Payoff

Pen-based computing offers mobility to workers at remote locations who spend much of their time collecting information. Because pen-based computing is different enough from other types of computing, many companies use pilot projects to get the systems into the hands of these users to see what reaction pen systems receive. Using actual pilot projects in user organizations as examples, this article discusses pen-based technology assessment techniques, implications for the IS development process, implementation obstacles and guidelines, and criteria for management and user acceptance.

Problems Addressed

Industry analysts predict substantial market growth in the area of pen-based computing. Among the factors contributing to this market growth are the introduction of more advanced pen-based products and the fact that numerous software companies are writing applications for both vertical market and general-purpose use.

This article explores the continued evolution of pen-based computers by assessing the effectiveness of pen-based computers in real-world implementations. The assessment is based on interviews with independent users of pen-based computer applications and their practical experiences in introducing the technology to users. The experiences of these early adopters lead to suggestions for the IS management team to ensure successful adoption of pen-based computers.

Pen-Based Computers: A Brief Overview

Pen-based computers are small, tablet-like devices that use an electronic pen (commonly called a stylus) rather than a keyboard or a mouse as the input device. Aside from actual text, commands given with the pen, called gestures, tell the computer what to do.

Pen-based computers use built-in pattern recognition software, and most products incorporate a liquid-crystal display screen with a transparent wire grid that generates an electromagnetic field. The pen interface emits a faint signal from its tip; when it comes in contact with the screen, the electromagnetic field is interrupted and directions are sent to the microprocessor, which measures exactly where and in what order each pen stroke was made. Some products have the ability to detect differences in pressure of pen strokes. The machine's software then either interprets and executes the gestures, translates the handwritten information into digitized characters, or saves the information in bit-image format. Various operating systems and applications offer handwriting training facilities. Some of these handwriting trainers allow users to train the computer to recognize their writing; others give users practice in writing recognizable characters and gestures—in effect training the user.

Several major factors have affected the growth of pen-based computers during the past few years. These factors include the availability of released operating systems, the growing number of established as well as start-up companies developing pen-based software,
various hardware advances, and an increased awareness of the possible applied uses for systems that give users greater mobility.

**Operating Systems**

Only recently have hardware manufacturers had access to released operating systems from third parties (as opposed to developer release or beta test versions). Before the release of both PenPoint (Go Corp.) and Windows for Pen Computing (Microsoft Corp.), vendors had to supply an operating system with their hardware, usually an MS-DOS 3.2x derivative. Vendor-supplied operating systems are still required for computers that are based on other than an 80286 or 80386 processor. New pen-based computers are capable of running either PenPoint or Windows for Pen Computing (aka Pen Windows).

**Software**

Unlike the hardware vendors, few software vendors currently offer applications for both PenPoint and Pen Windows, but the number of established and start-up software companies lining up behind either of these operating systems is growing. Communication Intelligence Corp.'s less well-known operating system, PenDOS, has a following of start-up software developers. For users, the most promising sign in this area is the commitment of established software companies to develop software from scratch under a new operating system.

**Display Technology and Other Hardware Advancements**

The features of pen-based computers that seem to most affect industry growth are display and storage enhancements, interfaces with desktop computers, and increased miniaturization. IBM's ThinkPad offers an etched glass screen. The extra friction of the pen against the textured surface more closely mimics the action of an actual pen on paper. Tactile control of the pen is greatly enhanced in comparison with writing on the slippery glass displays of other products.

One of the most significant advancements in the area of dynamic storage is flash memory. Intel Corp.'s 20MB flash memory card can be used in pen-based computers. Although flash memory cards (also known as Personal Computer Memory Card International Association cards) have been used in pen-based computers for program storage, this is the first application of flash memory cards for dynamic storage.

The price per megabyte of flash memory is more expensive than that of hard drives; however, the size, speed, power requirements, and durability of Personal Computer Memory Card International Association cards make them well suited to the pen-based computer environment. In addition, flash memory cards are less power-hungry to operate and are more durable because they have no movable components. There is one drawback, however. The power supplies in most of today's pen computers are either 3-volt or 5-volt supplies, but a 12-volt power source is required to perform the write operation on a flash memory card.

