CHAPTER 9
ADVANCED TECHNOLOGY APPLICATIONS

Michael Merriken
Information Division, Galaxy Scientific Corporation

9.1 INTRODUCTION

Advanced technology can help maintenance and inspection (M&I) technicians as well as the aviation safety inspectors (ASI's) to achieve the twin goals of safety and productivity. This was demonstrated by the Performance Enhancement System (PENS) which used pen-computer technology. This technology was developed and evaluated in Phase V of the research project. Under the PENS program in Phase V and Work Order 01, Mods 02 and 03, several advanced technologies were evaluated with the goal of identifying applications that could be integrated into PENS. The activities described in this report used the recommendations from these advanced technology evaluations as a starting point. We decided to focus in on the following areas: 1) Development and evaluation of an improved display prototype, 2) Documentation output options for PENS, and 3) Evaluation of specific advanced technologies. We selected these areas because they matched the Flight Standards Service (AFS) requirements for recording and accessing data. Prototypes of these technologies and attributes were integrated into the PENS software and evaluated. The PENS program has since migrated from a research prototype to a pre-operational system that is called the On-line Aviation Safety Inspection System (OASIS). OASIS will be fielded this summer by the Flight Standards Service (AFS) at a limited number of Flight Standards District Offices (FSDO's).

9.2 DEVELOPMENT/EVALUATION OF PROTOTYPE FLIGHT STANDARDS AUTOMATION SYSTEM (FSAS) INTERFACE

The purpose of this task was to develop a prototype display to demonstrate how existing AFS reference documents and databases would benefit from the application of a user-centered design approach to display design and data access. This prototype capitalized on graphical user interface (GUI) technologies and Human Factors research on information presentation (color, formatting, direct manipulation, etc.). The prototype emphasized ease of use and information utilization. The research team evaluated this prototype with the Aviation Safety Inspectors (ASI).

9.2.1 Flight Standards Automation System (FSAS): Interface Weaknesses

A detailed study of the AFS database systems (Galaxy Scientific Corporation, 1995) had outlined the manner in which the ASIs interact with the numerous database systems provided for their use. This study identified several inherent weaknesses that are unique to the Flight Standards Automation System (FSAS). Based on these results we developed a prototype to address some of the important weaknesses in the FSAS interface. The goals of the prototype were:

1. Demonstrate improved FSAS functionality in the Windows environment.
2. Provide data entry guidance to users within the Windows-based FSAS.
3. Demonstrate a more efficient search function within the Windows-based FSAS.
4. Demonstrate an easier way to access supporting screens (e.g., comment screens) within the Windows-based FSAS.
5. Demonstrate how selected Windows-based FSAS subsystems would react if the subsystems were more tightly integrated.

6. Demonstrate how selected Windows-based FSAS subsystems would function if the database was normalized resulting in the elimination of duplicated data between the subsystems.

7. Demonstrate a more efficient text editor for entering comments within the Windows-based FSAS.

During prototype development, several trips were made to the FSDO in Atlanta, GA, to demonstrate the prototype and to gather feedback. The responses received from the ASIs and managers were incorporated in the prototype. During the detailed study of the AFS existing database systems, we had been informed that the AFS is planning to upgrade the existing Paradox database system to a client/server environment in the near future. This prototype also demonstrated some of the benefits that the AFS will realize under the client/server environment.

The prototype is not a fully functional FSAS system. It merely demonstrates how some of the FSAS weaknesses can be addressed. The prototype demonstrated enhancements to only two of the subsystems of the FSAS: a) The Program Tracking and Reporting System (PTRS) which enables the FSDOs to compile and track information gathered by the ASIs and b) The Vital Information System (VIS) which enables the FSDOs to maintain information about air operators, air agencies, designated airmen, check airmen, facilities, and organizations engaged in non-certificated activities. However, the issues addressed in these two subsystems are applicable to the other FSAS subsystems as well. The next section describes the prototype and how it will benefit the AFS.

9.2.2 The User Interface Prototype

The prototype demonstrates how a Micro Soft (MS) Windows-based FSAS system would operate in a client/server environment and how it would benefit the AFS. Because the FSAS prototype adheres to standard MS Windows design, users who are already familiar with MS Windows will also be familiar with the functionality of the prototype. Each subsystem is designed with the same look and feel and offers similar functionality. Hence, very little time will be spent retraining users to use this system.

