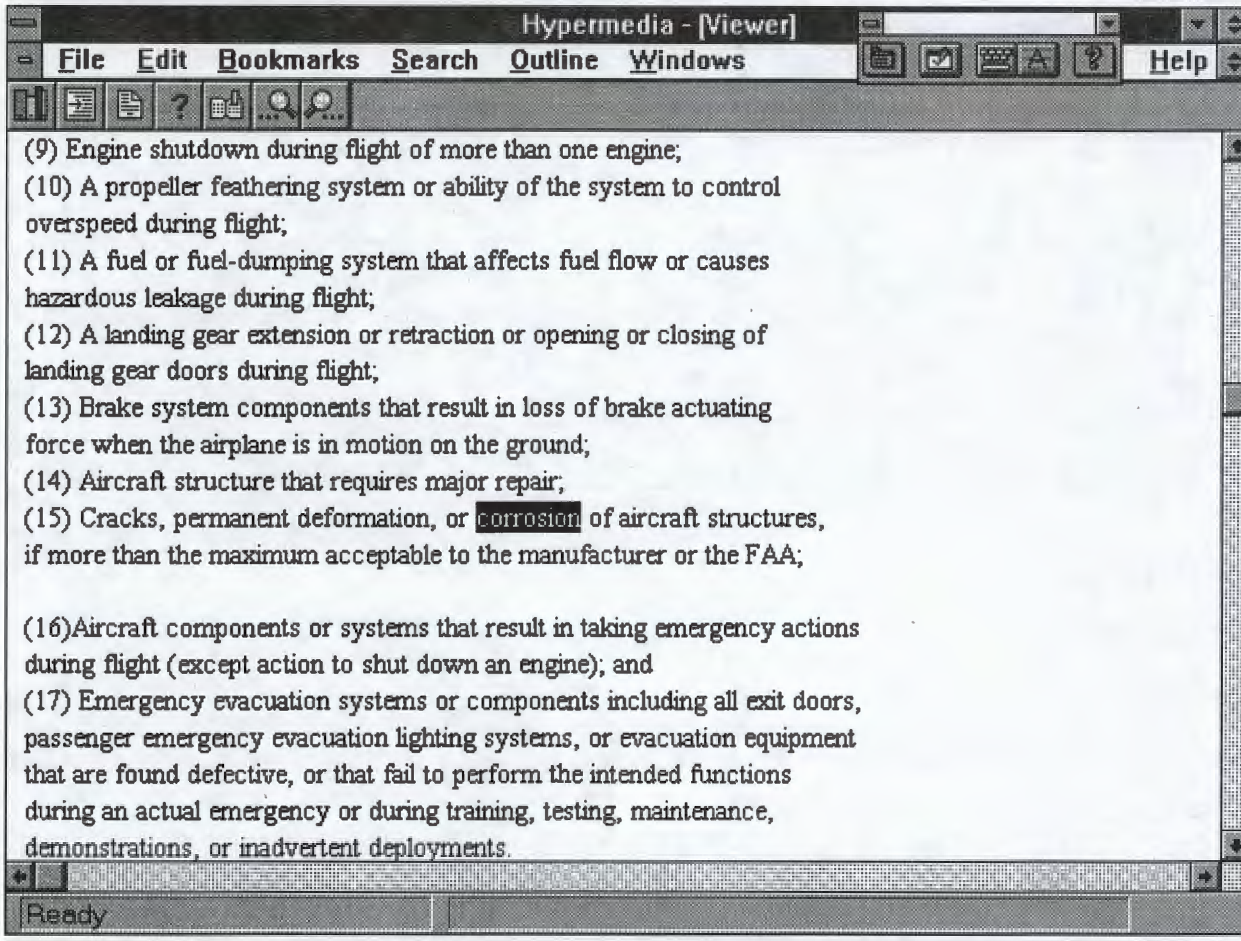


Figure 2: Example On-Line Search

For in-depth inspections, inspectors could load database information into PENS prior to leaving the office so that they could run the Safety Performance Analysis System (SPAS) while in the field, thus supporting decision making. A portable printer would allow inspectors to issue certificates in field. These capabilities are just some of the things we have in mind for PENS. (SPAS is being developed to assist inspectors in tracking the performance of operators with regard to specific safety parameters. SPAS will help field personnel to decide when resources should be reallocated to operators that are having difficulty.)

For each capability, a prototype will be thoroughly field tested before it is fully implemented. This will ensure that the tools will be designed to meet inspectors' needs. The following is a description of the first such study. This study investigated the feasibility of field computers for ASIs by fielding four such computers running an enhanced PTRS form, a data transfer utility, and on-line FARs and the Airworthiness Inspectors' Handbook.

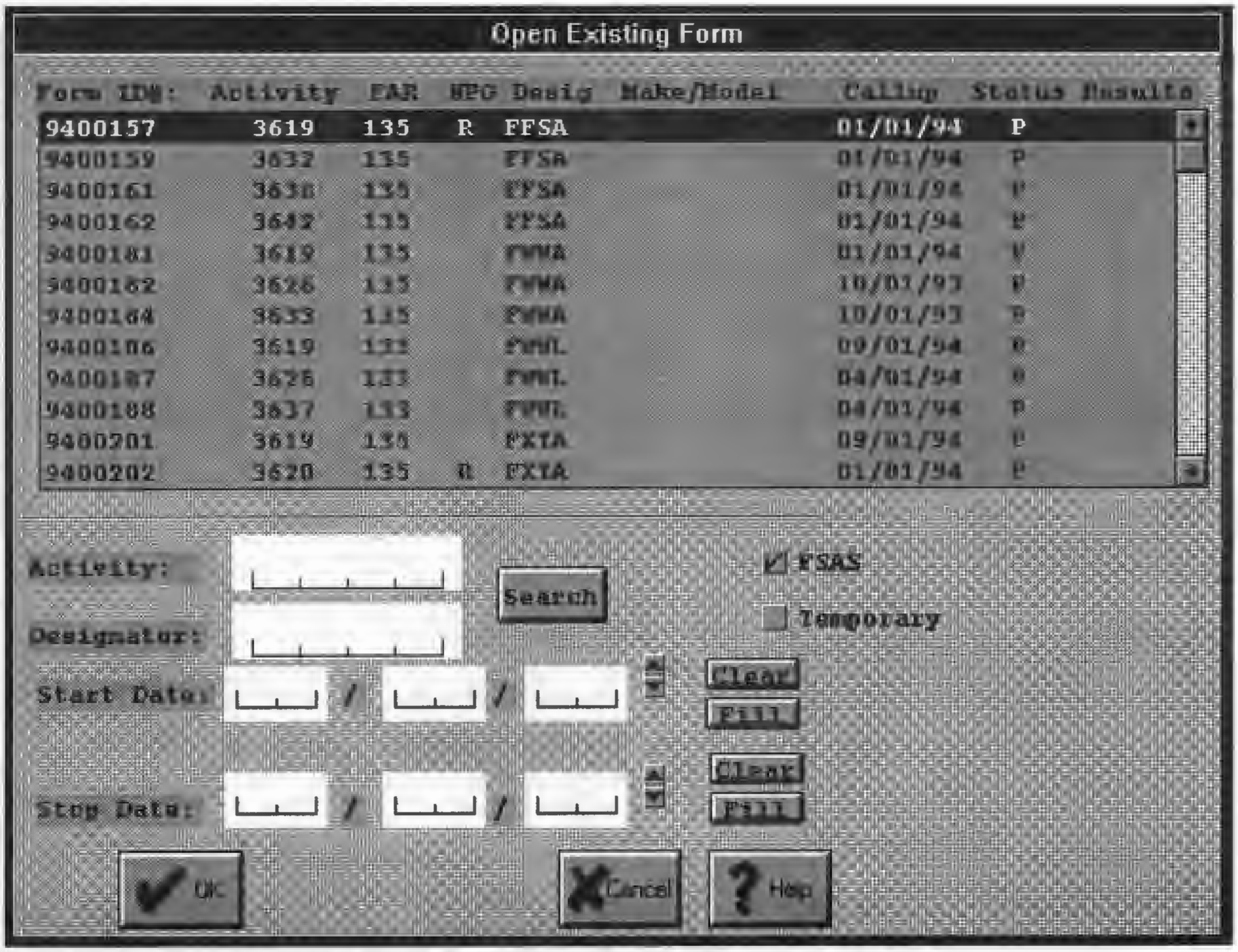


Figure 3: Prototype Work Program Utility

FIELD STUDY

The field study was conducted in all nine regions of the FAA to test the equipment in a wide range of environmental conditions. The study was conducted from mid-November until early March, from offices as far north as Fairbanks, Alaska, to as far south as San Juan, Puerto Rico.

The PENS field study was developed to test the viability of field computers and to learn the hardware and software issues that would need to be addressed by an implemented system. The study subjected the computers to a wide range of environmental conditions, from the cold and snow of Fairbanks, to the heat and humidity of San Juan. Inspector computer expertise was also investigated as part of the study. The following is a description of the field study methods, results, and discussion.

Methods

The field study was conducted from November 15, 1993 through March 1, 1994. Each FSDO in the study participated for approximately one month. Nine offices, one per region, participated in the study; these offices, the installation dates, and prevalent weather conditions are shown in Table 1.

Table 1: PENS Field Study Sites

Region	FSDO	Environment	Installation Dates
Great Lakes	Milwaukee, WI	Cold, snow	November 15-16
Central	St. Louis, MO	Cold, rain, snow	November 18-19
Southwestern	Ft. Worth, TX	Warm, dry	November 21-24
Western Pacific	Long Beach, CA	Warm, humid	November 29-30
Northwest Mountain	Seattle, WA	Average, humid	December 2-3
Alaskan	Fairbanks, AK	Extreme cold, dry	December 6-7
New England	Boston, MA	Cold, snow	December 13-14
Eastern	Harrisburg, PA	Cold, snow	December 16-18
Southern	San Juan, PR	Hot, humid, rainy	January 10-11

These offices were selected with the help of Regional Managers because they were medium in size and they were willing to participate. The criterion that one office per region participate meant that the study would undergo a wide range of environmental conditions. The two extremes were Fairbanks with daytime high temperatures in the -10° to +10° F range and snow and San Juan with daytime high temperatures in the 85° to 100° F range, high humidity and thunderstorms. The remaining offices were intermediate between those extremes, both in temperatures and weather conditions.

In addition to the nine regional sites, a pilot evaluation was performed at the Atlanta FSDO to test the evaluation plan and identify potential problem areas. Thus, the pilot evaluation served as a dry run to ensure that the full evaluation would proceed smoothly.

Hardware

A total of thirty-six computers (nine units of each of four models) were fielded. These computers were selected based on their particular combination of features and differentiating characteristics. That is, the computers were selected because they had some features in common, but they also had a particular feature that made them unique compared to the others. These features are described in Table 2.

Table 2: Computer Platforms

GRiD Convertible	NEC VersaPad	TelePad SL	Toshiba Satellite T1900
486/25 MHz CPU	486/25 MHz CPU	386/25 MHz CPU	486/20 MHz CPU
200 Mb Hard Drive	80 Mb Hard Drive	200 Mb Hard Drive	120 Mb Hard Drive
Built-in Keyboard	Separate Keyboard	Separate Keyboard	Built-in Keyboard
Pen Stylus	Pen Stylus	Pen Stylus	Trackball

These computers allow us and inspectors to address the following questions:
1. Is a field computer a viable solution?
2. Is a pen computer required, or will a standard notebook computer suffice?
3. Does a faster processor make a difference?
4. Is a separate or built-in keyboard preferable (given that it adds weight)?
5. Which is preferable: A lightweight machine with limited functionality or a slightly heavier machine with increased functionality?

Features common to all four computers:
- 8 Mb RAM
- Backlit LCD Monochrome display
- PCMCIA Data Storage Card
- DOS 6.0
- Windows (Windows for Pen Computing or Windows 3.1; functionally equivalent except for handwriting recognition)
- Microsoft Word 2.0 (except NEC VersaPad)
- PENS Prototype Software

The complete specifications for these computers are listed in Appendix A.

The PENS prototype software was common to all four computers and runs nearly identically on each of the three pen computers. (The NEC VersaPad did not have sufficient hard disk space to contain the Airworthiness Inspector's Handbook or Microsoft Word.) The software ran essentially the same way on the trackball computer, with the exception that there was no handwriting recognition on that computer. (Because it used a trackball, not a pen stylus, the Toshiba Satellite ran Windows 3.1 instead of Windows for Pen computing.) The PENS software consisted of an enhanced PTRS form, the FARs, the Airworthiness Inspectors' Handbook, and Data Transfer (a utility to transfer PTRS data to and from FSAS). The PENS software demonstrated the ability to record information graphically and it was equipped with on-line help.