Another challenge for users of pen computers lies in interfacing the devices with desktop computers. The introduction of applications common to both desktop and pen computers will facilitate data transfer between machines. Other software solutions to the interface challenge include the fax and E-mail utilities available from Go Corp., as well as cc:Mail and Notes from Lotus. The common in-house process of data transfer by sharing diskettes has not been available because pen-based computers do not have floppy disk
drives and desktop computers do not have PCMCIA slots. This dilemma is being addressed by products from such vendors as Databook, Inc., which has introduced a product that allows desktop computers to read and write flash memory cards.

**Organizational Issues and Technology Adoption**

Organizations use various techniques to assess and adopt pen-based computer technology into their environments. This article explores the following specific issues:

- How the idea to use pen-based computing arose in the organization.
- The type of applications currently being developed.
- The benefits (if any) that have been realized from pen-based computing.
- The technical environment and development process for pen-based applications.
- The management and user acceptance level of pen-based computing.
- The reasons an organization may decide not to adopt the technology, and factors that must change in order to justify reconsideration.
- Problems encountered in implementing pen-based computing.
- Suggestions to potential adopter companies about how to assist in successful implementation of the technology.

The suggestions made are based on actual practices in user organizations. For this article, individuals from 13 companies were interviewed in a range of industries and geographic locations. The organizations included consumer-product companies, health care organizations, utilities, city and state services, pharmaceuticals, and systems integrators/software developers. The interviewees were located in Michigan, Pennsylvania, Tennessee, California, Arizona, Illinois, and Texas. These organizations were developing applications to support a variety of mobile workers, such as police patrol officers, field sales representatives, utility crews, market researchers, social service caseworkers, building inspectors, and health care researchers. The leads were provided by GRiD Systems Corp. and NCR Corp. Exhibit 1 profiles the organizations and the general application areas.

**Users of Pen-Based Computers**
<table>
<thead>
<tr>
<th>COMPANY</th>
<th>INTERVIEWEE'S TITLE</th>
<th>APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Data Research (developer of</td>
<td>President</td>
<td>Market survey and research systems</td>
</tr>
<tr>
<td>systems for automakers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City Human Services</td>
<td>Application programmer/analyst</td>
<td>Social services delivery-tracking system</td>
</tr>
<tr>
<td>Department*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City Light, Gas and Water Utility*</td>
<td>Supervisor of information systems</td>
<td>Work management system</td>
</tr>
<tr>
<td>Lion Computer Systems</td>
<td>President</td>
<td>Police patrol division data collection system</td>
</tr>
<tr>
<td>(developer of system for city police</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dept.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fastech (developer of system for</td>
<td>Account manager</td>
<td>Sales information system for field sales represent-</td>
</tr>
<tr>
<td>consumer product company)</td>
<td></td>
<td>atives</td>
</tr>
<tr>
<td>Food Product Company*</td>
<td>Director of MIS</td>
<td>Sales information system for field sales represent-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>atives</td>
</tr>
<tr>
<td>Health Care Provider*</td>
<td>Social science research assistant/operations coordinator</td>
<td>Demographic data collection system for nurses</td>
</tr>
<tr>
<td>Pennsylvania Gas &amp; Electric Utility Co.</td>
<td>Senior consulting engineer</td>
<td>Time reporting and material acquisition system</td>
</tr>
<tr>
<td>San Francisco Bureau Building Inspection</td>
<td>Assistant superintendent</td>
<td>Inspection data collection system</td>
</tr>
<tr>
<td>San Jose Police Department</td>
<td>Systems officer</td>
<td>Police mobile data collection system</td>
</tr>
<tr>
<td>G.D. Searle &amp; Co.</td>
<td>Associate director of technologies</td>
<td>Field sales support system</td>
</tr>
<tr>
<td>Stanford Medical Center</td>
<td>President</td>
<td>Smoking cessation program data collection system</td>
</tr>
<tr>
<td>State Department of Health*</td>
<td>Bureau chief</td>
<td>Nursing home inspection and cow and milk inspection systems.</td>
</tr>
</tbody>
</table>

*NOTE:* The name of the organization is not published at the interviewee's request.