The prototype attempts to guide the users through the system. Emphasis is placed on ease of use and on presenting the users with valuable information when appropriate. Figure 9.1 shows the main FSAS screen. From this screen, all FSAS subsystems (PTRS, VIS, OPSS, KEYMGR, JOBAIDS, and PLANNING) are accessible. The user-id and user information displayed is acquired from the Flight Standard Electronic Office system (FSEO) (Galaxy Scientific Corporation, 1995) which provides a single point of user login. Figure 9.2 represents the VIS main entry screen that contains the most often used functions.

Figure 9.1 Main FSAS Screen of The Prototype

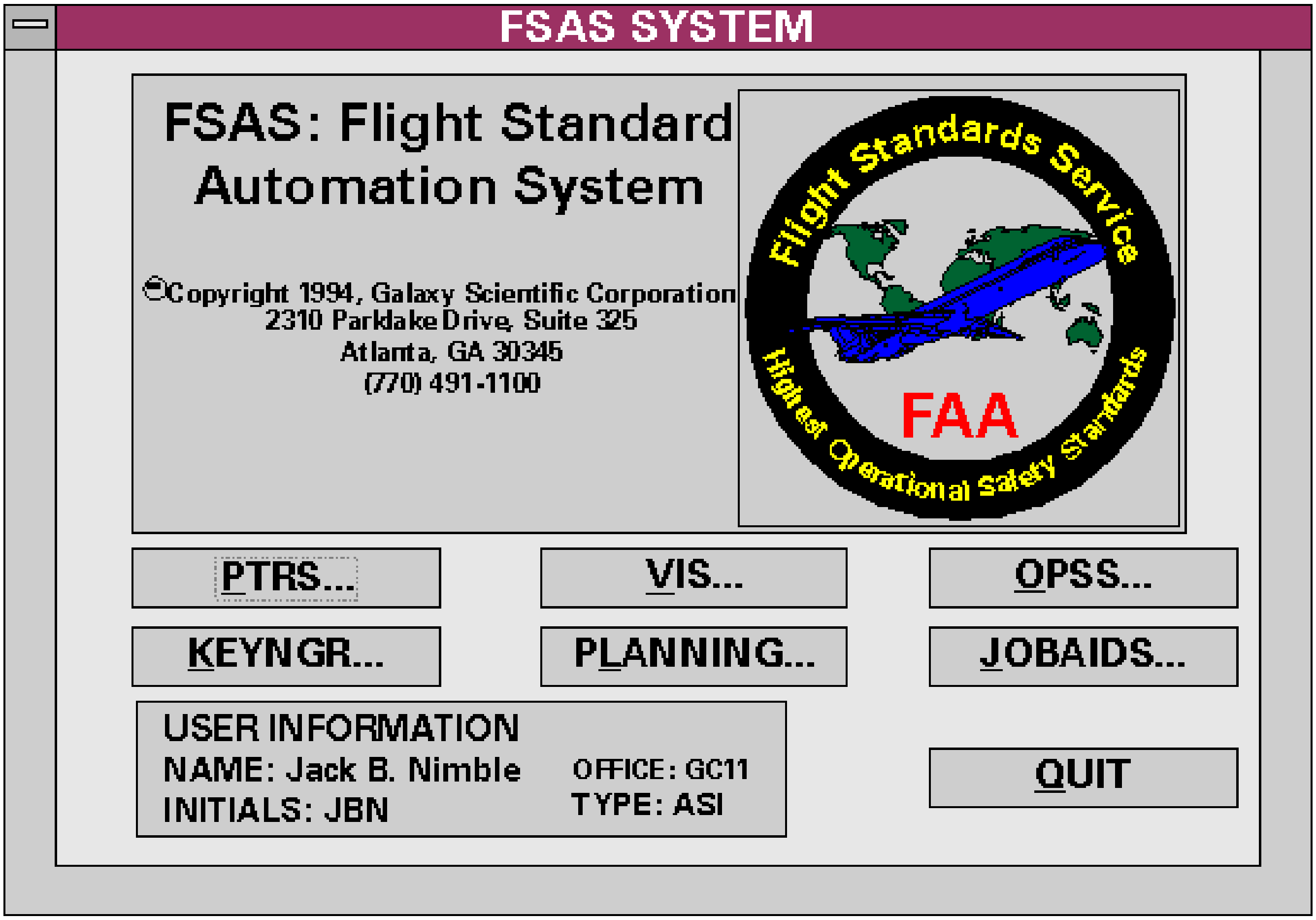
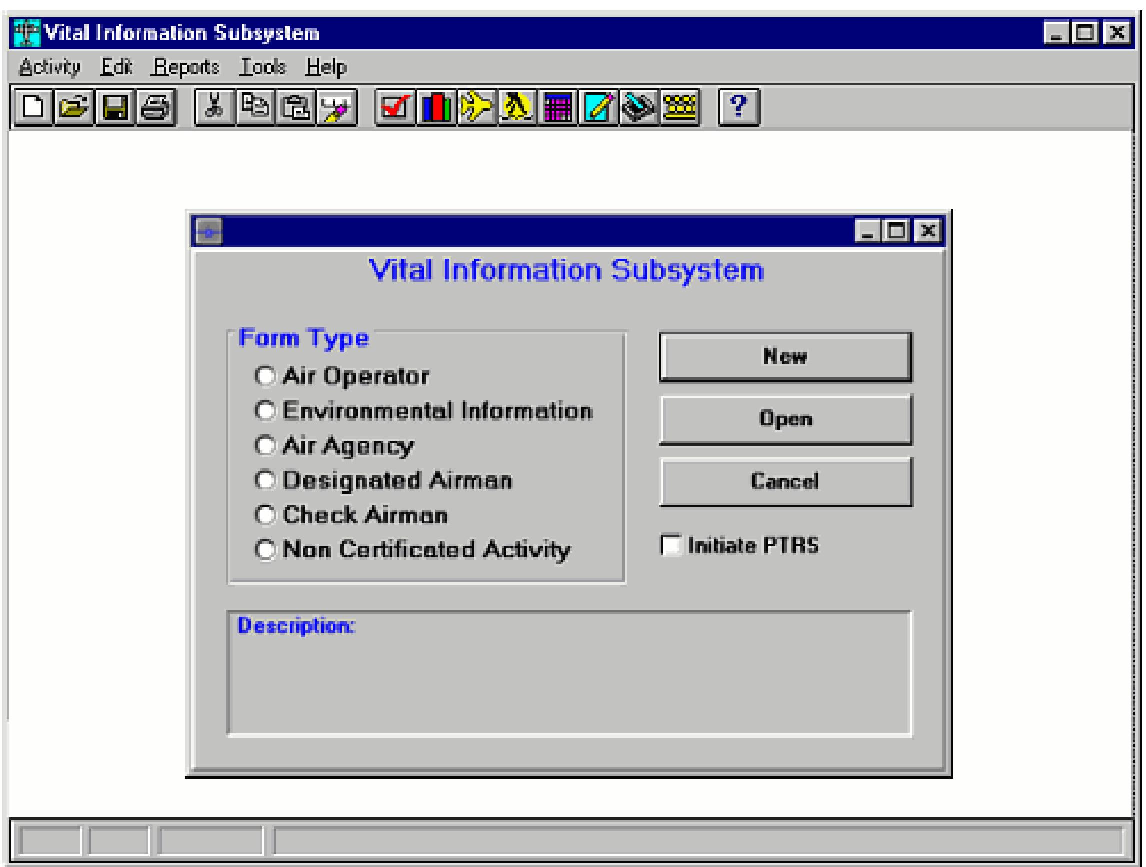
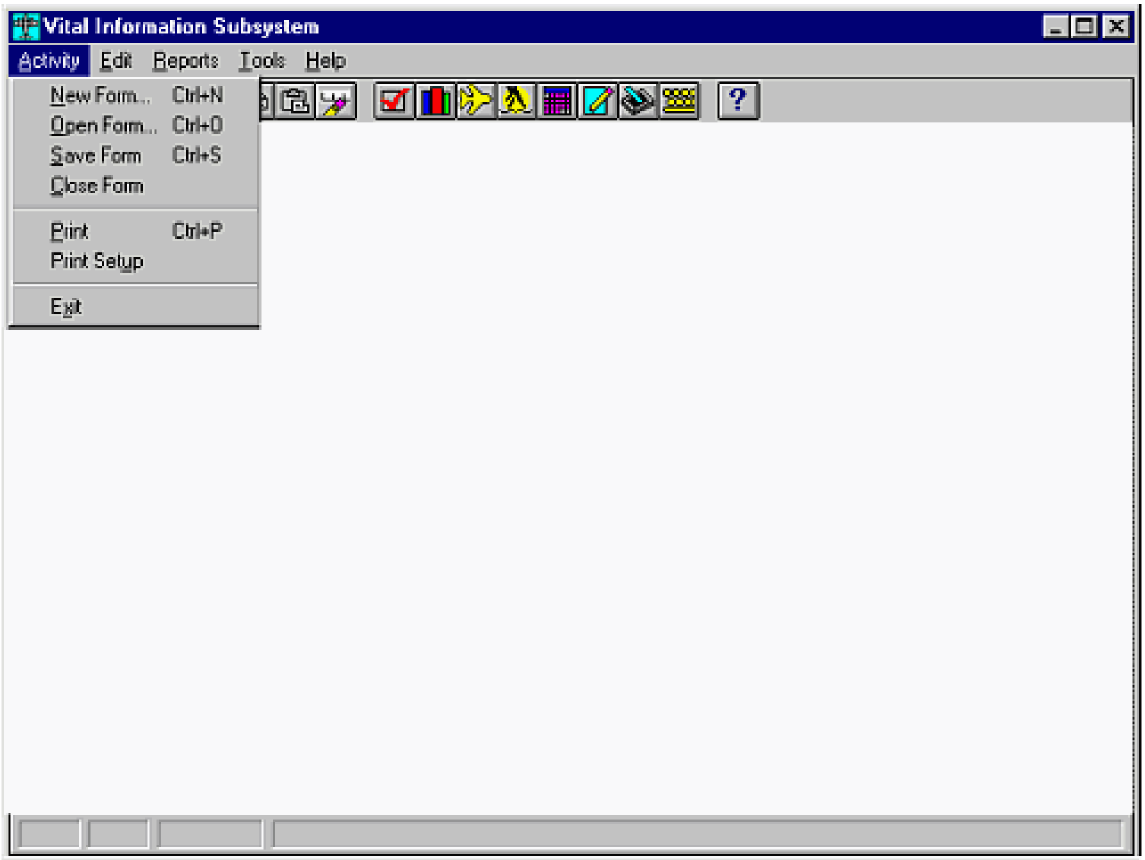


