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PEN-BASED COMPUTERS: COMPUTERS WITHOUT KEYS

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ABSTRACT

The National Space Transportation System (NSTS) is comprised of many diverse and highly complex systems incorporating the latest technologies. Data collection associated with ground processing of the various Space Shuttle system elements is extremely challenging due to the many separate processing locations where data is generated. This presents a significant problem when the timely collection, transfer, collation, and storage of data is required. This paper describes how new technology, referred to as Pen-Based computers, is being used to transform the data collection process at Kennedy Space Center (KSC). Pen-Based computers have streamlined procedures, increased data accuracy, and now provide more complete information than previous methods. The end result is the elimination of Shuttle processing delays associated with data deficiencies.

INTRODUCTION

As paperwork associated with Shuttle processing continues to grow in volume, along with it grows the need to increase manpower and equipment (Figure 1). Todays budget cuts and continued reduction in the workforce made the problem seem hopeless. An innovative way to collect data in an accurate and timely manner, and at the same time provide automated validation, was needed. The Pen-Based computer has provided the solution to this problem. The system not only collects data but also provides a historical database for analysis. Through networking capabilities, this data can be made available to users at all National Aeronautical Space Administration (NASA) centers and contractor locations.

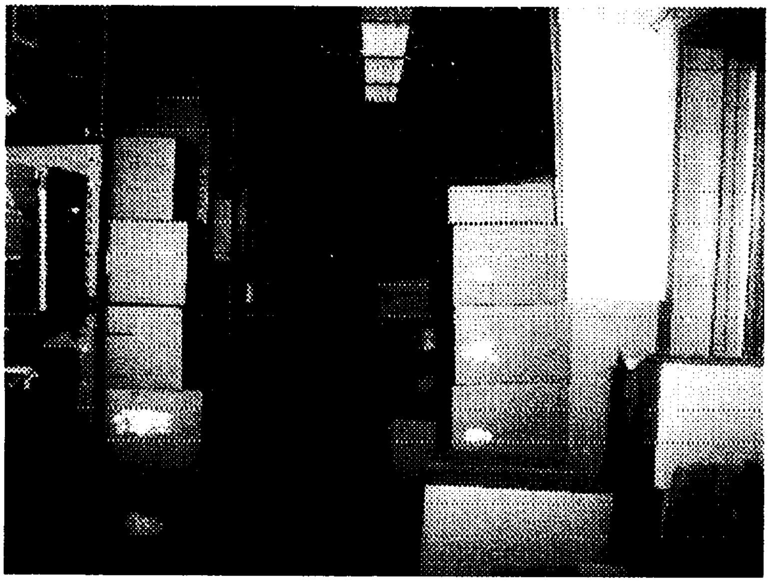


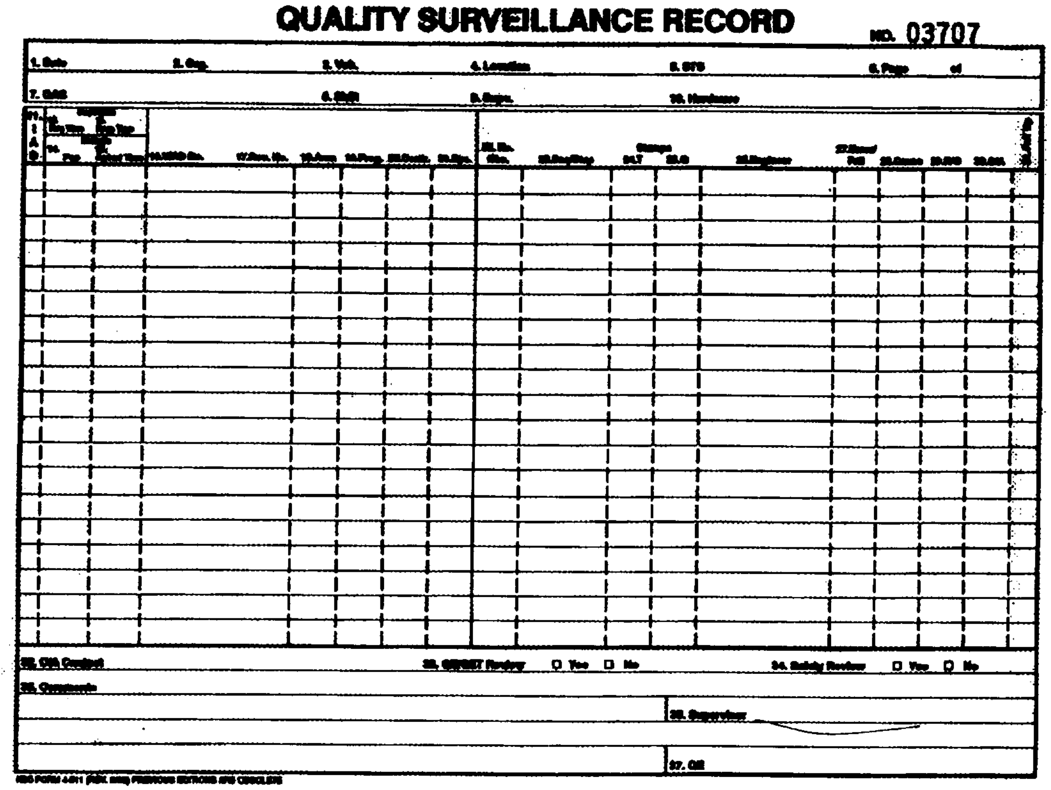
Figure 1 Data Storage Area at KSC

BACKGROUND

The existing process of collecting data at KSC is time consuming, labor intensive, and cannot provide real-time support. These deficiencies become extremely critical when dealing with shuttle quality inspections. Mission Managers utilize data from these inspections to make decisions relating to safety, manpower, and funding. The overall impact of quality data on NSTS mission success was the prime reason for selecting the Quality Assurance function as a process improvement project. After a review of new technologies, it appeared that Pen-Based computers would meet improvement requirements.

In 1992, NASA funded a project to research and assess Pen-Based computer technology. The project's goal was to determine if Pen-Based computers could improve the data collection process at KSC and simultaneously reduce the use of paper forms required by the Quality Assurance Program. Before the project could begin, a thorough review of the data collection process was required.