**Uncovering the Appeal of Pen-Based Computing**

The idea to try out pen-based computing may originate at various levels within the organization. In one case, the idea was sponsored by a division president who was an advocate of hand-held computing for sales representatives. In another organization, the computer operations department recommended a pen system to reduce the costs and errors associated with forms data entry. At a utility company, the idea came from the top down
and from the bottom up: management decided to provide some kind of hand-held unit to crews; at the same time, a quality circle at a service center recommended the use of hand-held computers after a member of their group saw a demonstration. The organization secured several hand-held devices and the users stated their preference for the pen-based system.

The organization must recognize a need (e.g., to reduce paperwork) and identify pen-based computing as a feasible approach to meeting this requirement. For example, when considering how to automate the collection of data from police officers, one organization determined that pen-based computers were the most natural replacement for the officers’ clipboards. G.D. Searle & Co. found that a large amount of paper was generated by government legislation that required the pharmaceutical company to obtain a physician’s signature when the physician requested drug samples. A pen-based system enables Searle’s sales representatives to capture all the data, including the physician's signature, electronically.

Most companies do not have a formal process in place for reviewing new technology such as pen-based computing. At Searle, the sales and marketing group had historically searched out technology to help its sales force become more efficient and effective. These sales force applications had progressed from simple to more complex hand-held devices, then to laptops and pen computers. In several organizations, the decision to proceed with a pilot project was based on the encouragement and experience of a trusted outside systems consultant. In general, however, no particular individual or group was identified as having responsibility for reviewing and approving the adoption of the new pen-based computing technology in the organizations interviewed.

Applications of Pen-Based Computing

Pen-based applications are primarily employed for field-based data entry by organizations that want more rapid access to information, as well as improved accuracy and cost-effectiveness in the data-recording process. Usually, pen-based applications are implemented to replace paper-based forms such as those used in market research surveys. Pen-based computing is often viewed as a more natural approach to automating the data collection process, especially for mobile workers who are accustomed to taking reports or filling out forms using a clipboard. Data entry frequently is accomplished with check boxes and selectable lists that provide applicable status codes. Pen-based computing seems especially suited to workers who spend a lot of time in the field and need lightweight, portable devices that can communicate back to a central location. To better convey the range of applications that are being developed on pen-based systems, brief descriptions of four specific applications are presented.

Market Survey and Research Systems

Advanced Data Research of Rochester Hills MI has developed pen-based systems for automakers. Its systems have been used in more than 40 different projects to conduct 40,000 interviews. One implementation involved gathering data at advanced product clinics where people reviewed prototype cars. The application used check boxes and a graphic field to capture comments, so handwriting recognition was not required. Pen-based systems are also used to collect the names of prospects attending auto shows. Later, the prospect information is provided to dealers who can follow up with letters to these potential buyers. Overall acceptance of pen-based systems by management and users in this industry has been excellent. Marketers can obtain results in a cost-effective and timely manner. In addition, they can obtain information that was not available to them before.
Social Services Delivery-Tracking System
A large city human services agency has five intake sites for social services. Caseworkers at each site fill out a two-part form to track the services delivered and determine client eligibility. This form then goes to casework supervisors for review and back to the intake person for corrections. In this process, each supervisor spends an average of 10 hours a week checking forms for errors. Once the form is complete, one copy is kept on file at the site and the other part is sent to the data entry staff. After a two- to five-day lag time in interoffice mail, the data entry staff reviews the forms, sets those with errors aside, and begins to enter the error-free forms. The data entry staff usually finds at least one error on 10% of the forms. To resolve an error, the data entry person contacts the caseworker, who gets the form from the on-site file, re-creates the information, and calls back and tells the data entry staff the solution. Once the data has been successfully entered, the city can bill funding agencies for the social services it provided.