Figure 9.2 VIS Main Entry Screen



The screen allows the user to select the appropriate form from the form type section and then selects whether to create a new form or open an existing one. The description on the bottom of the dialog box (Figure 9.2) describes the form type that is selected. The main screen also has a menu bar with menu options including activity, edit, reports, tools, and help. The "Open" and "New" options presented in the dialog box on the main screen also can be accessed from the Activity menu option. Figure 9.3 is a representation of this menu option.

Figure 9.3 Activity Menu Option



The Edit menu option (Figure 9.2) offers the standard edit options available in the Windows environment such as Cut, Copy, Paste, and Clear. These options under the Edit menu allow data to copied within or between applications. The Reports menu option will provide access to pre-defined reports and to the ad-hoc reporting system. The Tools menu option provides quick access to the PTRS and VIS subsystems. The Tool Bar located at the top of the screen contains icons and provides the same functionality as the menu items. The tool bar icons can be used to gain quick access to frequently used applications. A balloon help function was integrated into the prototype so that whenever the cursor is moved over an icon on the Tool Bar a brief description of the item is displayed.

9.2.3 Implications of Moving to Windows

The current implementation of FSAS is a DOS-based, Paradox-driven application that is not compatible with the MS Windows operating environment. The ASIs and other AFS users often use several windows-based software packages along with FSAS on a daily basis. Both FSAS and the MS Windows Operating System cannot operate simultaneously on the ASI's desktop computer. Therefore, if a user is in FSAS and he/she needs access to an MS Windows-based software package, the user will be required to exit FSAS and then start the Windows Operating System. It is the intention of the AFS to convert all of the major safety-related database systems to run within MS Windows. When this takes place, the ASIs and other AFS users will no longer be required to exit one subsystem in order to start another. This will reduce the time and effort it takes to access these subsystems.