Training

Training was given according to time, rather than to criterion. Inspectors were trained for two days. The first day of training consisted of an explanation of file storage conventions, DOS, Windows, and handwriting recognition (including training the computer to the inspectors' handwriting). The second day consisted of training on the PENS software. Copies of the training slides can be found in Appendix B.

Much more time was spent covering basics in Windows than was originally thought necessary. Even though each office had Windows installed on its workstations, inspectors were generally inexperienced with respect to that operating environment. The most likely reason for their inexperience was that few of the inspectors had a need to run Windows software. Approximately half of the inspectors used FSAS (which is a DOS application), and few of them appeared familiar with even Windows word processors. The extra Windows training did not significantly affect the amount of training devoted to PENS, as there was usually some time left at the end of the second day of training.

Evaluation Process

A team of four inspectors in each FSDO evaluated PENS. These inspectors represented a cross-section of the inspector population in terms of age, sex, work experience, and computer experience. The inspectors were asked for background information on themselves prior to training. After training, the inspectors were asked about their comfort with the training and proficiency with the PENS hardware and software tools. Each inspector used one computer model for a week and then switched to a different model. The rotation was counterbalanced to eliminate order effects. At the end of each week each inspector evaluated the computer he/she had been using. The rotation continued until each inspector had an opportunity to use each model. (Thus, the evaluation lasted approximately four weeks per site.) At the end of the rotation, each inspector completed an evaluation form that requested him/her to evaluate the software. Copies of the evaluation forms can be found in Appendices C-F.

Results And Discussion

Several mitigating factors intervened in the study such that evaluation data are incomplete. Of the 36 inspectors participating in the study, one unfortunately passed away and one who was on temporary assignment returned to his home office. The network administrator at one site, Seattle, did not support transferring data between the field computers and FSAS, thus nullifying any results there. (As a result of not transferring data directly, the inspectors had to complete paper forms and enter the data through FSAS, as well as the PTRS form on the field computers, thus doubling their efforts with no apparent benefit to them. These inspectors quickly lost any enthusiasm for the project or the computers.) Other factors, such as travel, training, vacation, and equipment failure contributed to incomplete data. Fourteen of the thirty six inspectors evaluated all four computers and the software. The remaining inspectors evaluated between one and three computers.

<u>Inspector Background</u>

Prior to beginning training, the inspectors were asked to describe their background in terms of age, years as an ASI, computer expertise, and the like. A copy of the background questions can be found in Appendix C. The results of these questions are shown in Table 3. Blank cells indicate incomplete data. As can be seen in the table, an average inspector in the study was 49 years old and had been an ASI for five years. Nearly all of the inspectors had computer experience, with an average duration of five years. Three quarters of the inspectors have experience using FSAS. The inspectors were also asked to give their opinion (Favorable, Unfavorable, or No Opinion) on the computer manufacturers (GRiD, NEC, TelePad, and Toshiba) to determine whether they were predisposed to favoring or disfavoring a computer; nearly all of the responses were "No Opinion".

Table 3: Inspector Background Information

Office	Inspector Initials	Age	ASI Experience in Years	Computer Experience in Years	Do You Own a Computer?	Years of Computer Ownership	Do You Use FSAS?
Boston	BVO	58	3	3	No		Yes
	AR	52	7	5	Yes	8	Yes
	ALO						
	RSL						
Fairbanks	RRH	53	6	3	No		Yes
	JQG	48	6	2	Yes	2	No
	HAK	58	7	2	No		Yes
	SKJ	43	3	3	Yes	3	Yes
Ft. Worth	TLT	32	3	13	No		Yes
	LEV	57	3	12	Yes	9	No
	LNW	52	2	7	Yes	5	No
Harrisburg	RNS	50	6	7	Yes	0.5	Yes
	RRS	47	4	5	Yes	2	Yes
	FNG						
	HEG	58	8	4	Yes	3	Yes
Long Beach	JAS	50	9				
	DEG						
Milwaukee	DMH	47	4	2	No		No
	KEL	50	3	9	Yes	9	No
	ECS	52	13		No		No
	HCE	45	5	15	Yes	15	No
San Juan	FSM	35	4	2	No		Yes
	RDR	50	4	3	No		Yes
	REG	50	7	7	Yes	5	Yes
	AAP						
St. Louis	RLH	46	8	2	Yes	0.5	Yes
	CHB						
	RLS						
Average		49.19	5.48	5.58	60%	5.17	65%
Std. Dev.		6.74	2.66	4.06		4.34	
Responses		21	21	19	20	12	20

Post-Training Comfort Level

After training, the inspectors were asked how comfortable they were using the computers and the software. The materials used to ask these questions are in Appendix D. The questions and responses are summarized in Table 4. The range of possible responses was from "1, not at all comfortable" to "5, quite comfortable". In general, inspectors' responses averaged between "somewhat comfortable" and "very comfortable" with PENS after the two days of training. While it would have been nice for everyone to be "quite comfortable" after the training, the fact that the inspectors were somewhat comfortable is reassuring that the training was successful given its relatively short duration and the limited computer experience of many of the inspectors.

Table 4: Post-Training Comfort Level

"How comfortable are you with using..."

Office	Inspector Initials	a computer?	a pen computer?	handwriting recognition?	PENS?	the on-line references?
Boston	BVO	3	4	2	4	4
	AR	4	5	4	5	3
	ALO	2	2	2	1	1
	RSL	5	5	4	5	4
Fairbanks	RRH	3	3	5	4	3
	JQG	5	5	4	5	5
	HAK	3	3	3	4	3
	SKJ	4	4	4	4	4
Ft. Worth	TLT	5	5	5	5	5
	LEV	5	4	4	4	4
	LNW	3	3	1	4	2
Harrisburg	RNS	4	3	3	4	4
	RRS	4	4	5	3	3
	FNG					
	HEG	3	2	1	2	1
Long Beach	JAS	3	3	3	2	4
	DEG	3	2	2	1	1
Milwaukee	DMH	3	3	2	3	
	KEL	5	5	3	5	5
	ECS	4	4	4	3	3
	HCE	5	4	2	5	5
San Juan	FSM	4	4	4	4	4
	RDR	4	4	3	5	5
	REG	4	5	4	5	4
	AAP	3	3	3	3	4
St. Louis	RLH	3	3	3	4	5
	CHB					
	RLS					
Average		3.76	3.68	3.20	3.76	3.58
Std. Dev.		0.88	0.99	1.15	1.23	1.28
Responses		25	25	25	25	24

<u>Computers</u>

The inspectors were asked to rate a number of usability characteristics of the computers. Such characteristics included weight, ease of use, screen characteristics, environments in which the computer was used, and the like. Appendix E contains copies of the evaluation questions for each model of computer.

Inspectors were asked to use a three point scale for judging each attribute. The possible responses for "Weight", for example, were "Too Heavy", "Adequate", or "Too Light/Fragile". While responses were verbal, they were normalized to a numeric scale. In the "Weight" example, "Too Heavy" was assigned a value of 1, while "Too Light" was assigned a value of 3. The following will aid interpretation of the data:

Table 5: Interpretation of Evaluation Responses

Attribute	Response/ Normalized Value	Response/ Normalized Value	Response/ Normalized Value	Interpretation of Average Response
Weight	Too Heavy 1	Adequate 2	Too Light 3	<1.67 Too Heavy >2.33 Too Light
Size	Too Large 1	Adequate 2	Too Small 3	<1.67 Too Large >2.33 Too Small
Speed	Too Slow 1	Adequate 2	Too Fast 3	<1.67 Too Slow >2.33 Too Fast
Disply inside	Too Dark 1	Adequate 2	Too Bright 3	<1.67 Too Dark >2.33 Too Bright
Display outside	Too Dark 1	Adequate 2	Too Bright 3	<1.67 Too Dark >2.33 Too Bright
Pen Responsiveness	Too Slow 1	Adequate 2	Too Fast 3	<1.67 Too Slow >2.33 Too Fast
Trackball Speed	Too Slow 1	Adequate 2	Too Fast 3	<1.67 Too Slow >2.33 Too Fast
Pen Feel	Too Slick 1	Adequate 2	Scratchy 3	<1.67 Too Slick >2.33 Too Scratchy
Trackball Ease	Too Cumbersome 1	Adequate 2	Easier than a Pen 3	<1.67 Too Difficult >2.33 Easy to Use
Overall Comfort	Not Comfortable 1	Adequate 2	Comfortable 3	<1.67 Uncomfortable >2.33 Comfortable

The "Interpretations" should be considered as guidelines, rather than absolutes. Average responses near the margins are open to interpretation because the cutoff points are arbitrary. For example, the "Size" attribute for the GRiD Convertible received an average rating of 1.68, which puts it just inside the "Adequate" range; in fact, one would be justified in saying that it may be a little large.

Appendix F contains the individual inspector responses to the questions.

Tables 6-9 and Figures 4-7 summarize the inspectors responses for each of the computers.

Table 6: Evaluation of GRiD Convertible

"Please rate the computer on the following factors:"

	Weight	Size	Speed	Display Inside	Display Outside	Pen Responsiveness	Pen Feel	Overall Comfort
Average rating	1.52	1.68	1.89	1.86	1.93	1.74	1.96	1.92
Std. Dev.	0.51	0.48	0.57	0.36	0.60	0.45	0.53	0.81
Responses	27	28	28	28	28	27	26	25
Interpretation	H	A	A	A	A	A	A	A

H = Heavy; A = Adequate

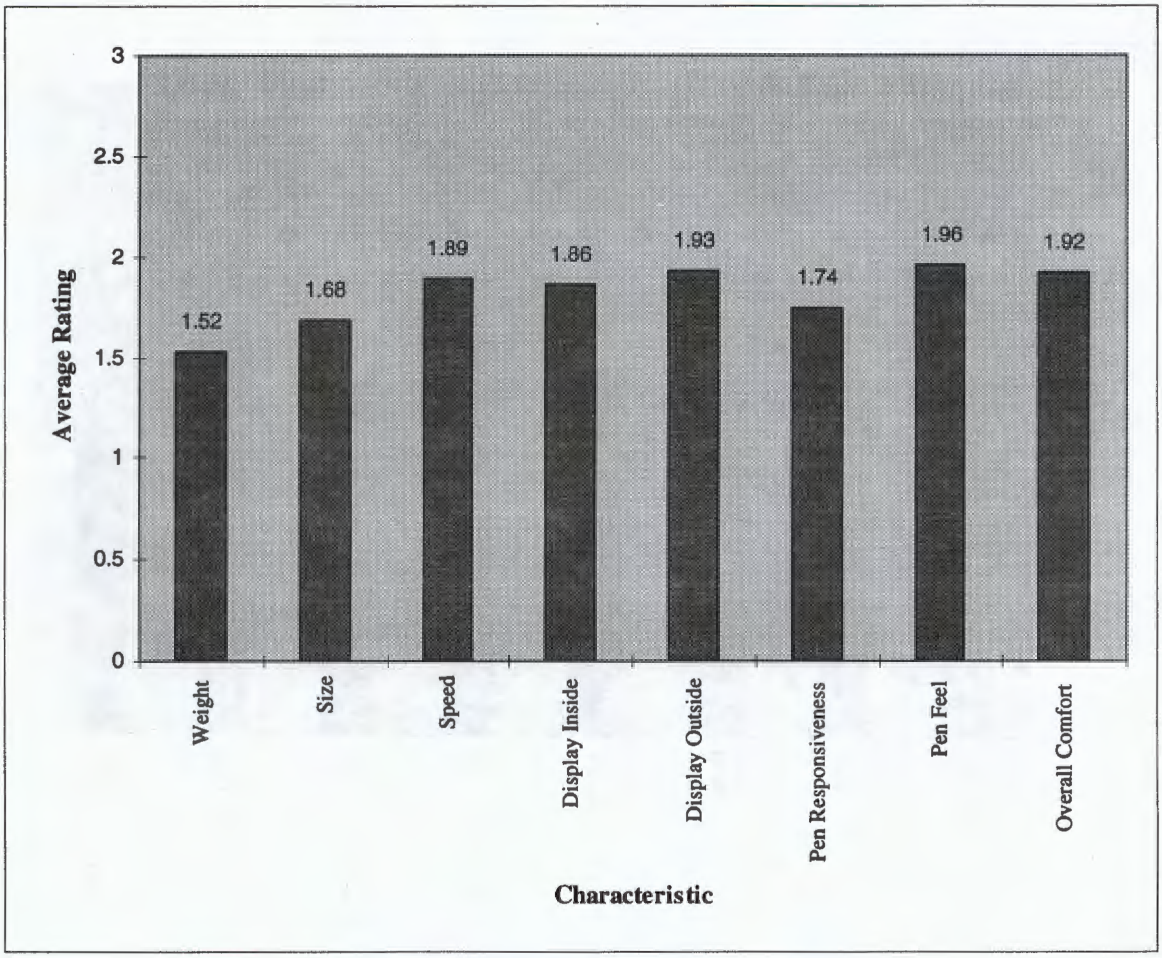


Figure 4: Graph of GRiD Convertible Ratings

Table 7: Evaluation of NEC VersaPad

"Please rate the computer on the following factors:"

