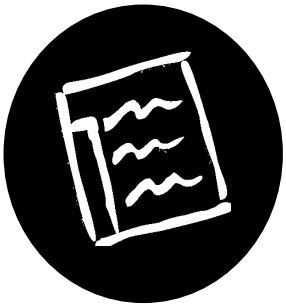
white-paper

Mobile Computing

Breaking Barriers to Field Automation



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BREAKING BARRIERS TO FIELD AUTOMATION

Introduction

A recent study of over a hundred large organizations using mobile pen computing found that "enterprises today, whether they are in the governmental, private or public sector, can experience an immediate and appreciable performance gain in efficiency and effectiveness from mobile, pen technology."[1]

This MapFrame white paper looks at the benefits of mobile technology for field applications and reports on the current state of pen computing, both from a historical perspective, and a "current user" point of view.

One of the conclusions of the paper is that mobile applications today not only provide relatively low-cost quick fixes to existing systems, but also allow for broad, company-wide benefits through the redesign of whole business processes.

To help you evaluate the relevance of mobile solutions for your organization, we have included a section describing specific applications.

Because some of the material may be familiar to persons already involved in the mobile computing industry, the report is divided into individual topic areas. We invite readers to pursue those topics that interest them.

As providers of mobile software solutions, our goal for this white paper has been to convey a high level of information and to avoid inflated and sensationalistic claims. The reality of pen computing today, though, is that high performance pen tablets are now capable of doing almost everything a desktop system does.

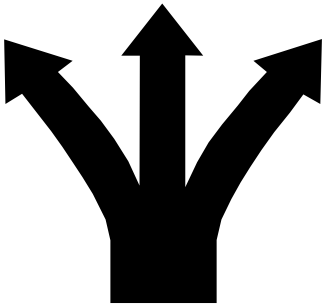
In the future, incremental performance gains will continue to be important in the area of office functions, but the large gains will come from automating activities that have resisted automation in the past. These activities tend to be operations tasks that are highly mobile in character.

[1]Source: The Business Case for Pen, Mobile & Wireless Technologies, Center for the Measurement of Business Benefits from Technology.

Field Automation:
The New Bottom Line

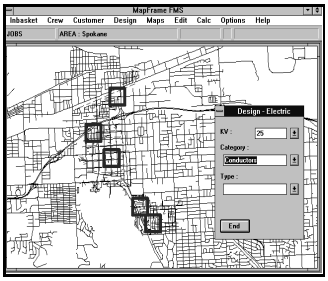
For many companies, the attraction of mobile computing is based on the fact that large productivity gains are still possible only in the out-of-office workplace. With a substantial portion of corporate industrial and/or office activities already automated, mobile computing is a way for efficiency and cost-conscious organizations to secure major new sources of productivity gain.

Among the the current users of mobile solutions are utilities, healthcare, transportation, surveying, telecommunications, and emergency response organizations. Platforms and packages vary considerably. In some cases, simple hand-held devices such as PDAs (Personal Digital Assistants) are providing efficient and effective automation tools for functions of limited scope such as collecting patient data, doing warehouse inventories, or coordinating transportation schedules.



In other cases, automation goals -- and resultant performance gains -- demand powerful pen tablets and highly complex applications that connect to critical corporate systems. An example of this type of powerful pen-based application is a mobile system for designing electric distribution facilities on-site.

This report does not attempt to detail every possible mobile solution. Instead, it focuses on those applications that tend to yield the highest return in terms of bottom-line improvements. As a group, these applications combine graphics with database and forms capabilities and run on high-performance pen tablets.

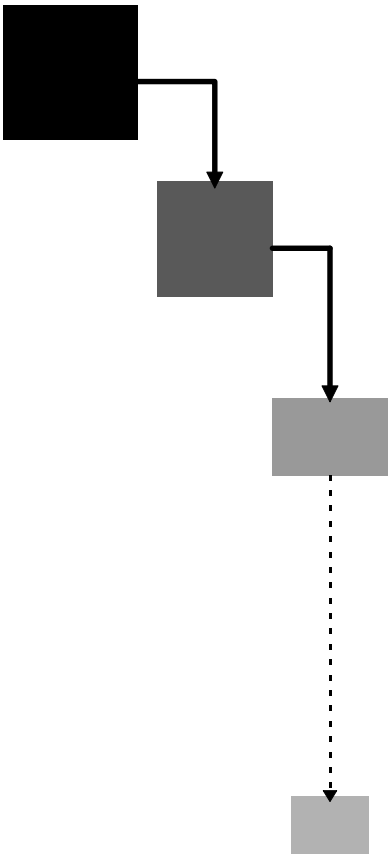


Because MapFrame specializes in integrating mapping into mobile applications, a section is included in the report on the use of mapping technology in mobile settings. Not every mobile application will need mapping, but many will. Applications that can benefit from this technology are referred to in the report as “map-based”. Map-based mobile solutions imply industry-specific packages that include mapping as a set of tools within a larger application.