A pen-based delivery-tracking system was proposed to reduce errors and speed up the turnaround time in the review process and billing cycle. Because many of the forms require a signature, a pen-based system seemed well suited to capture this data. A pilot system was developed that is currently used by 7 of the 45 caseworkers to record client intake data. At the end of the day, these intake files are uploaded to the client tracking and billing system. The casework supervisor and data entry staff reviews are eliminated because of detailed error checking on the pen computers, which results in a one-day turnaround as compared with the average of two weeks.

A cost/benefit analysis indicated that $550,000 would be saved over a four-year period if the pen-based system were to be fully implemented at all five intake sites. However, management decided not to fully implement the system because a city budget review recommended that the system should also support spreadsheet and word processing.

City Light, Gas, and Waterworks Management System
A city utility determined that the bulk of its crews' paperwork was concerned with time sheet entry and work reporting to construction standards. Data must be gathered on labor, material, and equipment used for each individual activity (e.g., install a pole, install a cross arm, string wire, dig a trench) performed when new services are installed.

Utility crews were inundated with paperwork. A pilot system was developed that downloaded engineering specifications for crew tasks to a pen-based system. When crews go out on installations, the pen-based application allows them to complete detailed reporting on each job task, indicate any field changes, and do their time reporting. Crew members see the pen computer as a way to reduce the time spent doing paperwork. These time savings were reflected in a cost/benefit analysis that projected $640,000 yearly savings with full implementation ($400,000 from clerical savings and the remainder from increased crew productivity). The benefits of the system are not just reflected in the cost/benefit analysis; in a management survey of 24 users, all installation crews answered yes to the question, Is this (i.e., the pen-based system) something you want to use on your job?

Consumer-Product Sales Information System
Fastech of Broomall PA is a systems integrator that developed a hand-held pilot system for a consumer-product company and recommended the use of pen computers. More than 200 pen computers are now in use nationwide by sales representatives who call on grocery stores and by account managers who call on store headquarters. Sales representatives record information at the store on their products and those of competitors, such as number of product facings, number of displays on end of row, product price, and the time spent in
the store. Sales representatives make five to eight calls per day and the information they
gather is communicated nightly over modem to the corporate mainframe. Using laptops,
account managers go online the next day and request reports on the sales information.

The pen-based system gives account managers up-to-date information (e.g., on shelf
space compared with sales volume) to sell their product and better manage their people.
The pen-based system is also flexible. For example, marketing can put questions on the
mainframe and send them out to the field. Questions can go out nationwide or to a select
group, and marketers can get their answers the next day. The consumer-product company
has determined that the pen-based system provides a competitive edge, especially when
compared with the previous paper-based approach.

Technical Environments and Development Process

Most organizations used the C programming language for applications development. In
several cases, an existing Disk Operating System application was modified to incorporate a
pen interface using, for example, the GRiDPad API (GRiD Systems Corp., Fremont CA)
for the interface development. Several companies were already using Clipper or FoxPro in
their development environment and the availability of pad-based development products that
supported their preferred tool was viewed as a distinct advantage. Advanced Data Research
used a proprietary language designed for survey use. The San Jose Police Department
purchased a software package for use in its pilot project.

One somewhat different development approach used the vendor’s tools to generate
screens, C for the application code, and Informix for the file/data storage. Client data was
captured and stored initially on pen computers using Informix C-ISAM. This data was
dumped at the end of each working day to a microcomputer at each service center and
merged into one Informix ISQL data base. Finally, the data bases at each site were
uploaded nightly with a telephone link to a minicomputer running Informix where the
client tracking and billing systems resided.

User Input

Organizations vary in the amount of user input into the development process. For some
developers, little user input was sought because their system was mimicking existing paper
forms and there were no real changes made in the order or position of fields. Other
developers took a fresh approach that is not limited by existing form design in order to
make the applications as intuitive as possible. Generally, organizations benefit from
extensive user involvement. One organization worked in the field with 10 users at each
level of the organization and then had a committee of 5 sales representatives back at
headquarters to iron out details. In the City Light, Gas, and Water utility project, a user
representative from the field crews worked with developers on the design of the specific
screen layouts. At G.D. Searle & Co., the sales representatives designed their system.