	Weight	Size	Speed	Display Inside	Display Outside	Pen Responsiveness	Pen Feel	Overall Comfort
Average rating	1.42	1.57	1.61	1.70	1.87	1.64	1.87	1.42
Std. Dev.	0.50	0.51	0.50	0.56	0.81	0.49	0.55	0.65
Responses	24	23	23	23	23	22	23	24
Interpretation	H	L	S	A	A	S	A	U

H = Heavy; L = Large; S = Slow; A= Adequate; U = Uncomfortable

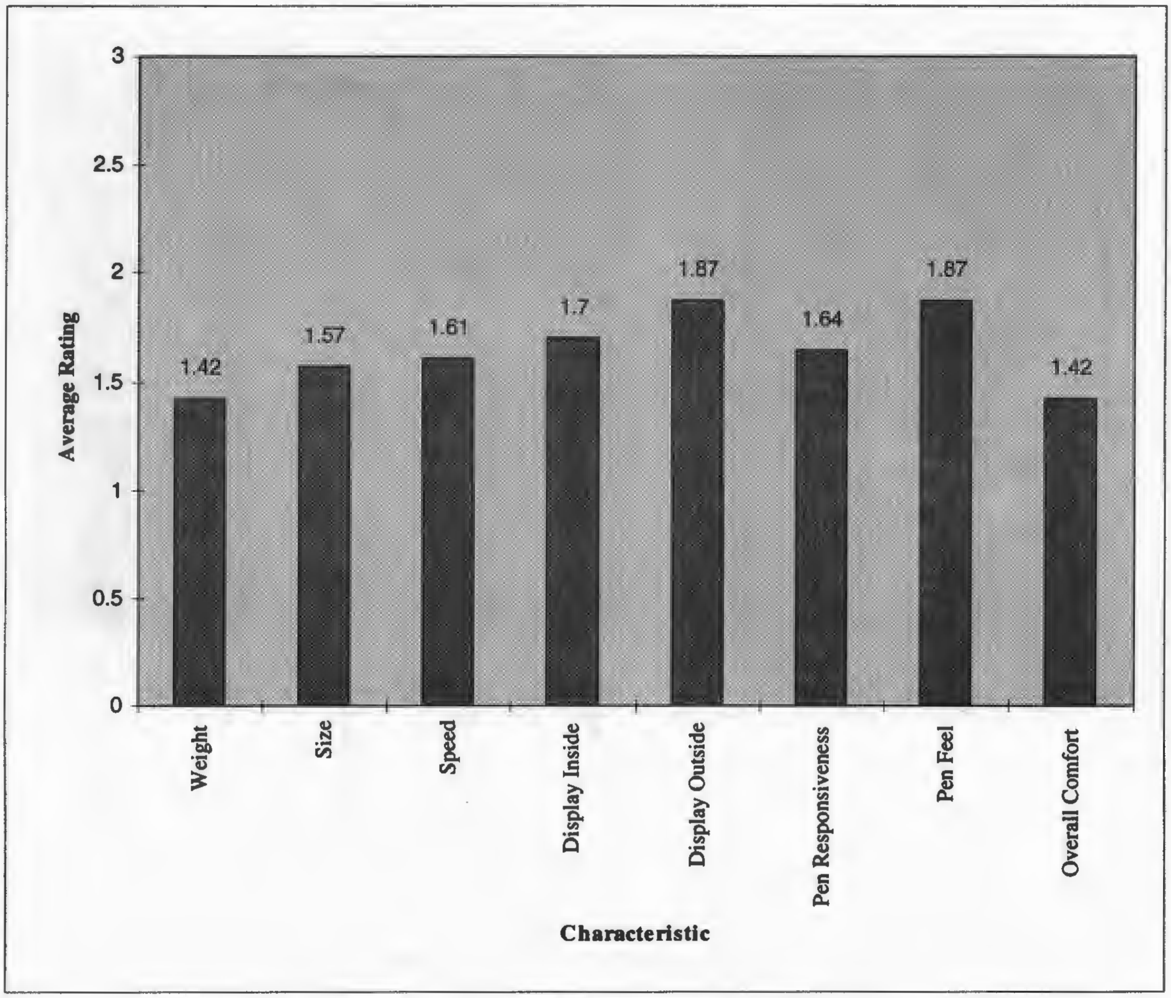


Figure 5: Graph of NEC VersaPad Ratings

Table 8: Evaluation of TelePad SL

"Please rate the computer on the following factors:"

	Weight	Size	Speed	Display Inside	Display Outside	Pen Responsiveness	Pen Feel	Overall Comfort
Average rating	1.63	1.65	1.91	1.91	1.82	1.74	1.91	1.61
Std. Dev.	0.49	0.49	0.42	0.51	0.66	0.45	0.51	0.72
Responses	24	23	23	23	22	23	23	23
Interpretation	H	L	A	A	A	A	A	U

H = Heavy; L = Large; S = Slow; A = Adequate; U = Uncomfortable

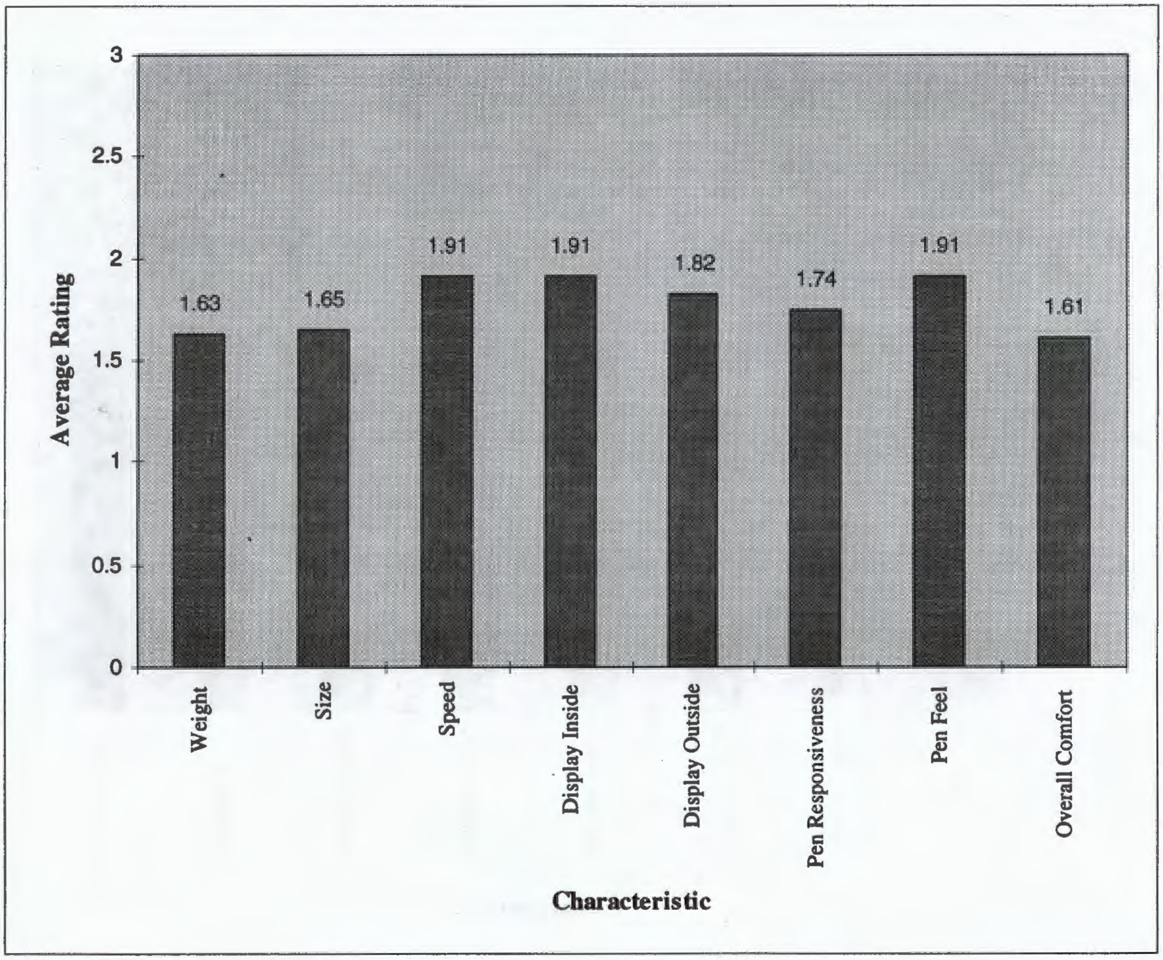


Figure 6: Graph of TelePad SL Ratings

Table 9: Evaluation of Toshiba Satellite T1900

"Please rate the computer on the following factors:"

	Weight	Size	Speed	Display Inside	Display Outside	Trackball Speed	Trackball Ease	Overall Comfort
Average rating	1.58	1.77	1.38	1.85	1.81	1.62	1.46	1.65
Std. Dev.	0.50	0.43	0.50	0.37	0.49	0.57	0.58	0.69
Responses	26	26	26	26	26	26	26	26
Interpretation	H	A	S	A	A	S	C	U

H =Heavy; A = Adequate; S = Slow; C = Cumbersome; U = Uncomfortable

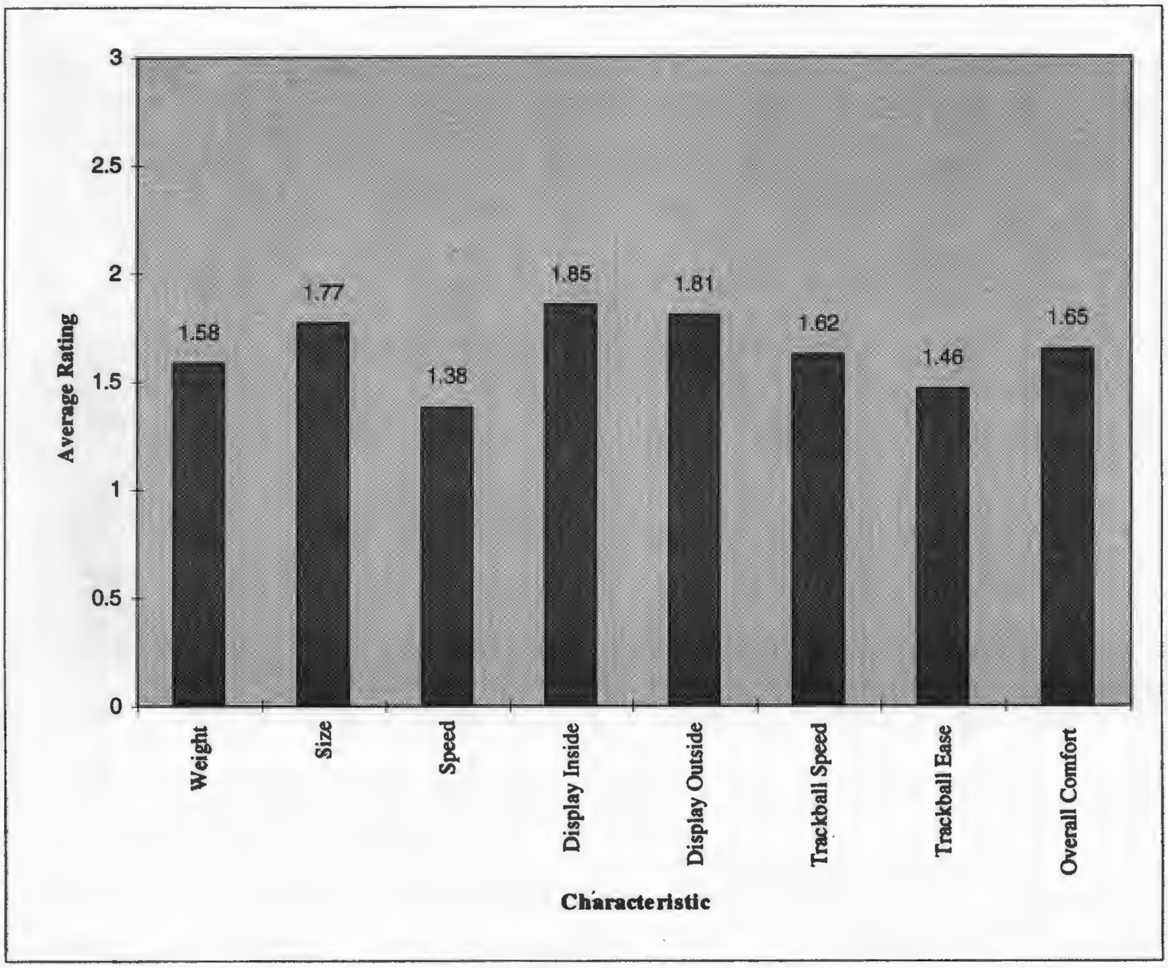


Figure 7: Graph of Toshiba Satellite T1900 Ratings

In comparing the particular characteristics of the pen computers, the only significant difference was that the GRiD Convertible was judged to be more comfortable than the NEC VersaPad (t pooled = 2.383, $\alpha = 0.043$). This result is consistent with inspector comments that the case made using the VersaPad difficult and cumbersome, whereas the Convertible was much more compact and easy to use. More is said about the VersaPad below.