From Mainframes to Mobility

If general computer trends are any indication, mobile computing has been inevitable from the moment computers were conceived. In fact, mobile computing is the next step in a long and well-established pattern.

Movement Towards The Workplace...



Look at the history of computing and you find that each generation of hardware -- from mainframes in the computer room to minicomputers in an office cluster to personal computers on a desktop -- has gotten smaller, easier to use, and closer to the individual's place of work. In short, computing is a history of movement towards the workplace.

Today this trend is continuing in the form of portable and mobile computing.

Portable computers are generally thought of as computers that can be picked up and carried from one location to another. The term "portable" often includes lightweight desktop PCs, laptop machines, "convertibles", and mobile, pen-based computers.

Within the context of the term portable, though, there are important distinctions. "Portable" generally refers to a machine that is conventionally designed with a keyboard interface. Portable machines can be used anywhere anytime as long as the user conforms to the "desktop mode", i.e. he or she sets the computer down and uses it like a conventional machine.

Mobile computers fall in the portable category by virtue of the fact that they can be carried from place to place, but there is an important distinction. Mobile computers as a class can be used anytime anywhere regardless of whether a person is standing, walking, or sitting. These machines are truly mobile in the sense that they are free from "location" constraints.

Pen Computing

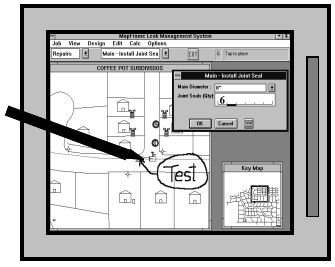
In physical form, the first pen computers were much like notebook machines with the functionality of desktop systems. They were heavy (over five pounds in weight) and not very rugged. They were also uncomfortable to use while standing or walking.

...truly mobile applications

Nonetheless, they exhibited many of the qualities necessary for truly mobile applications. *Most importantly, they had the functionality of a desktop system and used a pen instead of a keyboard.*

With regard to both form and functionality, pen machines have changed quickly, especially the high-performance pen tablets.

Averaging 2 to 3 pounds in weight, pen tablets have a fast processor, high memory capability (up to 64 megabytes), and include mass storage in disk or IC Card form. Rugged enough to survive in the field and powerful enough to support highly complex applications, pen tablets are fast and highly intuitive to use.



In summary, they...

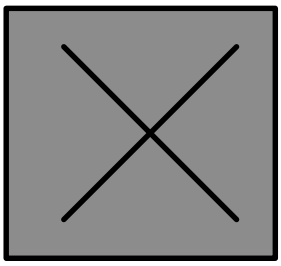
- ⇒ **Provide quick access.**
- ⇒ **Can be used while standing or walking.**
- ⇒ **Are uncomplicated to learn.**
- ⇒ **Are easy to customize and facilitate self-reliance.**

It is this combination of qualities . . . rugged, yet light in weight . . . powerful but uncomplicated . . . which defines the ultimate success of pen technology: the ability to deliver more with less in a form uniquely suited to the out-of-office workplace.

How Pen Computers Work

A pen computer is based on the principle of marking directly on the screen to activate a command. The marking can take a variety of forms including the following:

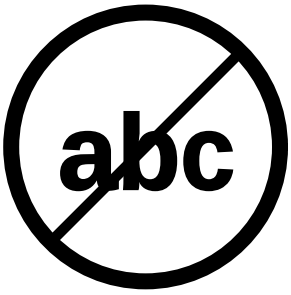
- **Tapping to select from a list or activate a menu choice.**
- **Writing or printing in designated fields.**
- **Making "gestures" on the screen.**
- **Drawing freehand lines which are treated like ink.**



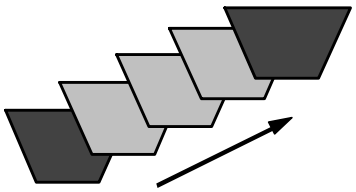
Pen-based applications typically consist of a combination of the above activities with "gestures" being the most powerful. Gestures are a form of shorthand to tell the computer what to do next.