Management Acceptance of Pen-Based Systems

Almost every organization started with a pilot project to evaluate pen-based computing
technology. Of the organizations profiled, some were in the middle of their pilot evaluation
project, as in the case of the San Jose Police Department, in which pen computers were
being compared with laptop computers. A few companies had expanded to full-scale
implementation of pen-based computing on the basis of the pilot project’s results. Exhibit 2
shows the status of each implementation at the time of the interviews.
## Status of Pen-Based Implementations

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>TECHNOLOGY EVALUATION</th>
<th>CURRENT STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Data Research (developer of systems for automakers)</td>
<td>Pilot project</td>
<td>Full implementation with 160 units</td>
</tr>
<tr>
<td>City Human Services Department*</td>
<td>Pilot project with 11 units</td>
<td>Full implementation was not approved</td>
</tr>
<tr>
<td>City Light, Gas and Water Utility*</td>
<td>Pilot project with 6 units</td>
<td>Full implementation with 140 units</td>
</tr>
<tr>
<td>Lion Computer Systems (developer of system for city police dept.)</td>
<td>Developing test applications on 1 unit in-house</td>
<td>Planning pilot project</td>
</tr>
<tr>
<td>Fastech (developer of system for consumer product company)</td>
<td>Pilot project</td>
<td>Full nationwide implementation with more than 200 units</td>
</tr>
<tr>
<td>Food Product Company*</td>
<td>Pilot project</td>
<td>Decided not to proceed with full implementation</td>
</tr>
<tr>
<td>Health Care Provider*</td>
<td>Pilot project with 4 units</td>
<td>Cost/benefit study indicated units were not a sound investment</td>
</tr>
<tr>
<td>Pennsylvania Gas &amp; Electric Utility Co.</td>
<td>Pilot project with 4 units</td>
<td>Cost/benefit analysis indicated units were too expensive</td>
</tr>
<tr>
<td>San Francisco Bureau Building Inspection</td>
<td>Pilot project with 2 units</td>
<td>Cost/benefit analysis was positive; full implementation planned</td>
</tr>
<tr>
<td>San Jose Police Department</td>
<td>Pilot project involving 35 officers</td>
<td>Too early to gauge results</td>
</tr>
<tr>
<td>G.D. Searle &amp; Co.</td>
<td>Pilot project involving 33 representatives</td>
<td>Excellent results; proceeding with full implementation</td>
</tr>
<tr>
<td>Stanford Medical Center Medical Information Corp.</td>
<td>Pilot project with 4 units</td>
<td>Mixed acceptance; evaluating the vendor's latest hardware platform</td>
</tr>
<tr>
<td>State Department of Health*</td>
<td>Six-month pilot project</td>
<td>Full implementation of more than 100 units</td>
</tr>
</tbody>
</table>

NOTE:* The name of the organization is not published at the interviewee's request.

In many organizations, the decision to proceed was made at the vice-presidential level, and in several cases the financial approval was from the chairman of the board.
Management acceptance of the pen-based applications was often based on a variety of factors.

**Capturing Information That Was Previously Unavailable.**

For example, in the case of the automaker's advanced product clinics, a scanned image of a prototype vehicle is shown on the screen and the participants are asked to circle the car parts that are expensive and sporty. In this way, auto designers and marketers are able to capture the public's perception on aspects of vehicle appearance that are highly subjective and difficult to quantify.

**Faster Access to Information.**

Most organizations reported that pen computers gave them more rapid access to information gathered in the field. For example, automakers were able to get market survey results two weeks earlier. Consumer-product company managers obtained sales representative information the next day by accessing the mainframe from their laptop computers. The ability to access more timely information sometimes generated new processing requirements. Multiple departments in the San Jose Police Department, for example, made new requests based on the up-to-date information made available by the pen-based system.

**More Complete and Accurate Information.**

Organizations generally found that better data was gathered when the data is entered and error checked by the originator.