When the ratings for the pen computers are compared against the notebook computer (Toshiba Satellite T1900), both the GRiD Convertible and the TelePad SL were judged to be faster (t pooled = 3.694, $\alpha = 0.00106$, and t pooled = 4.006, $\alpha = 0.000437$, respectively). These judgments may be attributed to the fact that the PENS software had to be modified for the Toshiba to ensure that the data were backed up when changes were made. The result was that the software ran slower on that computer. However, in speaking with inspectors, they also stated that the Toshiba ran slower on standard applications, such as Microsoft Word. Note that the Toshiba had a 486/20 MHz processor, while the GRiD and the NEC both had 486/25 MHz processors, while the TelePad SL had a 386/25 processor. It is curious that the TelePad was judged faster than the Toshiba, while the NEC was not. The TelePad used a RAM cache, which probably increased its apparent speed.

The NEC was generally disliked by the inspectors, and that dislike may have generally biased the inspectors when evaluating it. The VersaPad originally was thought to be a good computer to examine the tradeoffs between computer characteristics: it had a smaller hard disk, but was also much lighter in weight. In discussing the computer with the inspectors, it became apparent that a number of factors contributed to their dislike of it. First, a technical problem with the network adapter required that the keyboard be attached whenever the inspectors booted the computer. The best way to carry both the detached keyboard and the computer was in the case, which led to the second problem: the case concealed dials that were used to adjust the screen brightness and contrast and it prevented access to the parallel port which was required for the network adapter. Coincidentally, whenever the computer was put back in the case after taking it out to transfer data to the network, the screen adjustment dials would rub against the interior of the case and darken the screen. Many inspectors complained about the screen being difficult to see without realizing that they could adjust the display characteristics.

Finally, the inspectors addressed the tradeoff between weight and capability: many of the inspectors complained that the NEC didn't have enough "memory" because the hard disk was too small to contain the on-line versions of both the FARs and the Airworthiness Inspectors' Handbook. (The inspectors universally called hard disk capacity "memory". This is a common mistake made by computer novices because random access memory, RAM, and hard disk capacity are measured in the same units--kilobytes, megabytes, etc. Only RAM is conventionally called "memory". All of the computers had the same amount of memory.)

The comparisons of the computers are summarized in Appendix G.

Perhaps the most telling data collected on the computers was in response to the question "Would you use this computer in the field as part of your job?" The responses to this question are summarized in Tables 10 and 11. Table 10 lists all responses to that question, while Table 11 lists only those response from inspectors who evaluated all four of the computers. As can be seen from the data in the two tables, the GRiD Convertible and the TelePad SL were generally preferred over the NEC VersaPad and the Toshiba Satellite. While the percentages in the two tables do not match, they do maintain the trends. A discrepancy arises with the NEC VersaPad, however, in that the smaller sample would seem to indicate that this computer had more proponents than indicated in the larger sample. A binomial test for dichotomous outcomes indicates that the GRiD Convertible and the TelePad SL are preferred over the Toshiba Satellite ($B = 1.67$, $p = 0.0471$ for both tests). Given the above discussion of the NEC VersaPad and the large sample percentage of preferences, one would suspect that the Convertible and the SL would be preferred over the VersaPad, although we can't draw such a conclusion based on the statistical evidence. (Because of the nature of the data, there does not appear to be an appropriate statistical test for this hypothesis given that not all of the inspectors used all of the computers.)

Table 10: Responses of All Inspectors

"Would you use this computer in the field as part of your job?"

Office	Inspector Initials	GRiD Convertible	NEC VersaPad	TelePad SL	Toshiba Satellite T1900
Boston	BVO	Yes	Yes	Yes	Yes
	AR	Yes	Yes	Yes	Yes
	ALO				
	RSL	No	No		No
Fairbanks	RRH	Yes			
	JQG	Yes	No	Yes	Yes
	HAK	Yes	Yes	Yes	Yes
	SKJ		Yes	Yes	Yes
Ft. Worth	TLT	Yes	No	Yes	
	LEV	Yes	No		No
	LNW	Yes	Yes	Yes	Yes
Harrisburg	RNS		Yes	Yes	Yes
	RRS	Yes	Yes	Yes	Yes
	FNG	No	No	No	No
	HEG	No	No	No	No
Long Beach	JAS				Yes
	DEG	No	No	No	
Milwaukee	DMH	No	No	No	No
	KEL	No	No	No	No
	ECS	Yes		Yes	No
	HCE	Yes			
San Juan	FSM	Yes	Yes	Yes	No
	RDR	Yes	Yes	Yes	No
	REG	Yes	No	Yes	No
	AAP	Yes			
St. Louis	RLH	No	No	No	No
	CHB	Yes	No		No
	RLS	No	No		
Average		67%	41%	68%	43%
Responses		24	22	19	21

Table 11: Responses of Inspectors who Evaluated All Computers
"Would you use this computer in the field as part of your job?"

Office	Inspector Initials	GRiD Convertible	NEC VersaPad	TelePad SL	Toshiba Satellite T1900
Boston	BVO	Yes	Yes	Yes	Yes
	AR	Yes	Yes	Yes	Yes
Fairbanks	JQG	Yes	No	Yes	Yes
	HAK	Yes	Yes	Yes	Yes
Ft. Worth	LNW	Yes	Yes	Yes	Yes
Harrisburg	RRS	Yes	Yes	Yes	Yes
	FNG	No	No	No	No
	HEG	No	No	No	No
Milwaukee	DMH	No	No	No	No
	KEL	No	No	No	No
San Juan	FSM	Yes	Yes	Yes	No
	RDR	Yes	Yes	Yes	No
	REG	Yes	No	Yes	No
St. Louis	RLH	No	No	No	No
Average		64%	50%	64%	43%
Responses		14	14	14	14

None of the fielded computers are currently in production. The GRiD Convertible and the NEC VersaPad have been removed from the market. The TelePad SL is due to be replaced this Fall with the TelePad 3, and the Toshiba Satellite T1900 has been replaced by another model. The only pen computer on the market that has similar capabilities to those in the study is the Compaq Concerto.

Environmental Conditions

With regard to environmental considerations, the inspectors commented that the computers stopped working once the temperature approached freezing. Apparently the batteries are subject to a slow degradation, wherein the computer slows down and eventually stops working when the temperature drops to the freezing range. Such cold temperatures also make it more difficult to use computers because of the need to wear gloves, bulky coats, etc. As might be expected, the inspectors were also reluctant to use the computers in the snow or rain for fear of damaging them. There were no reported problems with high temperatures or humidity.

Software

The PENS software was developed as an expedient means to evaluate the efficacy of field computers. Indeed, without such prototype software, the field study could not have been conducted; it would not have been possible to collect meaningful data on the usability of field computers without an application to run on them. Any study that purported to analyze field computer usability without actually using them in conjunction with a proposed application would be limited to anecdotal evidence (e.g. Edens, 1992). During the course of the field study, the software was frequently updated to reflect changes requested by the inspectors.

The PENS software was evaluated according to a number of usability, functionality, and effectiveness criteria. The evaluation measures included several true/false statements, comment sections for software features, and interviews with the inspectors. The software comment sections can be found in Appendix H and the true/false statements and the responses are listed in Table 12.

Table 12: PENS Software Evaluation Statement Responses

	Percentage of "True" Responses
I enjoyed using PENS.	74
I am eager to see PENS evolve to meet my additional needs.	85
I would like all of my forms linked together so that I don't have to fill in the same information on multiple forms.	88
I will continue to use PENS after the evaluation period.	52
I would rather use paper in the field and transcribe the forms at the office.	85
I would rather use the current transmittal system (FSAS) for transcribing forms.	52
I like the On-Line References (Hypermedia), such as FARs and Handbooks.	81
I would like more On-Line References (Hypermedia), such as ADs, ACs, etc.	77
The On-Line References (Hypermedia) are the best part about PENS.	38
I had difficulty transferring my files from the computer to the network.	96

A surface analysis of these data would provide a rather confusing picture of inspector opinions. However a deeper analysis that takes into account the inspectors' comments provides a more coherent view. The inspectors enjoyed using PENS and liked the concept. In fact, they want to see PENS expanded to incorporate more of their forms, more references, and greater performance support capabilities (such as work program management, report and letter generators, a scheduling system, etc.).

Automation Difficulties

But the following questions arise: If they are so enthusiastic about PENS, how come they don't plan on continuing to use it? and, Why would they prefer to use paper forms and transcribe the data using FSAS? One answer to both of these questions lies in the last evaluation statement: ninety-six percent of the inspectors had difficulty transferring their data to the office databases on the network. There were several causes for such difficulties, including StarLAN (a network architecture and software), the network hardware connections, and the software design.

StarLAN was the single largest contributor to data transfer problems. Because of the StarLAN architecture, data could be easily transferred to the network database only when there were no users other than the inspector on the network; other network activities would greatly slow down the data transfer process. Milwaukee provided the worst data transfer performance: with nobody on the network, it would take approximately 10-15 minutes to transfer one record to the PTRS database. (This is comparable to entering the data into the system manually. Although the amount of time is the same, the transfer could be performed without supervision, thus allowing an inspector to accomplish other tasks.) Loading an inspector's work program onto a computer would take literally hours. Other sites would take 5-10 minutes to transfer a record, which is not acceptable. Given that inspectors had to transfer up to 100 records in a week, this transfer performance would be excruciatingly slow and frustrating. Shortly after completion of the study, the Atlanta FSDO converted to Novell Netware. Transfer performance there improved drastically to the point that it took approximately nine minutes to transfer an entire work program of over 400 records. Therefore, the network speed problems should no longer be an issue.

The network hardware connections were a bit cumbersome. The computers were connected to the networks with Xircom Pocket Ethernet Adapters via the parallel port. These connectors were chosen because Personal Computer Memory Card International Association (PCMCIA) ethernet cards were not readily available and were prohibitively expensive. The Xircom adapters also came with the necessary software drivers to support StarLAN and Novell. The adapters required that the adapter be connected to the computer, to their own power supply, and to the network cable. Once connected, the computer needed to be rebooted for it to detect the network. Inspectors commented that it was difficult to keep track of all of the steps and equipment. Indeed, we had several trouble calls from sites that couldn't log on because they had forgotten to plug in the adapter power supply.

After logging on to the network, the inspectors started a data transfer utility to transfer their completed inspections to the network databases. (Many of the sites had the network set up such that inspectors did not have network access or did not have access to the proper drives for data transfer. This problem was corrected during training, but did create some confusion among the network administrators and the inspectors.) It was emphasized during training that the inspectors did not need to "baby-sit" the data transfer process. However, inspectors reported during the debriefings that in fact they felt did need to baby-sit the process because StarLAN would frequently shut down on their computers, thus halting the process.

Finally, development of the data transfer utility was rushed to meet the field evaluation deadline. Early in the study it was determined that there were some bugs in this utility such that it occasionally, albeit rarely, overwrote an existing database record. These bugs were discovered and corrected two weeks after the initial installation. Unfortunately, the bugs resulted in the deletion of a required item at the Fort Worth FSDO. Repeated attempts to recover that data were unsuccessful.