For example, if you want to erase something all you do is mark an X on the object and it disappears. To zoom in, circle the area of interest. Because users are marking directly on the screen, separate actions are now combined into a single motion. This gives the system a simplicity and directness that makes it easy to learn even for beginners.

Handwriting recognition plays almost no role in the development of mobile field applications. The reason is this: if designed correctly, field applications let users manipulate graphical images and select from standardized lists, check-off boxes, and pre-defined icons. The need for handwriting is limited to printing or writing in form fields rather than writing out large amounts of text.



A field engineer, for example, can designate the location of an electrical transformer on a project map or sketch by choosing a transformer symbol from a standardized list and tapping the screen to place this symbol at the desired location. Not only is the symbol displayed, but location information and transformer attributes are also stored in a database.



Pressing and dragging the same symbol would move it to a new location. Double tapping might bring up its attribute data.

Hand printing would play a minor but useful role in this example with users printing the transformer I.D. number in a pop-up window.

THE SCREEN AS AN ACETATE OVERLAY

While handwriting recognition is of little significance in field applications, it is helpful to use the computer screen much like an acetate overlay for entering field notes. Because pen applications recognize "ink" as a data type, free-hand notes can be entered, stored, and kept track of by pen software. These handwritten notes or graphical images can be written anywhere on the form or map, then moved, copied, or organized.

The three primary guarantors of success in pen applications:

- ✓ **Pen Technology is easy to learn and easy to use**
- ✓ **It does the job better than current methods from the user's standpoint**
- ✓ **It is relatively low cost and fast to implement**

Automating and Streamlining Field Operations

Mobile computing is a relatively low cost way to achieve major productivity gains in the midst of downsizing, consolidations, and cutbacks. These gains result from both streamlining and improving existing functions and from introducing innovative new applications that are only possible with the advent of mobile computing.

...mobile computing breaks barriers to field automation...

In either case, mobile computing breaks barriers to field automation, supporting activities such as facilities design, data entry, mapping, editing, calculation, analysis, list making, and data transfer.

In addition, the availability of mobile computing allows for the redesign of entire business processes. In the past, organizations with field operations have had to eliminate some processes as candidates for redesign. With much of the work being done outside the office, and without a mobile computing component to bring to bear on field activities, re-engineering didn't make sense.

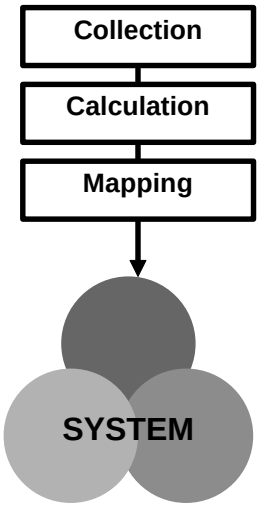
Now with the availability of mobile computers, these organizations have an opportunity to subject new processes to the rigors of re-engineering.

Mobile Computing Applications

Field Data Collection

Mobile technology upgrades data collection from a series of activities involving paper notes, paper maps, and paper-based reference materials to an automated business process that combines graphics with forms and database capabilities.

Carrying mobile computers, field personnel can create drawings; display geographic data; accurately map and insert data; selectively display and edit information; and update corporate data bases using checklists and selection boxes.



An example of this type of application is adding map viewing and verification to environmental data collection (in the case of a hazardous waste inventory, for example). The automated system combines the now separate steps of data collection, calculation, and mapping. Integrated images and data can be uploaded to a central database and further integrated into a corporate GIS.

With mobile technology, time sensitive data can be quickly submitted via data communication links. GPS adds a way to capture "where" along with the "what" functions of the pen machine.

PLANNING & DESIGNING PROJECTS ON SITE

Fully automating the planning and design process achieves the goal of increased productivity in two important ways. It leverages employee skills and time by allowing them to capture and manipulate information at the source. It also eliminates redundant data entry.

A good example of this type of application is a mobile design tool that lets field engineers plan and design electric distribution facilities on site and initiate or edit work orders.

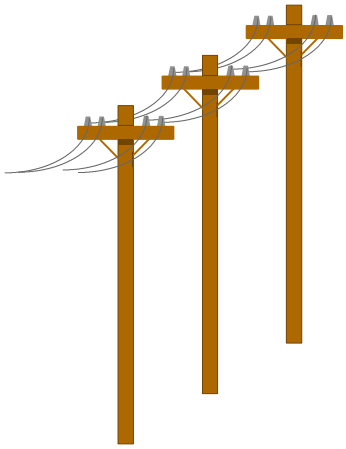
...a geographically referenced drawing...generates a materials list in a single step

The process works as follows. Using a 3-pound pen-based tablet, a field engineer creates a geographically referenced drawing and generates a material list in a single step at the project site.