In addition, by having all major systems running under the MS Windows environment, data can be easily transferred within and across subsystems. For example, if an ASI needs to write a memo in MS Word and he/she needs to reference information in FSAS, this information can be transferred from the appropriate subsystem to the memo directly by using the standard cut and paste functionality in MS Windows.

Another advantage of having all major database systems running in the MS Windows environment is that several safety related subsystems can be run simultaneously. Therefore, a user can potentially have PTRS, VIS, and OPSS running at the same time, which is important if the user needs to copy information across subsystems. The only limit to the number of subsystems that can be up and running simultaneously is the amount of memory that is installed on the user's desktop computer.

Although the AFS will eventually migrate its major applications to the MS Windows environment, this will take time. This will result in some systems continuing to reside on the mainframe computers before the transition is complete. However, access to the mainframe via MS Windows will not be a problem as there are several software packages on the market that effectively address this issue. Procomm for Windows and IBM Personal Communication System are two such packages that allow users working in the Windows environment to access the mainframe. This will allow a user to cut and paste information from mainframe applications to Windows-base PC applications.

9.3 DOCUMENTATION OUTPUT OPTIONS FOR PENS

The PENS program currently provides an unformatted report option to print out a transmittal record. The ASI who uses PENS still needs to fill out an original form to sign and give to his/her supervisor to approve. It would obviously be more convenient if PENS could print out formatted reports that closely resemble the original forms. This activity evaluated different print applications to print out forms from PENS. The PTRS form was used as a sample form to be printed. We met with ASIs to discuss various issues to be considered when printing out a form. Then different ways of printing the forms were considered

9.3.1 Printing a Form

There are two steps to print a form. First, the form has to be digitally re-created and secondly, the form populated with data has to be printed out. We looked at existing applications in which the forms could be designed easily. These applications also had to provide programming interfaces so that the PENS program can communicate with them to print the forms. There are two characteristics of the PTRS form affecting the ease of creating the form: data model and the layout of the form.

Data Model

The data on the PTRS form contains four sections: 1) Transmittal general information, 2) Personnel information, 3) Equipment information, and 4) Comment. These data are stored in different database tables. Section 1 is stored in "Master" table while the rest of data are stored in "Detail" tables. It was discovered that different applications support different data models. Some do not support Master-Detail tables but only support a single table for each form. For such applications, we need to retrieve the data from multiple tables and save them into a temporary table. Later the application will use the temporary table as the data source to print the form.

Layout of The Form

On the PTRS form, the master data are located on the left. The Detail tables are below and to the right of it. The layout is critical because some applications may not support random placement of data. These applications usually allow Detail data to be put below the Master data rather than next to it.

9.3.2 Programming Interface

The common programming interfaces that applications provide include: development library (DLL), custom control for development (VBX), Dynamic Data Exchange (DDE), Object Linking and Embedding (OLE), and simple languages like scripts or macros. Usually DLLs and VBXs provide more low-level functions and are more powerful. They also take up fewer resources than the rest of interfaces. Since PENS is a large software application and uses up significant computer resources, it is better to choose applications that use fewer resources in order to avoid interference with PENS. Moreover, it is easier to program and control using DLLs and VBX. If the application does not provide any interface, other work-around methods will need to be found in order to use that application.

9.3.3 Applications Evaluated

Three applications were studied for the design and printing of forms: 1) Crystal Reports by Crystal Computer Services, 2) OmniForm by Caere Corporation, and 3) FormFlow by Delrina Corporation. FormFlow was selected for further evaluation due to better compatibility with the existing PENS software

OmniForm

This application was very easy and fast to create the layout of the PTRS form. First, the paper form was scanned into the computer and a digital image of the form was produced. The image was then imported to OmniForm where the application automatically generated an electronic form that looked exactly the same as the inputted form. Depending on the quality of the image, some recognition mistakes like spelling mistakes and some missing lines may have to be fixed. OmniForm was able to recognize most of the fields on the form. Only a few fields had to be added or deleted. The time it took was less than an hour per form, if the developer is familiar with OmniForm.

However, OmniForm only allows one table for each form. That means Master-Detail feature is not supported. Therefore, a single table had to be created containing all the data of the transmittal record. The data was then imported to the form and the form was printed out.