Another interesting occurrence at Fort Worth resulted from unintended use of the data transfer utility. After the utility transferred data from the field computer to the network databases, it archived the records on the field computer and removed them from the list of currently active records. The inspectors in Fort Worth, however, wanted to keep track of their completed items. Therefore, they copied their database files prior to running the data transfer utility and then reinstated the deleted records after running the utility. The inspectors kept track of which items had been transferred and did not transfer them again. Because the utility creates blank records in the network databases as place holders for items that are not part of the work program, the result of this procedure was that dozens of blank records were created every time the data transfer utility was run. In fact, the inspectors at Fort Worth were explicitly instructed not to follow such a procedure for this very reason. The network administrator instructed the data entry clerks to use these blank records for paper PTRS forms. We learned from the Fort Worth network administrator that the inspectors at least one other used the same unintended procedure with the same results (dozens of blank PTRS entries).

The hardware and software problems point to the need for a sophisticated data transfer utility that runs automatically when the computer is connected to a docking station. (A docking station generally consists of a case that contains a network card, a video card and video port, serial and parallel ports, a power connection for the portable computer, and a full-size keyboard. Some docking stations also have additional hard drives.) The docking station would eliminate the need for keeping track of and connecting peripherals. The automatic utility would transfer the data in the background as soon as the computer is logged onto the network, thus eliminating the need for inspector supervision or intervention. This utility would track which inspections had already been transferred and would allow the inspectors to view all of the items in their work program without making backup copies.

On-Line References

As discussed above, the Federal Aviation Regulations and the Airworthiness Inspectors' Handbook (FAA Order 8300.10) were put "on-line". That is, these documents were stored in a digital format on the hard disks of the computers and were coupled with an easy to use interface that supported retrieval of those documents in real time. The documents could be browsed similar to their paper counterparts and they could be searched for specific information. This prototype software was designed to indicate similar FAA libraries that were in development but unavailable for test at the time of the study. (There were several DOS-based libraries available, but the two leading Windows-based libraries were still in development. One is now completed, while the other is still in development.) The FARs and the Handbook are now over one year out of date and there are no plans to update them as part of this project. Such information is becoming available through commercial publishers and will be purchased if needed.

The inspectors were very enthusiastic about the on-line references. They appreciated the fact that they would not have to maintain nor carry the bulky paper documents. Furthermore, they appreciated the ability to quickly and easily search for specific information. It was quite common for inspectors to continue to search for information during breaks from training. The inspectors were eager to see the on-line documents supplemented with ADs, ACs, additional FAA Orders, Bulletins, and the like. The inspectors remarked that such a capability would be invaluable to them at their desks, as well as in the field.

Interviews with Inspectors: Problems and Solutions

Interviews with the inspectors were conducted repeatedly during the course of the study, primarily during training and debriefings after a site had completed its portion of the study. Several issues which had not been anticipated were brought up during the interviews. These issues and possible solutions to them are discussed below.

Inspector Attitudes

Problem. A significant proportion of the inspectors have wary or antagonistic attitudes regarding PENS and computers in general. No doubt many of these attitudes have been engendered by past attempts to apply automation to ASI tasks. In fact, it was quite common for members of the team to be advised not to discuss the fact that we were "computer people" with some of the inspectors because we were liable to end up on the receiving end of a litany of complaints. To say that inspectors dislike StarLAN, Paradox, the PTRS data-entry system, and the other "stovepipe" automation systems would be an understatement. Many of the inspectors feared that PENS was another "WPMS" (Work Program Management System)--an attempt to throw technology at a problem without making an effort to learn the duties and responsibilities of ASIs.

Some inspectors' attitudes were so negative at the outset that they could not be overcome. For instance, the first words spoken by one inspector to the author (even prior to introductions) were, "I view this project the same way I do that pager over there. It's just another high tech ball and chain." This inspector, and another at the same site, held this opinion throughout the study. Others declared, "I was hired for my knowledge and experience, not to become a computer operator or data entry clerk." This type of attitude was not uncommon among inspectors.

Fortunately, most of the inspectors who did not have computer experience remained open minded. These inspectors made comments to the effect of "Well, I need help to do my job, and if you say this will help, then I'm willing to give it a try."

Proposed Solution. There may be no way to combat negative attitudes, other than through attrition. Some inspectors will be slowly convinced by their peers who use the field computers and by repeated demonstrations of the benefits to them.

Data Collection Device versus Information Management Tool

Problem. Field computers will definitely not be supported if they are used solely as data collection devices. This approach would end the same way the Work Program Management System (WPMS) did: the computers would break, disappear, or end up in the back of a drawer with the hand-held tape recorders within two months. This suggests that while the On-Line Forms Initiative will greatly ease data entry burdens in the office, it will not gain broad acceptance for use in the field.

Proposed Solution. Inspectors clearly want to use field computers to manage inspection information. They want to access previous inspections to recall their results so that they know what to look for during current inspections. They want to access information about operators (e.g. Vital Information System and Operations Specifications information) while doing inspections. They want the convenience of automatic letter and report generators. They want to use the computers to manage their workload. For these reasons, any final solution must comprise a suite of tools that supports these needs. Such a suite of tools is referred to in the Human Factors literature as an "electronic performance support system" (Gery, 1991) or a "decision support system" (cf. Thierauf, 1988). A hallmark of such systems is the application of artificial intelligence techniques to integrate data, information resources, and automation tools to support problem solving, rather than data or computer maintenance. That is, such systems are "user-centered" in that they are designed to support real user needs, as opposed to systems that subjugate the user to the role of data gatherer.

Task Specific Appropiateness of Field Computers

Problem. Another factor which contributed to the preference of paper and pencil for many of the inspectors was the nature of the inspection tasks themselves. A computer can be very difficult to use on the ramp, especially when time is short, one's hands are full with a flashlight and a mirror, and it is raining. Similarly, a switched-on computer in the cockpit is generally frowned upon (and even prohibited by the FAA during takeoff and landing) by the cockpit crew for fear of radio frequency interference with the navaids. Inspectors also commented that cockpit space is cramped and there frequently isn't sufficient room to use a computer, particularly in commuter or light aircraft. Airworthiness inspectors may be more sensitive to such difficulties because of their typical work environments.

Proposed Solution. The inspectors did point out that the computers would be extremely useful during base or line station inspections or when on itinerary. Base and line station inspections are protracted compared to ramp inspections and the inspector frequently has a desk or table to work from. Itineraries provide a compelling reason for having a computer along: inspectors are gone from the office for days or even weeks at a time and they need to have all of their materials with them. In short, their are many situations in which a computer is not an appropriate solution, but there are also many situations that are ripe for computer use; inspectors should not be mandated to use computers at all times.

Inspector Computer Experience

Problem. As noted above, many of the inspectors did not have much, if any, computer experience and most had limited Windows experience. Nearly all of the inspectors had inappropriate mental models of the way computers operate (recall the confusion between RAM and hard disk capacity).

Proposed Solution. Inspectors must be extensively trained on computer concepts and Windows functionality. Computer concepts can be difficult to learn, particularly given their "black box" nature. "Training" itself is not a particularly novel concept, but it is critical to the success of a PENS system. Some of the inspectors were quite adept at picking up computer and Windows concepts (doubtless because of previous exposure), while others were rather slow. Thus, while classroom instruction will be effective in many instances, individualized and self-paced instruction will also be necessary. Given that many inspectors have negative attitudes toward computers, it will be critical to devote significant amounts of time demonstrating the benefits *to inspectors* of computer systems.

Ease of Data Transfer

Problem. As discussed above in "Automation Difficulties", there were significant difficulties with the data transfer process, both in terms of connecting the computer to the network and selecting which records to transfer.

Proposed Solution. As discussed above, the best solution to such difficulties is to provide inspectors with a docking station and a utility that automatically transfers data between the network and the field computer. The docking station would simplify connecting the computer to the network and reduce the number of peripherals. The automatic transfer utility would resolve differences between office data and field computer data without inspector supervision. A report would be generated detailing the transfer and any problems encountered.

Number of Peripherals

Problem. The inspectors generally complained that they had to keep track of too many peripherals with the fielded computers: all of the computers had network adapters with cables and power supplies; the pen computers had external floppy disk drives; and the notebook had a trackball that fell off, etc. Inspectors were afraid they would either lose some of these peripherals or they would not have them when needed. If a portable CD ROM drive were added for the document library system, it would make matters worse because it would have its own cable and power supply.

Proposed Solution. A docking station would greatly reduce the number of peripherals required. The docking station would have a network card built in and would allow for a full-size keyboard and a full-size monitor.

The TelePad 3, due to be released this Fall, has an attached/detachable keyboard, and hard disk, floppy disk/PCMCIA, CD ROM drive, and cellular phone modules. The TelePad 3 is a pen computer that also has a built-in pointing device. This computer would allow the inspectors to carry their necessary peripherals in a single integrated unit, rather than as separate parts.

Single versus Multiple Computers

Problem. Inspectors were adamant that they did not want a desktop computer and a field computer. They saw no need for the duplication of equipment and they did not want the additional file maintenance difficulties presented by having two computers. (With two computers, it becomes difficult to recall on which computer a particular document, or version of it, resides.)

Proposed Solution. Once again, a docking station is the natural solution to such concerns. The docking station allows an inspector to take the computer in the field, as well as use it on the desktop. Thus, one computer fills both roles. Furthermore, files reside in only one place: the hard disk of the double-duty computer.

Aptitude

Problem. Many of the inspectors feared that they would appear inept using computers in front of operators. They were consequently afraid that this apparent ineptitude would compromise their authority with operators. One inspector said, "There I was looking like a damn fool in front of my operators and they were laughing at me because I couldn't make it work."

Proposed Solution. Nobody likes to appear inept. A field computer, like any other tool, requires practice to develop skilled use. Additional training would also have helped in this regard.

Data Security

Problem. Some of the inspectors expressed concern that they did not want operators to see their notes about an inspection. They worried that if they left their computers unattended, the operator might be tempted to look at what they had written. Furthermore, the inspectors said that it was more difficult to make surreptitious notes with the computer than with a small pad of paper.

Proposed Solutions. The computers can easily be configured with password-protected screen savers and log-ins that would prevent unauthorized access. With regard to surreptitious note-taking, the inspectors can either remember to make such notes outside the view of the operator, or they can make these notes on paper as before and then transcribe them to the computer later.

Permanence of Data

Problem. Some of the inspectors felt that their operators were less forthcoming with information because the computer lent an air of permanence to the matters.

Proposed Solution. The data recorded on the computer is no more or less permanent than that recorded on paper. However, it is the operators' perception of permanence that must be dealt with. One solution is to offer to print a copy of the inspector's notes for the operator. Another solution is for the inspector to use discretion in deciding when to make notes.

Liability for Equipment

Problem. Many of the inspectors voiced concern over who would be liable for the equipment should it be inadvertently left on a plane, accidentally broken, or stolen from a hotel. A couple of inspectors even said that they would never take the equipment out of the trunk of their car if they were personally liable.

Proposed Solution. The solution to this perceived problem will have to be handled the same as it is for other work equipment, such as cameras and cellular phones: through administrative policy. In administering that policy, however, it is important to realize that a field computer costs substantially more than a camera or cellular phone (on the order of $5000).

Handwriting Recognition

Problem. Some of the inspectors never became comfortable with the handwriting recognition capabilities of the pen computers. At the end of the study, they still had a significant proportion of misrecognition errors.

Proposed Solution. PENS team members do not have significant problems with misrecognition of handwriting. However, the team members dedicated time to improving the personalized recognition files on their computers. Furthermore, the team members probably have a better conception of what is needed for recognition accuracy. These issues can be addressed through training. Note, however, that if FSS decides to purchase a pool of computers for the inspection force, then each inspector will have to train each computer in the pool to his/her handwriting. This problem can be mitigated if a single computer is dedicated to a small number of inspectors (say three).

Lessons Learned

A number of lessons were learned by the PENS team in the course of conducting the field study. First, future studies should be conducted with fewer sites because the logistics of supporting nine sites are problematic. The usability information garnered from each site was largely the same across sites. Now that environmental issues have been identified, there is no further need to test the equipment in a diverse range of environments. Fewer sites would allow greater dedication of project resources and personnel to those sites than was achievable during this study. Thus, more time can be spent on training, team personnel can spend more time at a site answering questions that arise, and closer working relationships can be forged with the inspectors.