The function of KSC's Quality Assurance Program is to collect information on the processing activities of the Space Shuttle in order to eliminate obstacles and to provide guidance to achieve maximum utilization, efficiency, and effectiveness of the processing resources [1]. In order to perform this function, data must be collected and analyzed. This is accomplished by the KSC Quality Assurance Surveillance Program. The program assigns a Quality Assurance Specialist (QAS) to an area to survey activities. The task of the QAS is to perform scheduled and unscheduled surveillance of contractor activities, and to verify, monitor, witness, and perform inspections. This surveillance often requires the use of Work Authorization Documents (WADs) which identify Mandatory Inspection Points (MIPs). If surveillance is performed against a WAD, a status stamp is required for the steps surveyed. Once the surveillance is complete, the QAS records the results of the activities on a Quality Surveillance Record (QSR) (Figure 2). At the end of the shift, all the QSR forms are collected and reviewed by the Functional Supervisor. The QSRs are then routed to the Branch Supervisor. Once the Branch Supervisor has reviewed all the QSRs, they are forwarded to Quality Engineering (QE) for review and sign-off. The QSRs are then routed to a data entry clerk for processing. The QSRs are entered into a database, compiled once a month and then transferred to a floppy disk. The floppy disk and the original paper forms are routed to the NASA Trend Analysis Group for analysis. The trending group then processes the data and produces numerous trending reports for distribution.



QUALITY SURVEILLANCE RECORD NO. 03707

Figure 2 QSR Form

After completion of the process analysis, a technology survey was performed on Pen-Based Computers and related equipment. The survey addressed the areas of portability, durability, ease of use, ability to transfer and receive data, programmability, and cost. The search turned up over 195 commercial vendors of Pen-Based computers and associated hardware and software. These computers range from 286SXs without hard drives, to 486s with over 200 MB hard drives. Pen-Based computers are classified in four distinct categories: Tablet, Pentop, Tethered Tablet, and Palmtop. The Tablet Pen Computer is about the size of a standard notebook and uses the pen as the primary input device. The Pentop Pen Computer has a tilt up screen and provides both stylus and keyboard inputs. The Tethered Pen Computer has the pen input device attached to a desktop computer. This type of pen computer is very popular with secretaries and software developers because it can tie directly into their workstation. The Palmtop Computer does not have a built-in harddrive, therefore it is lightweight and can be hand-held. The Palmtop Computer uses the pen as the primary input device and most have communication networking capabilities. The survey concluded that Pen-Based computers would be extremely beneficial in streamlining the data collection process at KSC.