**Money Savings.**

Often the most tangible savings result from reducing or eliminating the need for clerical data processing staff. One utility company's analysis indicated a $400,000 yearly saving with the pen-based system because the company no longer needed data entry staff.

**Increased Efficiency and Productivity.**

The productivity impact of pen-based computing is often difficult to quantify. However, most user organizations believed increased efficiency in filling out paperwork resulted in greater worker productivity. Utility crews were able to handle more installations; sales reps could call on more clients. The San Francisco Bureau Building Inspection unit found that its pen-based systems resulted in a 20% to 30% increase in the number of inspections performed per day. Managers also indicated that their productivity was improved because pen-based systems generally gave them more and better information on which to base decisions.

**Increased Effectiveness.**

Previous systems implemented at G.D. Searle & Co. were designed to improve efficiency—to reduce paper and to get data into the system more quickly. Searle's current pen-based system is intended to make sales reps more effective. Before they enter a physician's office, they can easily access information on what was discussed during their
last call. Because they may have only a few minutes with a physician, it is important that they be able to pick up where they left off and bring continuity to their presentations.

**Maintaining Competitiveness or Providing Advantage.**

Some organizations determined that pen-based computing technology was currently too expensive to justify the investment on the basis of an expected increase in sales from sales force automation. Instead, organizations may have to justify the technological investment because their competitors are; in other words, they must invest in order to maintain competitiveness. Other organizations justify pen-based computing because it helps turn massive amounts of data into information that provides a competitive advantage.

**User Acceptance**

Users' acceptance of pen-based systems generally relates to their perceptions of the impact of the system on their job. New pen-based systems were accepted when users felt the system would save them time on their job and allow them to pursue tasks more rewarding than filling out paperwork. At one organization, the time for each sales representative call was reduced 30%, which was a factor in the decision to proceed with full implementation. Utility crew leaders, who bore the brunt of the paperwork, found that the pen-based system gave them significantly more time to spend watching their crews, thereby increasing safety levels. The San Jose Police Department determined that the pen-based system enabled officers to devote more time to community activities and neighborhood watch programs.

Many users find pen-based computing to be more intuitive than alternative technologies. Because the applications are usually picture driven, users are able to figure out how to use the system on their own. Users at Stanford Medical Center's Medical Information Corp. liked the fact that there was no screen barrier between the user and the patient.

For some organizations, however, system training requirements may take too long and there may be user resistance. Dealing with user resistance is a management function; however, in one case, use of the system was actually made mandatory.

Most organizations were especially concerned with understanding why users like or resist pen-based systems. User resistance to pen-based systems was attributed to a number of causes. Some users expressed fears about job security. Sometimes, reluctance to adopt the system was seen as resulting from a general resistance to change. Developers and management were especially concerned with the reaction of technophobes. Most respondents stressed the need to design systems that meet the users' needs and to involve users early in the development process to help ensure acceptance of the final product. An active end-user sponsor was considered invaluable.

**Obstacles to Implementation**

Several organizations had completed a pilot but decided not to proceed with full-scale implementation. The reasons for rejecting pen-based computing were varied, as indicated in the following implementation descriptions.

**Social Services Delivery-Tracking System**

After the pilot project, a cost/benefit analysis indicated that the city human services department would save $550,000 over four years if the pen-based system were fully
implemented. However, a city budget review recommended that the pen-based system not be implemented. The budget department did not disagree with the cost-savings figures, but it wanted to purchase platforms that would allow social services intake workers to do spreadsheets and word processing. The developers suspect that the budget department does not understand the pen technology or the job requirement of these workers. The pilot users like the system, and the developers are hoping to eventually port the applications to a platform that will support the capture of signatures and meet the budget department's requirements.

**Food Product Sales Information System**

Although management at a food product company supported the concept of a pen-based system, more than one-third of the application was text based, and in actual use, handwriting recognition limitations created productivity problems that made the system inadequate for the sales representatives' use. Problems with handwriting recognition and the additional cost of the technology resulted in management's decision not to proceed with full implementation. The cost/benefit analysis did not find that the value of the technology significantly enhanced the application. For the food company to proceed with pen-based computing, it would need to have information, such as competitor product names, displayed in list boxes and not entered as text. In addition, improvements in handwriting recognition and in the cost of the pen-based products could cause management to reconsider the development of pen-based applications.