Second, the PENS team needs to provide on-site support during future studies. Many problems that developed during this study were not communicated to team members. For example, although there were frequent discussions with the Seattle office, team members did not discover until the debriefing that data were not being transferred to the office database from the field computers. The presence of team personnel would allow them to address problems as they arise.

Third, fewer computer platforms should be tested in future studies. Coordinating with vendors regarding purchasing, delivery schedules, technical support, and the like became very difficult in this study. Furthermore, the study has answered many of the questions regarding computer platforms, so fewer platforms need be tested in future studies. More is said about recommendations for future studies in "Conclusions and Recommendations".

Finally, a test database on the FAA main frame is absolutely necessary for testing prototype software for evaluating field computers. Many of the errors discovered during the study would have been discovered prior to it had the team been able to subject test data to the upload procedure used for the PTRS databases. Thankfully, John Bent's office, AFS-620, has recently provided this capability.

CONCLUSIONS AND RECOMMENDATIONS

While not all of the inspectors support the notion of field computers, the majority of them who participated in this study do support it, provided that the tools are designed to meet their needs and provided they get to choose when to use them. That is, the computers will not be supported as simple data collection devices; they must support the broader information management roles of inspectors. Furthermore, a mandate that inspectors must always use a computer on an inspection will meet with a lot of resistance because it can be extremely difficult (if not impossible) to use a computer on some types of inspections. The worst thing that the FSS could do would be to purchase a number of pen computers, install them in the field without a properly designed electronic performance support system, and issue an edict to use them. If FSS management continues to keep the inspectors' concerns firmly in mind and strives to keep inspectors involved in program development, the system will be supported by the inspectors.

However, it would appear that the ideal field computer has yet to be developed. On the one hand, inspectors want all of the power and processing resources of a desktop computer (color display, large hard disk, CD ROM, fast processor, etc.), but they want the field computer to be small and light enough to fit in a coat pocket. Unfortunately, these demands conflict in that greater capabilities generally mean greater size and weight. There was also significant interest in speech recognition and magnetic stripe or bar-code readers.

None of the fielded computers are currently in production. The GRiD Convertible and the NEC VersaPad have been removed from the market. The TelePad SL is due to be replaced this Fall with the TelePad 3, and the Toshiba Satellite T1900 has been replaced by another model.

Inspectors themselves will have to make the determination of whether they want a larger, more powerful computer, or a smaller, less powerful computer. To this end PENS team members recommend a second field study, albeit much smaller in scope. Such a study might compare, for instance, a multimedia notebook computer (which supports integrated CD ROM, an integrated pointing device, and speech recognition) and a subnotebook computer, which is smaller in size and has fewer capabilities. Both the notebook computer and the subnotebook will support magnetic stripe or bar-code readers through the serial port. The subnotebook computer will support speech recognition and CD ROM, but only through the addition of peripherals.

This second field study should be conducted at a maximum of three sites in order to ensure that the sites can be properly supported. By reducing the size of the study, PENS team members can provide more training, more on-site support, and greater attention to individual inspectors' concerns. The participation of four inspectors per site, as in this study, provides sufficient personnel to ensure a broad cross section of inspector responsibilities and experiences. A total of twelve inspectors is also a large enough sample size to test hypotheses with sufficient statistical power. That is, with twelve inspectors participating, there is a greater probability that the results of the study will apply to the greater population of inspectors. These suggestions are subject to the approval of Flight Standards personnel and have not been finalized.

Because the concerns addressed above were raised by airworthiness inspectors, and because operation inspectors may have different needs, it is recommended that only airworthiness inspectors participate in the second study, as well. As a rule, it would appear that airworthiness tasks place more stringent demands on the ease of use of field computer hardware than do operations tasks. As an alternative, the study could be broadened to include eight inspectors per site (four airworthiness inspectors and four operations inspectors). By broadening the study in this manner, we could compare the needs of airworthiness inspectors with those of operations inspectors and still maintain a sufficiently large sample size.

Once again, the field study should last approximately four weeks per site. This length of study gives the inspectors ample opportunity to become familiar with the equipment and to use it as part of their daily routine. Training time should also be increased to three full days or five half days. This will have to be determined as the details of the study are finalized.

Rarely is a field study of this magnitude conducted because they are notoriously difficult. Fortunately, this one went exceedingly well. The study accomplished its two major objectives: evaluate the feasibility of applying field computers to Aviation Safety Inspector tasks and involve the inspector workforce in this evaluation. In the past, inspectors have had little opportunity to influence what tools are purchased or developed to support them and they appreciated the approach taken in this study: present inspectors with potential solutions and let them evaluate the solutions, suggest improvements, and guide future developments. This approach is an outgrowth of the Flight Standards Service Training and Automation Committee Information Systems Strategy project which is directly concerned with meeting inspectors' needs. From this standpoint alone, the study was a resounding success.

GLOSSARY

AAM	Office of Aviation Medicine
AC	Advisory Circular
AD	Airworthiness Directive
ASI	Aviation Safety Inspector
CD ROM	Compact Disc Read Only Memory
DOS	Disk Operating System
FAA	Federal Aviation Administration
FARs	Federal Aviation Regulations
FSAS	Flight Standards Automation System
FSDO	Flight Standards District Office
FSS	Flight Standards Service
PCMCIA	Personal Computer Memory Card International Association
PENS	Performance ENhancement System
PTRS	Program Tracking and Reporting Subsystem
RAM	Random Access Memory
SPAS	Safety Peformance Analysis System
WPMS	Work Program Management System

REFERENCES

Airworthiness inspector's handbook (Order 8300.10). Department of Transportation: Federal Aviation Administration. Washington, DC: U.S. Government Printing Office.

Air transportation operations inspector's handbook (Order 8400.10). Department of Transportation: Federal Aviation Administration. Washington, DC: U.S. Government Printing Office.

Code of federal regulations: Title 14--Aeronautics and space (1994). National Records and Archives Administration: Office of the Federal Register. Washington, DC: U.S. Government Printing Office.

General aviation operations inspector's handbook (Order 8700.1). Department of Transportation: Federal Aviation Administration. Washington, DC: U.S. Government Printing Office.

Edens, E. S. (1992). Aviation safety inspector job automated PTRS data collect and reporting human factors study. Federal Aviation Administration: Systems Technology Division Human Performance Program, Technical Report.

Gery, G. J. (1991). Electronic performance support systems: How and why to remake the workplace through the strategic application of technology. Boston: Weingarten.

Thierauf, R. J. (1988). User-oriented decision support systems: Accent on problem finding. Englewood Cliffs, NJ: Prentice Hall.

APPENDIX A
COMPUTER CHARACTERISTICS

GRiD Convertible

Features

Dimensions--1.6" H x 11.5" W x 9.3" D
486/25
8 MB RAM
130 MB Hard Drive
Math co-processor
Built-in keyboard
External floppy drive (parallel port) standard
Sidelit (backlit) 9.5" 64 shade VGA LCD display (blue) with brightness and contrast controls
Serial port
Parallel port/floppy disk drive port (requires adapter for parallel port)
Monitor port
PCMCIA Type II slot
Attached keyboard
Battery-operated pen
Rechargeable/replaceable computer battery
5 1/2 lb.

NEC UltraLite Autograph

<u>Features</u>

Dimensions--1.2" H x 10.9" W x 9.8" D
486/20
8 MB RAM
80 MB Hard Drive
Math co-processor
Optional external keyboard
External floppy drive standard
Backlit 9.4" 64 shade VGA LCD display (blue) with brightness and contrast controls
Serial port
Parallel port/floppy disk drive port (requires adapter for parallel port)
Monitor port
2 PCMCIA Type II slots
Separate keyboard
Battery-operated pen
Rechargeable/replaceable computer battery
3.9 lb.

TelePad SL

Features

Dimensions--1.3"H x 11"W x 11"D

386/25

8 MB RAM.

200 MB Hard Drive

Sidelit (backlit)/Transflective (backlighting can be turned off) 16 shade VGA LCD display (blue) with brightness and contrast controls

Serial port

Parallel port

Floppy disk drive port

Monitor port

2 PCMCIA Type II Slots

Built-in 9600 baud FAX/2400 baud Modem

"Hot Dock" docking port for power and/or other connections available.

Separate keyboard

Battery-operated pen

Rechargeable/replaceable computer battery; 2 batteries std.

4 lb.

Toshiba Satellite T1900

Features

Dimensions--2"H x 11.7"W x 8.4"D
486/20
8 MB RAM
120 MB Hard Drive
Backlit
Serial Port
Parallel Port
Floppy disk drive
Monitor port
PCMCIA Type II slot
Attached keyboard
BallPoint (Trackball)
Rechargeable/replaceable computer battery
6.4 lb.

APPENDIX B
TRAINING SLIDES

PENS

The Performance ENhancement System for Aviation Safety

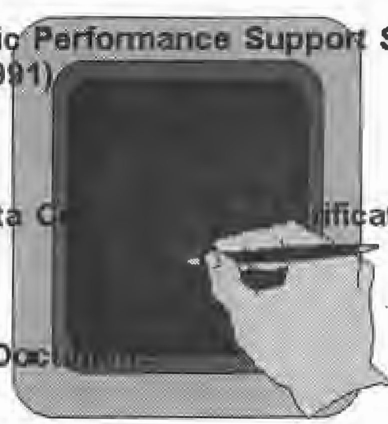
Flight Standards Service

Charles F. Layton
Clifford M. McKeithan
Galaxy Scientific Corporation

PENS

The Performance ENhancement System for Aviation Safety

What is PENS?



- Electronic Performance Support System (Gery, 1991)
- Field Data C... ...ification
- On-line Doc...

PENS

PENS Timetable

The Performance ENhancement System for Aviation Safety

1993	1994	1995
• Field Evaluation of Airworthiness Prototype	• Complete Airworthiness and Avionics PENS • Prototype Operations PENS • Field Evaluation of Operations Prototype	• Complete Operations PENS • Prototype General Aviation PENS • Field Evaluations of General Aviation Prototype • Complete General Aviation PENS

PENS

The Performance ENhancement System for Aviation Safety

Schedule Day One

- Demo
- Background Information
- Introduction to Computer
- Windows Tutorial
- Windows Practice
- Pen Computer Tutorial

PENS

The Performance ENhancement System for Aviation Safety

Schedule Day Two

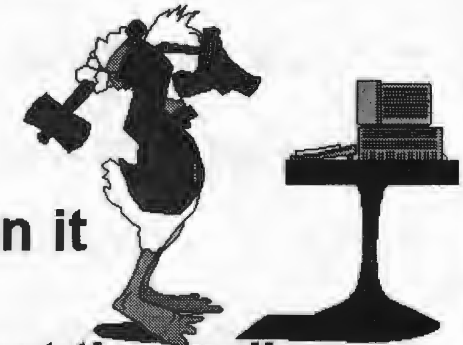
- PENS Training
- PENS Practice
- Data Transfer Training
- Data Transfer Practice
- Evaluation Forms
- Rotation Schedule
- Specific Computer Training

You cannot harm the computer by using it!

You can harm the computer by:

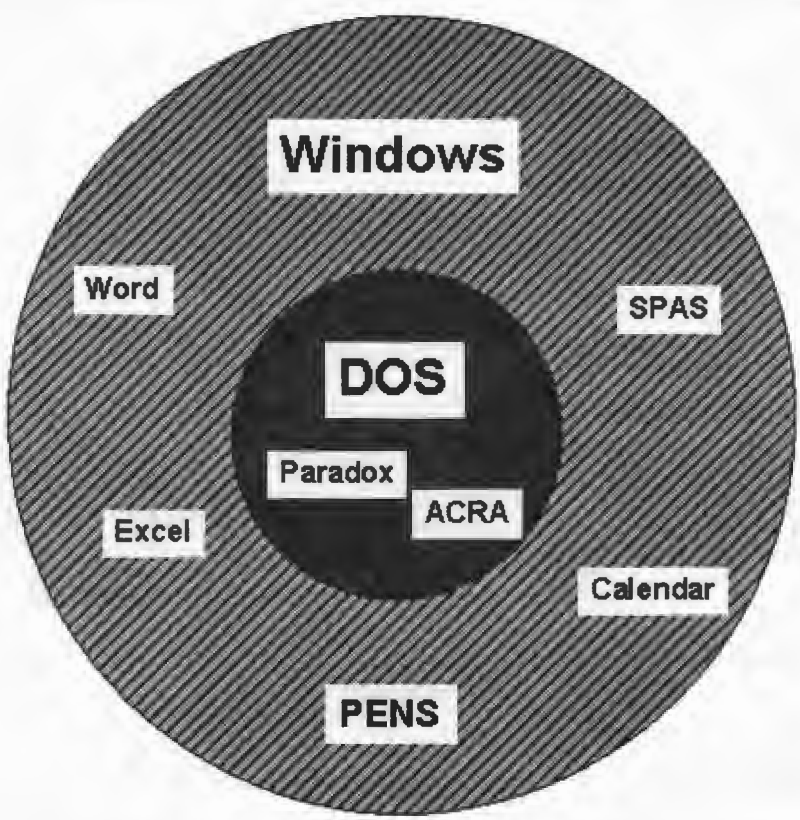
dropping it

spilling liquids on it



throwing it against the wall

But if you do, you will make several people very unhappy with you.