SYSTEM DESIGN

System Automation Requirements:

The system requirements for the Quality Assurance data collection efforts were evaluated and narrowed down to three items: size, weight, and the ability to be tethered. These criteria are important due to the working conditions that will be encountered. The system must be light enough to carry around for an entire eight hour shift. In addition to being light, it must also be small enough so that it can be maneuvered in tight areas. The most important requirement is the capability of tethering the system to the individual using the computer. NASA Safety requires that all items used in the proximity of the Shuttle be tethered, thus eliminating the chance of damaging the Shuttle or harming others. Based on these three criteria, the PalmPad computer, a member of the Palmtop category, was selected.

System Description:

The system selected for the data collection automation is comprised of three subsystems. They are the PalmPad computer, an operating system, and a Touch Memory peripheral. This section will describe each subsystem.

PalmPad:

The PalmPad weighs 2.9 lbs., provides hand-straps, and is equipped with a 2 MB Flash Card. The Flash Card, also known as a PCMCIA card, is a removable storage device the size of a credit card. The card inserts into a slot similar to a disk drive and replaces the permanent harddrive. There are two types of PCMCIA cards: memory cards and I/O cards. The memory cards are divided into four categories: static RAM, dynamic RAM, EPROM, and EEPROM (flash memory). The memory cards are used in place of a disk drive or harddrive and range from 2 MB to 20 MB of memory. Two important advantages for using this form of storage are increased access time (about 10 times faster than a hard disk), and decreased power consumption [2]. The primary disadvantage of memory cards is the cost, approximately $1000.00 for a 20MB card. The I/O cards, however, are used to support peripheral devices, such as modems, FAX cards, LAN adapter cards and bus adapter cards.

Operating System:

The operating systems of two leading competitors, Go Corporation and Microsoft Corporation, were evaluated for use. A closer look into each company's operating systems revealed distinct differences. One noted difference was that Microsofts' Pen for Windows did not require file or data conversion when dealing with existing applications which was a major factor in selecting their operating system. Microsoft also provided the ability to connect to a Local Area Network (LAN) which was an important feature. Pen for Windows includes all the networking solutions that are associated with the traditional Windows. The final issue, and most important, was handwriting recognition that also incorporated a handwriting learning capability. First time users complete a training exercise that requires them to print the letters of the alphabet three times. Information is then stored in that individuals own dictionary, which will be referenced anytime that individual logs onto the system. This becomes very helpful when a persistent problem recognizing a character arises. If this occurs, the user can call up the Trainer, reference the problem character, and select the correct translation. This character will then be added to the user's personal dictionary as a reference. The versatility of the above mentioned Pen for Windows features was the prime reason for selecting this software as the operating system.

Touch Memory:

Touch Memory is a peripheral device that can be integrated with the PalmPad for an electronic sign-off capability. When dealing with the legalities of electronic sign-off of forms, there are two solutions. The first solution is the capturing of a signature by use of bit map imaging. The second solution is that of a new technology called Touch Memory. Touch Memory is a innovative, nonvolatile memory chip packaged in a rugged, stainless steel can (Figure 3). This new, coin-shaped device makes it easy to transfer information simply with a touch. The reading and writing of the Touch Memory button is accomplished by momentarily contacting a Touch Button reader. Unlike the read-only bar code system, Touch Memory has a read/write capability and may replace bar-codes in the future. Touch Memory also records over 100 times the data of bar codes and is available with memory capacities of 4 KBs and more. This technology will be interfaced with the Pen-Based computers for handling signatures on the QSR forms. Touch Memory buttons will be assigned to each individual required to sign QSR forms. Sign-off will be accomplished by simply touching the button to a reader on the Pen-Based computer. This procedure transfers the individual's ID number onto the form.