**Health Care Provider Demographic Data Collection System**

Developers were not fully aware of the problems caused by their platform's limited character-recognition capability and designed applications that relied heavily (75%) on text entry. There was also no serious effort to obtain user input. The system was basically created by developers and presented to the nurses as a finished product. The users' comments concerning the problems with character recognition were initially ignored. In addition, the device did not have a backlit display, so it was difficult to use in the target environment of dimly lit hospital rooms. After the pilot, management decided that the pen-based system was not a wise investment. Future use of pen-based technology will probably depend on identifying an ideal application and finding software that is already available for that application.

**General Implementation Guidelines**

Generally, many of the problems encountered in pen-based implementations are the same as with any other technically sophisticated computer system. The hardware should be suitable to the task and the software should be focused on the users' needs. However, organizations that adopt pen-based computing should consider some additional factors. The implementation of any new technology, such as pen-based computing, may require changes in the systems development environment. In addition, the fact that many pen-based applications are being developed to replace paper-based forms suggests that many of the intended users may not be familiar with computer technology. Management, developers, and users must all become involved in a learning process. If the technology is not employed and managed appropriately, the risk of failure is higher. The organizations interviewed encountered many technical and organizational difficulties. These technical and user-related issues must be anticipated and examined to determine whether they are beneficial to the organization. What one group (e.g., management) considers a positive
impact may not be viewed similarly by another group (e.g., clients). Such problems need to be overcome before organizations can fully exploit the capabilities of pen-based systems.

**Key Technology Considerations**

Pen-based tools are rapidly evolving and improving. Organizations should research currently available pen-based technologies, alternative technologies, and future product possibilities. Because equipment costs are usually amortized over two or more years, users often have to live with the product that is selected (and its drawbacks) for a long time. Failure to consider technical constraints can result in implementation failure.

**Handwriting Recognition Requirements.**

Although the handwriting recognition capabilities of new products are improving, almost all of the developers of current applications strongly advised that handwriting recognition should be minimized or avoided altogether, if possible. More successful applications made extensive use of check boxes and select lists for data entry. Graphic fields were used to capture signatures and free-form text, where required. One developer felt that character recognition was helpful for number-crunching applications; however, another suggested using a keypad for numeric input.

**Ergonomic Issues.**

A variety of ergonomic problems may surface during a pilot project. One group of developers discovered that about one-third of users were left-handed, and because the pen cord came off the right side of the screen, it was in the way of those users. Fortunately, the developers were able to provide a relatively simply solution. A left/right button was added to the first screen; if the user is left-handed, the screen rotates 180 degrees so it appears as if the pen is coming off the left side of the screen. Another consideration is that compared with paper, the machine is heavy, which is an important consideration for mobile users who must carry the pen system for long periods. Several users had problems because their pen-based system did not have back lighting (e.g., the nurses using the system in dimly lit hospital rooms). Failure to anticipate ergonomic problems may put some implementations off to a poor start.

**Security Issues.**

Pen-based computers may not be as reliable as paper. Users are apt to drop their machines, and in the case of utility crews using pen-based systems, security was a concern because workers frequently left their pen computers lying on the front seats of their trucks.

**Technical Development Issues.**

Organizations that develop in such languages as Common Business Oriented Language may require additional training and expertise to develop successful pen-based applications. Pen-based programs are structured using a constant looping mechanism. If the developers' experience is in Formula Translation and not Windows development, it will take a different mind-set. Several organizations stressed the need to make maximum use of vendor support. One organization, unable to attend vendor training because of budget constraints, suffered severe setbacks in getting the project under way as well as
development delays. Companies that took advantage of vendor training said that vendor input was important to the final system design.