DOS

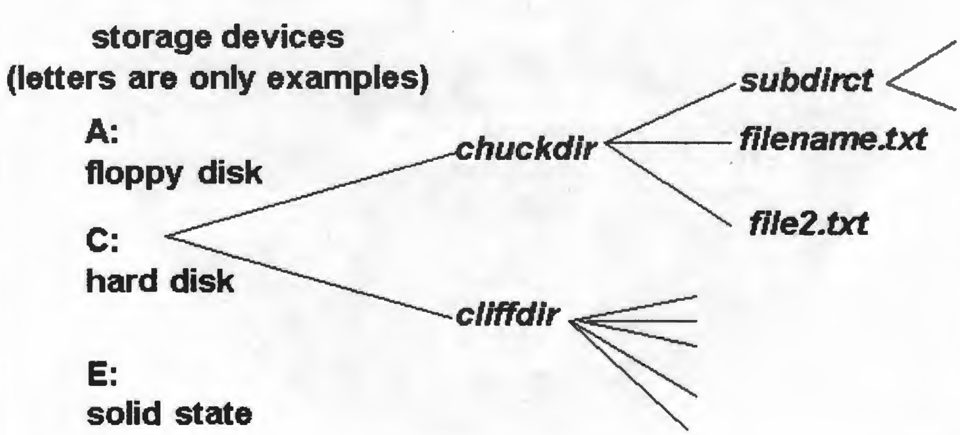
- Stands for: *D*isk *O*perating *S*ystem
- Basic operating level
- Runs programs and stores data
- Hierarchical organization of data

  --files: lowest element

  --subdirectories: hierarchies of files

  --both are limited to eight letter names and three letter extensions: eg. *filename.txt*

DOS (cont.)



DOS (cont.)

To get out of DOS and back to Windows:

1. **Type *exit <Enter>***
2. **Type *win <Enter>***
3. **Restart the computer**

   Hold down *<Ctrl> <Alt>* and *<Del>* keys simultaneously

   Turn off the computer and turn it on again

Windows

- **Graphical User Interface (GUI)**
- **Shows programs as screen objects**
- **Take action on screen objects**
  - **Point**
  - **Click**
  - **Double Click**
  - **Drag**

Windows for Pen transcribes printed text to "typed" text

Tips

- ✔ Turn off the computer before plugging or unplugging any devices:

    --keyboard

    --floppy disk drive

    --network connection

    --CD-ROM

- ✔ Plug the computer into AC power when possible and convenient
- ✔ Plug the computer into the cigarette lighter when possible and convenient
- ✔ Turn off the computer if it will be idle for a half hour or more

APPENDIX C
INSPECTOR BACKGROUND QUESTIONS

Personnel Background

Initials: _______ FSDO: _______

Age: _______ Years as ASI: _______

Type of operator you inspect regularly: 121 125 129 133 135 137

other _______ _______ _______ _______

Type of operator you inspect most frequently: 121 125 129 133 135 137

other _______

Have you ever used a computer before? Yes No How many years? ______

What type of computer have you used? IBM PC Compatible (e.g. AT&T/NCR OATS)

Apple Macintosh

Other: ________________

Do you own a computer? Yes No How many years? ______

What type of computer do you own? IBM PC Compatible (e.g. AT&T/NCR OATS)

Apple Macintosh

Other: ________________

Have you ever used a "Mouse" before? Yes No

Have you ever used a "Trackball" before? Yes No

Have you ever used a "Pen Computer" before? Yes No

Do you currently use the PTRS Transmittal System (Paradox)? Yes No

At this point, how comfortable do you feel using a computer?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

What is your opinion of the following computer manufacturers:

GRiD	Favorable	Unfavorable	No Opinion
NEC	Favorable	Unfavorable	No Opinion
TelePad	Favorable	Unfavorable	No Opinion
Toshiba	Favorable	Unfavorable	No Opinion

APPENDIX D
POST-TRAINING COMFORT LEVEL QUESTIONS

Post-Training Comfort Level

Initials: ______ FSDO: ______

Now that you have been trained...

How comfortable do you feel using a computer?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

How comfortable do you feel using a pen computer?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

How comfortable do you feel with handwriting recognition?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

How comfortable do you feel with the PENS PTRS?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

How comfortable do you feel with the On-Line References (Hypermedia)?

1	2	3	4	5
not at all comfortable		somewhat comfortable		quite comfortable

Do you have any other comments?

____

____

____

APPENDIX E
COMPUTER QUESTIONS

Evaluation of GRiD Convertible

Initials: _______ FSDO: ________

Please rate the computer on the following factors:

Weight	Too Heavy	Adequate	Too Light/Fragile
Size	Too Large	Adequate	Too Small (e.g. screen)
Speed	Too Slow	Adequate	Fast
Display--inside	Too Dark	Adequate	Too Bright
Display--outside	Too Dark	Adequate	Too Bright
Pen Responsiveness	Too Slow	Adequate	Too Fast
Pen Feel	Too Slick	Adequate	Scratchy
Overall Comfort	Not Comfortable	Adequate	Comfortable

What were the environmental conditions in which you used the computer?

snow drizzle rain heat cold frigid

Did you use the computer for five working days? Yes No

If not, why not? Broken On Travel/Vacation/RDO Too difficult to use

Do you prefer to have the pen tethered to the unit? Yes No

Could you comfortably carry this unit throughout a typical day? Yes No

If a neck, shoulder, or waist strap were available, would you use it? Yes No

Which would you prefer? Neck Shoulder Waist

What are the three largest drawbacks to this product?

1. ____________________

2. ____________________

3. ____________________

Would you use this computer in the field as part of your job? Yes No

If not, why not?

Evaluation of NEC VersaPad

Initials: _______ FSDO: ________

Please rate the computer on the following factors:

Weight	Too Heavy	Adequate	Too Light/Fragile
Size	Too Large	Adequate	Too Small (e.g. screen)
Speed	Too Slow	Adequate	Fast
Display--inside	Too Dark	Adequate	Too Bright
Display--outside	Too Dark	Adequate	Too Bright
Pen Responsiveness	Too Slow	Adequate	Too Fast
Pen Feel	Too Slick	Adequate	Scratchy
Overall Comfort	Not Comfortable	Adequate	Comfortable

What were the environmental conditions in which you used the computer?

snow   drizzle rain   heat   cold   frigid

Did you use the computer for five working days?   Yes   No

If not, why not?   Broken   On Travel/Vacation/RDO   Too difficult to use

Do you prefer to have the pen tethered to the unit?   Yes   No

Could you comfortably carry this unit throughout a typical day?   Yes   No

If a neck, shoulder, or waist strap were available, would you use it?   Yes   No

Which would you prefer?   Neck   Shoulder   Waist

What are the three largest drawbacks to this product?

1. ____________________

2. ____________________

3. ____________________

Would you use this computer in the field as part of your job? Yes No

If not, why not?

Evaluation of TelePad

Initials: _______ FSDO: ________

Please rate the computer on the following factors:

Weight	Too Heavy	Adequate	Too Light/Fragile
Size	Too Large	Adequate	Too Small (e.g. screen)
Speed	Too Slow	Adequate	Fast
Display--inside	Too Dark	Adequate	Too Bright
Display--outside	Too Dark	Adequate	Too Bright
Pen Responsiveness	Too Slow	Adequate	Too Fast
Pen Feel	Too Slick	Adequate	Scratchy
Overall Comfort	Not Comfortable	Adequate	Comfortable

What were the environmental conditions in which you used the computer?

snow drizzle rain heat cold frigid

Did you use the computer for five working days? Yes No

If not, why not? Broken On Travel/Vacation/RDO Too difficult to use

Do you prefer to have the pen tethered to the unit? Yes No

Could you comfortably carry this unit throughout a typical day? Yes No

If a neck, shoulder, or waist strap were available, would you use it? Yes No

Which would you prefer? Neck Shoulder Waist

What are the three largest drawbacks to this product?

1. ____________________

2. ____________________

3. ____________________

Would you use this computer in the field as part of your job? **Yes** **No**

If not, why not?

Evaluation of Toshiba Satellite

Initials: _______ FSDO: ________

Please rate the computer on the following factors:

Weight	Too Heavy	Adequate	Too Light/Fragile
Size	Too Large	Adequate	Too Small (e.g. screen)
Speed	Too Slow	Adequate	Fast
Display--inside	Too Dark	Adequate	Too Bright
Display--outside	Too Dark	Adequate	Too Bright
Trackball Speed	Too Slow	Adequate	Too Fast
Trackball Ease	Too Cumbersome	Adequate	Easier than a Pen
Overall Comfort	Not Comfortable	Adequate	Comfortable

What were the environmental conditions in which you used the computer?

snow drizzle rain heat cold frigid

Did you use the computer for five working days? Yes No

If not, why not? Broken On Travel/Vacation/RDO Too difficult to use

Could you comfortably carry this unit throughout a typical day? Yes No

If a neck, shoulder, or waist strap were available, would you use it? Yes No

Which would you prefer? Neck Shoulder Waist

What are the three largest drawbacks to this product?

1. ____________________
2. ____________________
3. ____________________

Would you use this computer in the field as part of your job? Yes No

If not, why not?

APPENDIX F
INSPECTOR COMPUTER EVALUATIONS

GRiD Convertible Evaluation Responses

Inspector	Weight	Size	Speed	Display inside	Display outside	Pen Rspns.	Pen Feel	Comfort	Five days use?	Tether pen?	Carry comfort?	Strap?	Would use it?
BVO	2	2	2	2	2	2	2		Yes	Yes	Yes	Yes	Yes
AR	2	1	2	1	1	2	2	2	No	No	No	No	Yes
ALO	1	1	1	1	1			1					
RSL	1	1	2	2	2	2	2	1					No
RRH	1	1	2	2	2	2	2	3	Yes	Yes	No	No	Yes
JQG	2	2	2	2	1	2	2	2	Yes	Yes	Yes	Yes	Yes
HAK	2	2	2	2	2	2	2	2	Yes	Yes	No	Yes	Yes
SKJ	2	2	2	2	2	2	2	3	Yes	Yes	Yes	Yes	
TLT	2	2	3	2	2	2	2	3	No	No	Yes	Yes	Yes
LEV	2	2	2	2	2	2	2	2	Yes	Yes	Yes	Yes	Yes
LNW	2	2	2	2	2	2	2	3	No	Yes	No	Yes	Yes
RNS	2	2	2	2	2	2	2		Yes	No	Yes	No	
RRS	2	2	3	2	2	1	2	3	Yes	No	Yes	Yes	Yes
FNG	1	1	1	2	2	1	1	1	No	No	No	No	No
HEG	1	1	1	2	2	1	1	1	Yes	No	No	No	No
JAS	1	1	1	2	2	1	1	1	Yes	Yes	No	No	
DEG	1	2	1	1	1	1	1	1					No
DMH	1	1	2	2	3	1		1	Yes	No	No	No	No
KEL	1	1	2	1	1	2	2	1	No	Yes	No	No	No
ECS	2	2	1	2	1	2	2	1	Yes	No	No	No	Yes
HCE	2	2	2	2	2	2	3	2	No	No	No	No	Yes
FSM	1	2	2	2	3	2	2	2	No	No	Yes	No	Yes
RDR	2	2	2	2	3	2	2	3	Yes	Yes	Yes	Yes	Yes
REG	1	2	3	2	3	2	2	3	Yes	No	Yes	Yes	Yes
AAP	2	2	2	2	2	2	2	2	Yes	No	Yes	No	Yes
RLH	1	2	2	2	2	2	2	2	Yes	Yes	No	No	No
CHB		2	2	2	2	2	3		Yes	No	Yes	Yes	Yes
RLS	1	2	2	2	2	1	3	2	Yes	Yes	No	No	No
Avg.	1.52	1.68	1.89	1.86	1.93	1.74	1.96	1.92	0.72	0.48	0.48	0.44	0.67
Std. Dev.	0.51	0.48	0.57	0.36	0.60	0.45	0.53	0.81					
Response	27	28	28	28	28	27	26	25					