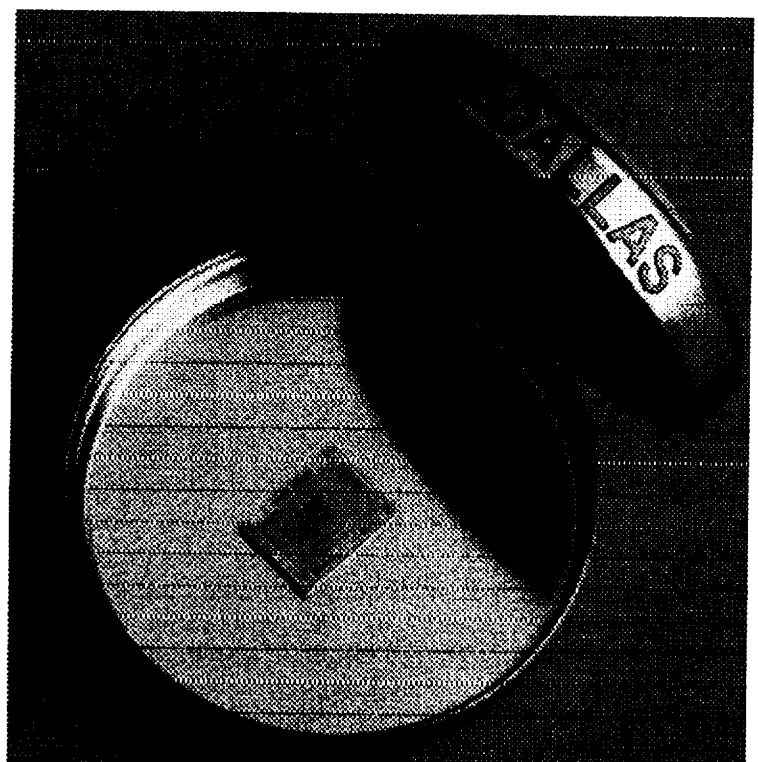


Figure 3 Touch Memory

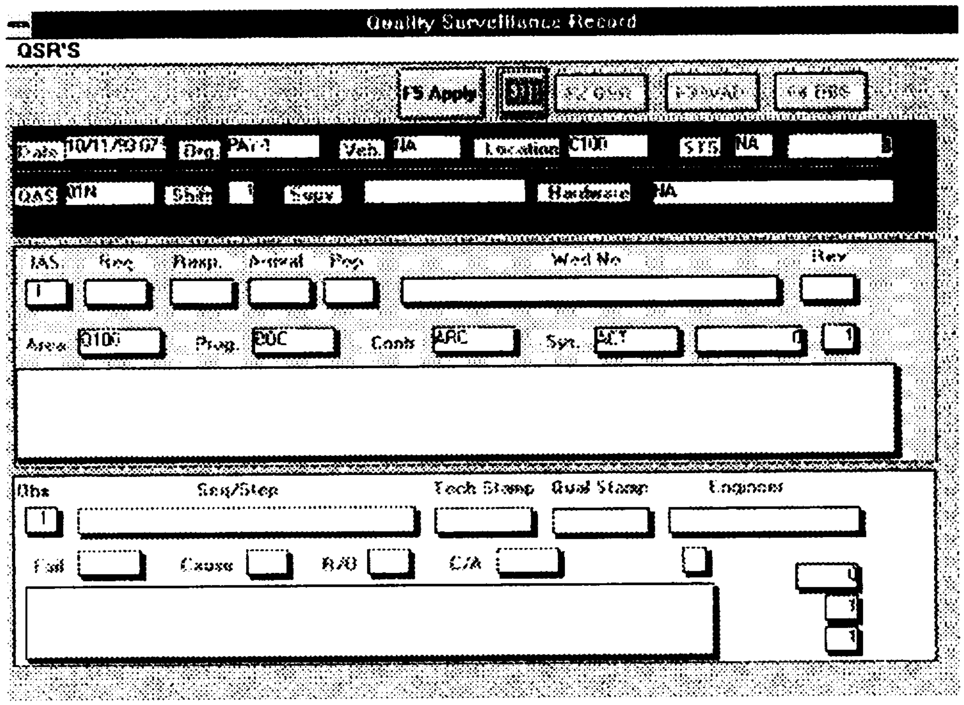


Figure 4 QSR Entry Screen

IMPLEMENTATION

After the identification, selection and procurement of hardware and software, the system was configured to meet the unique KSC data collection program requirements. The system required a log-on, log-off capability, and data entry capability which is accomplished through the use of a Main Menu and Data Entry screens. The original paper form was altered to allow for a smooth transition throughout the form and to allow ample room for data entry. The QAS using the Pen-Based computer will first log onto the system. The Main Menu will then appear. The "Add QSR" button will be selected which will bring up the entry screen as shown in Figure 4. The entry screen has been designed with legal value tables, and required field checks. Legal value tables have been set up for location, vehicle, organization, QAS, work area, program, contractor, system, failure code, cause, responsible organization, and corrective action fields. Certain areas of the form are automatically updated when a key value is entered. For example, when the name of the QAS is entered, the supervisor name, the QAS's mail code and shift will automatically be filled in. After each QSR record is completed, a verification check will be automatically performed. The QAS proceeds through the form, filling in the appropriate information, until all data entry is completed. At this point, an option for adding a new QSR or exiting the system is provided. Regardless of the action selected, a check will be made to verify that all required fields have been filled in. If a required fields has been left blank, an error message will appear and no further action will be permitted until the error condition has been corrected. The QAS is then allowed to add a new QSR or exit the system using the touch memory button.