There is another weakness of OmniForm. It does not have a programming interface with other applications. It may be possible to print out a form by sending messages from PENS to OmniForm to simulate key strokes entered by a user. However, this method is fragile and most programmers would try to avoid using such a method. Much time was spent scanning in the forms and writing the conversion program that stores data to a single table.

Crystal Report

Crystal Report supports Master-Detail table structure on the report. However, Crystal Report is more like a general report generator that expects data flow to be from top to bottom. It only allowed detail data to be placed below the master data but not next to it. If Crystal Report was used to print out the forms, a temporary table would need to be created in order to put all the data on the report. So, even though it has the Master-Detail feature, we were not able to take full advantage of it. Designing a form was straight forward. It was easy to insert a field into the report form, but it was difficult to position the field exactly where we wanted it. Crystal Report comes with VBX custom controls which can be used with Visual Basic making it easier to program and control. Most of the effort was expended on how to create the Master-Detail linkage; this was **not** a minor task.

FormFlow

A key capability of FormFlow is that it supports Master-Detail data structure and it also supports random placement of data. Therefore, no data conversion was needed. Data was read directly from the original tables containing the PTRS transmittal record. Designing the form was simpler than using Crystal Reports. The Data fields were generated directly from the data file. Master-Detail linkage also was defined easily. The FormFlow application that was tested was a stand-alone application version. PENS can print a report by starting the application with a macro file that prints the report automatically. PENS can also start the application and communicate with FormFlow using Dynamic Data Exchange (DDE). Moreover, FormFlow has a programming interface that PENS can use without using macros or DDEs. We spent a longer test period on FormFlow compared to the other two applications due to the better compatibility with the existing PENS software. The following sections describes the tasks that were completed in order to print out a correct PTRS report from FormFlow.

9.3.4 Form Flow Evaluation

Master and Detail Tables on the Report

The first thing we tried was to create a report of all transmittal records. We defined the data tables and linkages between tables. However, only the data from the Master table showed up and the data from the Detail tables were missing. Detail tables were linked to the Master table by the transmittal record ID and the inspector office code. These data were stored in two separate fields in the master table. In the detail tables, the same data were combined and stored in a single field. At that point, we thought it was because the linkages were abnormal and that FormFlow was not able to handle it. We then had to find another way to print out the report.

Report with a Temporary Table

We recognized that no matter what method we chose to print, we still needed to find a method for PENS to specify which transmittal record it wanted to print. So we created a temporary table. This table contained the transmittal record ID, the inspector office code, and combined information of these two. This table not only was used to specify the transmittal record but also acted as a bridge between the Master table and the Detail tables. This method worked and the data was correctly printed on the report.

Report Using SQL Tables

The report was created using Paradox tables. We then duplicated the report using SQL tables instead. This second report worked fine and showed and printed the data correctly.

Running from PENS

At the beginning, these two methods for printing reports were tested without PENS. That means we started the FormFlow application itself and opened the reports manually. We then converted the PENS application to print the report from within itself. The report using Paradox tables printed the form and the data correctly when it was run by itself and when it was run from PENS. However, the report using SQL tables was different. It printed the data and the form correctly if it was run by itself. If it was run from the PENS application, the report was printed without the data.

To determine why this occurred we tried several approaches. When PENS printed out the report, it actually started the FormFlow application and then commanded the application to print the report. At that time, we thought PENS took up too many resources so that FormFlow could not run properly. Then we tried running the FormFlow before running PENS. It turned out that FormFlow still could not work properly when it was with PENS. Then we asked for technical support from the manufacturer of FormFlow, Delrina. They told us the problems may be caused by the SQL server. Then we tried to vary the settings on the server but that did not work. We talked to the technical support people several times without any success. The last thing we tried was to increase the conventional (based) memory in DOS. It was done by loading a lesser number of programs in DOS before we ran Windows. The report printing then worked correctly. All data showed up on the report. This behavior of FormFlow shows that it is very sensitive to the amount of conventional memory available.

Summary

If the memory can be configured properly, FormFlow would be the best choice to print a form report. The forms are easy to design and can be easily integrated with PENS. Crystal Report would be the second choice. The main advantages of Crystal Report are that it is not sensitive to the amount of memory available and can be programmed easily. However, it takes longer to design the report and to integrate with PENS.

9.4 EVALUATION OF ADVANCED TECHNOLOGIES

The goal of this task was to identify appropriate applications of emerging advanced technology to support current and future activities of the FAA and aviation industry areas. These advanced technologies included mobile computing applications and personal digital assistants.