NEC VersaPad Evaluation Responses

Inspector	Weight	Size	Speed	Display inside	Display outside	Pen Rspns.	Pen Feel	Comfort	Five days use?	Tether pen?	Carry comfort?	Strap?	Would use it?
BVO	2	2	2	1	1	2	2	2	Yes	No	Yes	Yes	Yes
AR	1	2	2	1	1	2	2	1	No	No	No	No	Yes
ALO													
RSL	1	1	2	1	1	2	2	1					No
RRH	1	2		3	3		2	1	Yes	No	No	Yes	
JQG	1	1	2	2	2	2	2	1	No	Yes	No	Yes	No
HAK	2	2	2	2	2	2	2	2	Yes	Yes	No	Yes	Yes
SKJ	1	1	2	2	2	1	2	1	Yes	No	No	No	Yes
TLT	2	2	1	1	1			1	Yes	No	No	Yes	No
LEV	2	2	2	2	3	2	2	1	Yes	Yes	No	Yes	No
LNW	2	2	1	2	1	2	2	2	No	Yes	Yes	Yes	Yes
RNS	2	2	2	2	2	2	2	2	Yes	No	Yes	No	Yes
RRS	2	2	1	1	1	2	2	3	No	No	Yes	Yes	Yes
FNG	1	1	2	2	2	1	1	1	No	No	No	No	No
HEG	1	1	1	2	2	1	1	1	No	No	No	No	No
JAS	1	1	1	2	2	1	1	1	Yes	Yes	No	No	
DEG	1	2	1	1	1	1	1	1					No
DMH	1	1	1	2	3	1	1	1	Yes	No	No	No	No
KEL	1	1	2	1	1	2	2	1	No	Yes	No	No	No
ECS													
HCE													
FSM	2	2	2	2	3	2	2	2	Yes	No	Yes	No	Yes
RDR	2	2	2	2	3	2	2	3	Yes	Yes	Yes	Yes	Yes
REG	1	2	2	2	3	2	2	2	Yes	No	No	Yes	No
AAP													
RLH	1	1	1	1	1	1	2	1	No	Yes	No	No	No
CHB	2		1			1	3	1	Yes		No		No
RLS	1	1	2	2	2	2	3	1	Yes	Yes	No	No	No
Avg.	1.42	1.57	1.61	1.70	1.87	1.64	1.87	1.42	0.64	0.43	0.27	0.48	0.41
Std. Dev.	0.50	0.51	0.50	0.56	0.81	0.49	0.55	0.65					
Response	24	23	23	23	23	22	23	24					

TelePad SL Evaluation Responses

Inspector	Weight	Size	Speed	Display inside	Display outside	Pen Rspns.	Pen Feel	Comfort	Five days use?	Tether pen?	Carry comfort?	Strap?	Would use it?
BVO	2	2	2	2	2	2	2	2	Yes	Yes	Yes	Yes	Yes
AR	2	1	2	1	1	2	2	1	No	No	No	No	Yes
ALO													
RSL													
RRH	1	2	2	2	1	2	2	2	Yes	No	No	Yes	
JQG	2	2	2	3	3	2	2	1	Yes	Yes	No	Yes	Yes
HAK	2	2	2	2	2	2	2	2	Yes	Yes	No	Yes	Yes
SKJ	2	2	2	2	2	2	2	3	Yes	No	Yes	Yes	Yes
TLT	2	2	3	2	2	2	2	3	Yes	No	Yes	Yes	Yes
LEV	2	1	2	2		2	2	2	Yes	Yes	Yes	No	
LNW	2	2	2	2	1	2	2	2	No	No	Yes	Yes	Yes
RNS	2	2	2	2	2	2	2	2	Yes	No	Yes	No	Yes
RRS	2	2	2	3	3	2	2	2	No	No	Yes	Yes	Yes
FNG	1	1	2	1	1	1	2	1	Yes	No	No	No	No
HEG	1	1	1	2	2	1	1	1	Yes	No	No	No	No
JAS	1	1	2	2	2	1	1	1	Yes	Yes	No	No	
DEG	1	2	1	1	1	1	1	1					No
DMH	1	1	2	2	3	1	1	1	Yes	No	No	No	No
KEL	1	1	2	1	1	2	2	1	No	Yes	No	No	No
ECS	2	2	1	2	1	2	3	1	Yes	No	No	No	Yes
HCE													
FSM	2	2	2	2	2	2	2	3	Yes	No	Yes	No	Yes
RDR	2	2	2	2	2	2	2	1	Yes	Yes	No	Yes	Yes
REG	2	2	2	2	2	2	2	2	Yes	No	Yes	Yes	Yes
AAP													
RLH	1	1	2	2	2	2	2	1	1	No	No	No	No
CHB	2								No				
RLS	1	2	2	2	2	1	3	1	Yes	Yes	No	No	
Avg.	1.63	1.65	1.91	1.91	1.82	1.74	1.91	1.61	0.78	0.36	0.41	0.45	0.68
Std. Dev.	0.49	0.49	0.42	0.51	0.66	0.45	0.51	0.72					
Response	24	23	23	23	22	23	23	23					

Toshiba Satellite T1900 Evaluation Responses

Inspector	Weight	Size	Speed	Display inside	Display outside	Trackball speed	Trackball ease	Comfort	Five days use?	Carry comfort?	Strap?	Would use it?
BVO	2	2	2	2	2	2	1	2	Yes	Yes	Yes	Yes
AR	1	1	2	1	1	1	1	1	No	No	No	Yes
ALO												
RSL	1	1	2	2	2	1	1	1				No
RRH	1	1	1	2	2	1	1	1	Yes	No	Yes	
JQG	2	2	2	2	2	2	2	2	Yes	Yes	Yes	Yes
HAK	2	2	1	2	2	2	2	2	Yes	No	Yes	Yes
SKJ	2	2	2	2	2	1	1	2	Yes	Yes	No	Yes
TLT	2	2	2	2	2	2	2	3	Yes	Yes	Yes	
LEV	2	2	1	2	1	2	2	2	Yes	Yes	Yes	No
LNW	2	2	1	2	2	2	1	3	No	Yes	Yes	Yes
RNS	2	2	1	2	2	2	2	2	Yes	Yes	No	Yes
RRS	2	2	2	1	1	3	1	2	No	No	Yes	Yes
FNG	1	1	1	2	2	1	1	1	No			No
HEG	1	1	1	2	2	1	1	1	Yes	No	No	No
JAS	2	2	2	2	2	2	2	2	Yes	No	No	Yes
DEG	1	2	1	1	1	1	1	1				
DMH	1	2	1	2	2	1	2	1	Yes	No	No	No
KEL	1	1	2	1	1	2	1	1	No	Yes	No	No
ECS	1	2	1	2	1	1	1	1	Yes	No	No	No
HCE												
FSM	1	2	1	2	2	1	1	1	Yes	No	No	No
RDR	2	2	1	2	2	2	2	3	Yes	Yes	Yes	No
REG	2	2	1	2	3	2	2	2	Yes	No	Yes	No
AAP	2	2	1	2	2	2	1	1	Yes	No	No	
RLH	1	2	2	2	2	2	2	2	Yes	No	No	No
CHB	2	2	1	2	2	1	1	1	Yes	No	No	No
RLS	2	2	1	2	2	2	3	2	Yes	No	No	
Avg.	1.58	1.77	1.38	1.85	1.81	1.62	1.46	1.65	0.79	0.39	0.43	0.43
Std. Dev.	0.50	0.43	0.50	0.37	0.49	0.57	0.58	0.69				
Response	26	26	26	26	26	26	26	26				

APPENDIX G
SUMMARY COMPUTER COMPARISON STATISTICS

Summary Computer Comparison Statistics

GRiD vs. NEC	Weight	Size	Speed	Display inside	Display outside	Pen Response	Pen Feel	Comfort
Number of responses	15	17	18	17	18	18	18	17
t	0.717	0.822	1.879	1.252	0.297	0.777	0.598	2.383
Sp	0.507	0.490	0.538	0.458	0.707	0.468	0.537	0.739
t (0.025)	2.312	2.312	2.312	2.312	2.312	2.315	2.315	2.315
Significant?	no	no	no	no	no	no	no	yes

GRiD vs. TelePad	Weight	Size	Speed	Display inside	Display outside	Pen Response	Pen Feel	Comfort
t	-0.756	0.195	-0.142	-0.457	0.614	0.013	0.325	1.398
Sp	0.502	0.481	0.505	0.435	0.631	0.448	0.522	0.771
t (0.025)	2.312	2.312	2.312	2.312	2.314	2.314	2.315	2.317
Significant?	no	no	no	no	no	no	no	no

NEC vs. TelePad	Weight	Size	Speed	Display inside	Display outside	Pen Response	Pen Feel	Comfort
t	-1.446	-0.593	-2.244	-1.372	0.231	-0.732	-0.277	-0.956
Sp	0.499	0.497	0.460	0.537	0.745	0.471	0.532	0.688
t (0.025)	2.317	2.321	2.321	2.321	2.323	2.323	2.321	2.319
Significant?	no	no	no	no	no	no	no	no

GRiD vs. Toshiba	Weight	Size	Speed	Display inside	Display outside	Comfort
t	-0.423	-0.692	3.694	0.093	0.703	1.233
Sp	0.507	0.454	0.534	0.362	0.553	0.752
t (0.025)	2.310	2.308	2.308	2.308	2.308	2.312
Significant?	no	no	yes	no	no	no

NEC vs. Toshiba	Weight	Size	Speed	Display inside	Display outside	Comfort
t	-1.124	-1.525	1.574	-1.126	0.326	-1.246
Sp	0.504	0.467	0.497	0.467	0.663	0.673
t (0.025)	2.314	2.315	2.315	2.315	2.315	2.314
Significant?	no	no	no	no	no	no

TelePad vs. Toshiba	Weight	Size	Speed	Display inside	Display outside	Comfort
t	0.340	-0.894	4.006	0.528	0.063	-0.224
Sp	0.499	0.457	0.461	0.443	0.577	0.705
t (0.025)	2.314	2.315	2.315	2.315	2.317	2.315
Significant?	no	no	yes	no	no	no

APPENDIX H
SOFTWARE EVALUATION FORMS

PENS Software Evaluation

Initials: ______ FSDO: _______

Now that you have used PENS for a significant period of time, please tell us what you think.

I enjoyed using PENS.	True	False
I am eager to see PENS evolve to meet my additional needs.	True	False
I would like all of my forms linked together so that I don't have to fill in the same information on multiple forms.	True	False
I will continue to use PENS after the evaluation period.	True	False
I would rather use paper in the field and transcribe the forms at the office.	True	False
I would rather use the current transmittal system (FSAS) for transcribing forms.	True	False
I like the On-Line References (Hypermedia), such as FARs and Handbooks.	True	False
I would like more On-Line References (Hypermedia), such as ADs, ACs, etc.	True	False
The On-Line References (Hypermedia) are the best part about PENS.	True	False
I had difficulty transferring my files from the computer to the network.	True	False

If any of the following need improvement, please comment below:

<u>Section I</u>
PTRS Record ID function

Inspector ID, Inspector Type, Activity Number, and FAR screen

NPG

Status

Callup Date, Start Date, Completion Date

Designator

Airman Certification #

Airman Name/Other

Aircraft Registration #

Make-Model-Series

Loc/Departure Point, Arrival Point

Flight #

Investigation #

Tracking

Miscellaneous

Numeric Misc

Local Use

National Use

Activity Time

Travel Time, Travel Cost

Section II. Personnel

Personnel Name

Position

Base

Remarks

New Entry, Save Entry, Clear Entry

Section III. Equipment

Manufacturer

Model

Serial #

Remarks

New Entry, Save Entry, Clear Entry

Section IV, Comments
Primary

Key Heading

Key Word

Opinion

Clear Comment

Erase Last Ink

Erase All Ink

Undo Last Erase

Transcribe

Transcription Screen
Scratchpad Entries

Transcribed Text

Done For Now, Keep Ink

Done, Erase Ink

Aircraft Graphic

Help

Save

Save Verify

Open

New

Exit

On-Line References (Hypermedia)
Open Book

Topics (Table of Contents)

Viewer

Searching
--This Chapter

--Entire Book

Bookmarks

Copying

Other

Data Transfer

Inspector Name

Transfer List

Record List

Supervisory Review

Previous

Next

Transfer

Print

Delete

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