The complete QSR data collection system consists of a handheld Pen-Based computer utilizing Pen for Windows as the operating system. This system collects and stores data in a flat ASCII format on the PCMCIA card. At the end of each shift, the QAS will extract the PCMCIA card and place it in an external drive that is located at a stationary workstation. This data will then be uploaded to the network, and appended to the centralized database which stores all QSR data.

Testing and Validation:

System testing and validation was accomplished over a four month period by running the Pen-Based computers in parallel with the paper forms. The data from both systems was compared to make sure that it had not been corrupted or lost.

Training:

Pen-Based computers are extremely user-friendly and requires minimal training. System training at KSC will be conducted in two phases: Pen-Based unit familiarization and forms entry. It is designed to provide QAS personnel with "hands-on" experience, and will be required prior to certification.

CONCLUSION

Pen-Based computers are extremely versatile and can be used to automate virtually any data collection process. They can be tailored to unique requirements, integrated with any computer system, and networked for data exchange. Their use at KSC for the data collection, transfer, and storage process has greatly improved management decision support. Delays in shuttle processing related to data deficiencies have been reduced significantly. Pen-Based computers have been extremely useful in streamlining the NASA Quality Data Program and will be further utilized in other paper processes at KSC and other NASA centers..

ACKNOWLEDGEMENTS

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"THE VERTICAL"

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ABSTRACT

"THE VERTICAL" computer keyboard is designed to address critical factors which contribute to Repetitive Motion Injuries (RMI) (including Carpal Tunnel Syndrome) in association with computer keyboard usage. This keyboard splits the standard QWERTY design into two halves and positions each half 90 degrees from the desk. In order to access a computer correctly, "THE VERTICAL" requires users to position their bodies in optimal alignment with the keyboard. The orthopaedically neutral forearm position (with hands palms-in and thumbs-up) reduces nerve compression in the forearm. The vertically arranged keypad halves ameliorate onset occurrence of keyboard-associated RMI. By utilizing visually-reference mirrored mylar surfaces adjustable to the user's eye, the user is able to readily reference any key indicia (reversed) just as they would on a conventional keyboard. Transverse adjustability substantially reduces cumulative musculoskeletal discomfort in the shoulders. "THE VERTICAL" eliminates the need for an exterior mouse by offering a convenient finger-accessible curser control while the hands remain in the vertically neutral position. The potential commercial application for "THE VERTICAL" is enormous since the product can affect every person who uses a computer anywhere in the world. Employers and their insurance carriers are spending hundreds of millions of dollars per year as a result of RMI. This keyboard will reduce the risk.

ERGONOMICS AND RMI/CTD

The understanding of ergonomic factors for computer workstations is a relatively new area of research and application. The word 'ergonomic' explains the interaction of people to their environment and only first appeared in the workplace in the early 1980s with regard to the meat-packing industry. Although the need for ergonomic office furniture and furnishings has been recognized since 1986, due to the rapid increase of Repetitive Motion Injuries (RMI) and Cumulative Trauma Disorder (CTD) at computer workstations, modifications have been slow in coming. This is due to the perceived high-cost factors to the employer and the absence of governmental regulations.

During 1991 and 1992, media sources focused on business owners who had a difficult time paying for rising insurance costs due to increased workers' compensation claims for non-accident related injuries. The media began concentrating its attention on ergonomic solutions to work environment problems other than the computer keyboard. They blamed the computer industry, the video display terminal and lag time by a majority of employers, who over the past decade have used technology to double production, but have failed to protect the worker using that technology. By mid-1992, full media attention was focused on the recognition that the traditional computer keyboard design was the primary cause of repetitive motion injuries for computer keyboard users.

Repetitive motions (keystrokes) are an essential part of a computer operator's work function. According to the Bureau of Labor Statistics, repetitive motion injury claims, such as Carpal Tunnel Syndrome, have grown at an alarming rate over the last decade. These injuries can cost employers $30,000-$80,000 in health insurance, sick pay, disability, and workers' compensation benefits per incident.