9.4.1 Evaluation of New Computing Technologies

The future deployments of mobile computing applications for the AFS will be dependent on the notebook computers in production at that time. We reviewed the current technical literature and developed a list of specifications that would meet the current needs of the aviation safety inspectors and those needs in the future. This information is contained in Table 9.1.

Table 9.1 Desirable Features For A Mobile Computer

1. Upgradable processor
2. Rugged internal CD-ROM drive
3. Daylight readable display
4. Two Type II/one Type III PCMCIA drives
5. Large hard drive
6. Docking Station option
7. Reputation for low maintenance
8. Manufacturer has good reputation for customer service.

We identified two computers that met these criteria. These computers were manufactured by leading computer companies, and cost under $5,000 retail. They were -- the Toshiba 2150 CDT and the Panasonic CF-41. Table 9.2 is a comparison of these two units. We contacted these manufactures and were provided with a computer for a brief evaluation period.

Upon their arrival, we loaded the current version of the PENS software and tested its ability to run the application. Both computers proved to more than adequate to support the application. No problems nor deficiencies were found with either computer and the PENS software.

Table 9.2 Comparison of The Selected Mobile Computers

Computer	Processor	HDD	RAM	CD-ROM	Pointing Devise	Weight	Battery	Docking Station
Toshiba T2150	486/75	540 MB	8 MB STD + 8 upgrd	2x	Accu-point	6.9 lbs.	NiMH	No, port replicator only
Panasonic CF-41	486/100	810 MB	16 MB	2x	Integrated Trackball	8 lbs (9 lbs w/ 2nd bttry) *(1)*	NiMH	Yes with monitor stand

The computers were evaluated using the PENS software for a whole week. The following observations were made:

Durability

These computers will be taken on the road by the ASIs and therefore exposed to rougher treatment compared to a computer that would remain on a desk. Therefore, durability was a prime consideration. The CD-ROM drive design on the Panasonic CF-41 computer is located under the keyboard and is a much stronger mechanical design and less susceptible to damage than the slide-out carriage found on other computers. A damaged CD-ROM drive will result in the loss of the on-line reference material.

Desk Space

We noted that in most FSDO offices, the ASIs have minimal desk space. We therefore rated highly a desktop solution that minimizes the requirement for desk space. The Panasonic CF-41 computer utilizes a Docking Station concept that minimizes the desktop space requirements by stacking the monitor on top of the docking station and provides internal card slots for expandability. The Toshiba 2150 uses a port replicator that does not contain these features.

Cursor Control

The majority of inspectors had an opportunity to operate our test notebook computers preferred the trackball provided by the Panasonic computer over the "Accu-point"/Track-point" devices found on the Toshiba 2150 and other computers.

Battery options

The Panasonic computer's battery configuration was found to be superior. A second battery can be used in place of the 3.5 inch floppy drive for longer field use while retaining the CD-ROM drive. This feature is unique to the Panasonic computer. The Toshiba 2150 has no extra battery options. On the other hand, the Toshiba does use an integral ac adapter that obviates the need for an external adapter required by the Panasonic.

Sunlight Readable Display

The Panasonic was the only computer that has a special capability in its display unit that increases its sunlight viewing contrast. The display panel is also protected with a rugged magnesium cabinet to better withstand the rigors of mobile use.

Maintenance

The Panasonic and the Toshiba come with a three-year warranty.

Availability

The final consideration was that the Panasonic computers, plus docking stations, were in-stock and available to be shipped immediately. This availability issue was in question for the other computers based upon conflicting statements from several value-added resellers.

At this point in time it is our opinion that either of these computers would be a good choice for the program but our preference is for the Panasonic CF-41.

9.4.2 Personal Digital Assistants for PENS

We performed a study on the feasibility of using a Personal Digital Assistant (PDA) for data collection and information retrieval purposes with the PENS program. The Sony MagicLink PDA was used to conduct this evaluation. The Sony MagicLink interface with PENS was addresses in five areas: Physical Configuration, User Interface, Communication, Software Development, and Application Areas.