**User and Organizational Issues**

A pen-based computing application can be technically excellent, but if user and organizational factors are not adequately addressed, the end result can be implementation failure. Potential adopters of pen-based technology should be sure to consider three key issues.

**User Resistance.**

Many potential users of pen-based systems may not be accustomed to automated procedures. Organizations that focus on supporting their workers' needs and that are sympathetic to individual concerns seemed to have the most successful implementations. Most organizations that proceeded with full implementation of pen-based computing following a pilot project worked hard to address users' requirements by fully involving them in the design and development process.

**Unanticipated Impact on Existing IS Systems.**

Current systems may need to be adapted to accommodate pen-based computing. The availability of new or more accurate information may generate new processing requirements (e.g., user reports). The full benefits of an investment in pen-based computers may not be realized if they are not effectively integrated into existing organizational information systems.

**Unanticipated Impact on Business Processes.**

The implementation of a system can facilitate changes in individual job functions and organizational structures. For example, a consumer-products company found that its pen-based system assisted in a major reorganization of the sales force from horizontal market coverage (e.g., covering all stores in a geographic area) to vertical market coverage that concentrated on particular chains.

In some cases, the system implementation may force an organizational change to support the systems requirements. The social services delivery-tracking system would not allow intake workers to change a client's form after it was saved. This requirement posed a major problem because clients would often discover in the middle of the intake interview that they were missing a required document. With the previous paper system, the intake worker could just put the incomplete form aside. Because of the pen-based system's requirements, the social services workers had to revise the process to prescreen clients. If clients did not have all the required documents, they were told to come back for the intake interview. Although this change was forced on the organization, it made business sense and actually improved efficiency. Applicants who have all their materials do not have to wait while a caseworker spends 15 minutes with someone just to find out that that client is not prepared.
Recommended Course of Action

IS managers can follow these recommendations, based on the experiences of the user organizations discussed, if they are considering the adoption of pen-based computing technology. The guidelines are:

- Making sure the technology is well suited to the organization and its application.
- Using existing software, if possible.
- Making the application intuitive. Rather than simply using the technology to automate an existing manual process, developers should think in terms of exploiting the technology to redesign the business process to achieve the best organizational results.
- Ensuring that developers have a background in appropriate programming techniques and anticipating development start-up problems and delays.
- Involving users early on in the design and decision process, asking for their input on what they want to use on the machines, and taking them seriously. Users who were involved in the development process had more realistic expectations (e.g., about handwriting recognition capabilities) and were more likely to accept the system.
- Being prepared to sell the system to users. Detailed deployment plans are needed to ensure success.
- Developing strategies to address possible user resistance, including identifying end-user sponsors.
- Making maximum use of vendor support.

To maximize the possibility of successfully employing pen-based technology, organizations should consider using a pilot approach that will enable them to benefit from the experiences of early adopters, as reflected in this article. Furthermore, because each organization and application is unique, a pilot project can help management identify the unique characteristics of its users that need to be addressed in any full systems implementation.

The insight and experiences of organizations that have piloted or fully implemented pen-based applications reinforce the idea that these computers are in fact practical in real situations. Nonetheless, areas in need of improvement are easily found. Most notable is the need for acceptable handwriting recognition software. Users and implementers also hope for lighter-weight computers: IBM’s ThinkPad weighs in at just under 6 pounds, the weight of many laptop computers. Finally, there is the cost factor. No company has unlimited resources to spend on new technology, and as long as most pen-based computers are equal in cost to desktop machines, market expansion will be severely constrained until prices are lowered. The general opinion is that prices must reach the range of $500 to $1,000.

Although some organizations have failed to achieve sufficient benefits from pen-based computers to justify full implementation, others have successfully implemented large numbers of pen-based systems and obtained clear business benefits from improved efficiency and accuracy of data collection and information processing. Innovations for pen-
based computers continue to surface, such as the proprietary prototype chip under development by Scriptel that may make digitizing tablets (and specialized pen-based computer screens) unnecessary. If the potential of pen-based computers can be harnessed, their impact may rival that of desktop machines with applications beyond their current niche in vertical markets.

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