Physical Configuration

The MagicLink PDA is small in size (about 8 in. x 6 in.) and very light weight (1.3 lb.) making it easy for an Aviation Safety Inspector (ASI) to carry it around. However, due to its small size, it also has a small display screen. This limits the amount of information that can be either entered or viewed on a single display. The MagicLink does not have an attached physical keyboard. Data entry is accomplished by one of three methods: 1) Using the stylus device for selecting data from pick lists or utilizing the handwriting recognition feature, 2) Using the software keyboard on the screen, and 3) Connecting an external physical keyboard. The last option is the least desirable based upon the results of the earlier PENS evaluation in Phase V. In this evaluation the ASIs did not like to have additional equipment attached to the primary computer because it was too easily lost or damaged.

The MagicLink comes with a standard one megabyte of storage and can be extended to two megabytes by adding a memory expansion card. Unfortunately, this storage capacity is so small that it will not meet the needs to the current PENS program. A reduced capability version of the application could be developed in the future specifically for a PDA.

User Interface

The user interface of MagicLink makes use of the "desk" and "hallway" metaphors. It is intuitive and easy to use though limited in features because of the minimal processing power, screen size, and memory storage. The common input and output controls are text boxes, check boxes, radio buttons, command buttons, list, and icons. All of the controls allow only small amount of information to be displayed at one time. For instance, a long narrative describing an aircraft accident would be difficult to write and edit in a text box due to the fact that only several lines of text could be viewed at any time. The text box would be more appropriate for small inputs like a Model Number or a Name Code. Also, large databases commonly used within the AFS's Program Tracking and Reporting System (PTRS) would not be accommodated by Magic Link's look-up lists. Check boxes or options buttons would be suitable for responding to questions with Yes/No answers.

Communication

One of the strong points of the MagicLink PDA is its communications capabilities. There are a number of ways for MagicLink to communicate. It can connect through a telephone line to a number of services like AT&T Personal Services, America On-line, and CompuServe. Mailed messages with data can be sent or received using these services. There is a third-party terminal emulation program through which Magic Link can be connected to different bulletin board system (BBS) or different servers. Data can then be transferred via these networks. MagicLink can also be directly connected to a personal computer using a special cable and a software application called Magic XChange. Using Magic XChange, files and data can be saved to, or retrieved from, MagicLink. When used within the limitations identified earlier, being able to collect data using a PDA and then uploading the information to the PENS system is the area of interest.

Software Development

The only software development tool that is currently available for Magic Link is called Code Warrior. It is an add-on tool to the Macintosh Programming Workshop that is a programming environment on a Macintosh computer. Applications have to be developed on the Macintosh and tested using a MagicLink Simulator on the Macintosh before porting to the PDA. There is another software application called FreeStyle which allows a user to develop simple forms' applications on MagicLink directly. This application will allow the creation of input boxes, option buttons, lists, check boxes, and signature blocks on these forms. Once the data has been collected, it can be transferred back to a workstation and stored in a number of different database formats. FreeStyle also has a script language that can be used to perform some simple data processing.

Application Areas

The application areas for the PDA are limited because of limited capabilities of the user interface. Applications like a small checklist or small reports would be suitable for this operating environment. Generally, the inputs and outputs of an application have to be simple for use on the MagicLink PDA. They have to be segregated into smaller pieces of information. For the PTRS form, this would apply to the fields of inspector name, completion date, activity time, personnel position, manufacturer's remarks, etc. Based upon our evaluation of the product, if information can be organized well and broken down into small groups, MagicLink can be a useful tool for data collection.

9.5 CONCLUSION

A user interface prototype was developed and evaluated to enhance some of the observed weaknesses in the Flight Standards Automation System (FSAS). This prototype was well received by the FSDO managers and the ASIs. They all felt that this interface would improve task performance. Applications to design and print forms within the PENS program were investigated. It was concluded that FormFlow would be the best choice to print a form report. A list of specifications was developed for notebook computers to meet the mobile computing needs of ASIs. Two computers meeting these specifications were evaluated and found to be equally good. Finally the Sony MagicLink personal digital assistant was evaluated for data collection and information retrieval purposes. It was concluded that it could be a useful data collection tool for small checklists or reports.

9.6 REFERENCES

Galaxy Scientific Corporation (1995). *A Human Factors Study of Information Dissemination and Display for the Flight Standards Service* (Contract No. DTFA01-94-C-01013, Work Order # 2). Washington, DC: FAA/AAM.