Back in the office, job information is uploaded to a central database, including the drawing, the material list, and other work order data. This information is automatically distributed to the appropriate departments where it is used to update corporate data bases as well as schedule and budget materials and labor.

Another example of on-site design is an interactive graphic layout tool for landscape design and construction management. This type of system lets facility managers sketch a proposed project on-site, designating land use and cost constraints. In addition to generating a drawing, and calculating costs to help in the design process, the system serves as a way to monitor construction work as it proceeds.

INSPECTION & MAINTENANCE



Many of the activities carried on in the out-of-office workplace are inherently spatial in nature, i.e. they are location-based. Inspecting utility poles, for example, requires physically inspecting each pole and identifying the geographic location. So do fire, safety and building inspection.

The problem with an unautomated inspection process is that it necessarily separates the acts of gathering data and identifying geographic location. This separation increases the number of steps involved and reduces overall efficiency.

To insure reliability in their service territories, electric utilities have to regularly inspect and maintain their wooden distribution poles. Inspectors carrying paper maps find each pole in the field, checking for broken crossarms, woodpecker damage, etc. Next they fill out a paper form, indicating pole condition based on an ID number.

Eventually, this information is entered into a database and sent on to the maintenance department. The problem is that getting the data into the system is time consuming and error prone.

Mobile inspection makes the process fast, easy, and highly efficient. Inspectors can download a map from a desktop system onto their pen computers, displaying the map in the field and entering data by tapping on a pole. A form pops up on the screen and pole condition is specified by selecting from a check list.

NEW APPLICATIONS

Emergency Response

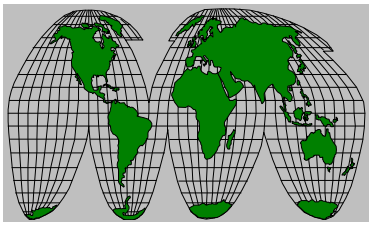
Sales

Leak Investigation

The ability to take computers outside the office is resulting in the development of highly innovative new applications. Using pen computers, for example, on-site emergency response teams can evaluate hazards and compare alternative response scenarios. In a less dramatic example, a sales representative downloads demographic data at a customer site, showing market potential under changing assumptions.

In both examples, mobile computers bring a powerful new dimension to field operations based on the analytic capabilities of high performance pen tablets. Leak investigation is another example. For gas companies, this application is possible only because a new generation of pen computers can overlay and analyze map data and incorporate highly complex diagnostic tools.

Mapping: Designing for Mobility



Mapping and Geographic Information Systems (GIS) have already revolutionized the way we solve problems in the office by applying computer power to spatial information. Mobile computing extends this capability out of the office into the field.

In the site planning example discussed above, the presence of a mapping component means that locational attributes and design attributes work in tandem. What would be the point of carrying a paper map in the field along with a mobile computer?

Each new generation of computer, however, brings with it the question of what is appropriate in terms of software design. The issue of mapping in mobile applications gets to the heart of this question.

In the past, the only alternative for organizations needing mapping and GIS was to acquire a general purpose package and adapt it as best they could for their own purposes. Desktop mapping systems were developed with the idea that they deserved a separate identity rather than being used as a set of tools within a broader application. But is this model appropriate for pen computing?

A travel analogy might be the best way to answer.

When most people go on a business trip, they tend to pack lightly because they know instinctively that the more luggage they have, the more hassles they have. It's the same with pen computing. Pen computers are designed for travel and they work best when excess baggage is eliminated.

The more specific an application, the less likely it is to be overloaded...

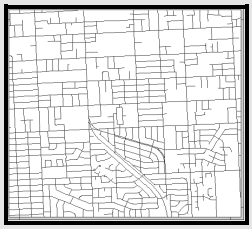
In the case of software design, that means specificity. The more specific an application, the less likely it is to be overloaded with excess baggage. Mapping software flexible enough to meet everyone's needs (i.e. a general purpose system) is less useful for specific applications.

The better alternative is to integrate specific mapping and spatial analysis tools into applications packages. When used this way, map tools "disappear" as a separate program and emerge as functions in a broader system.

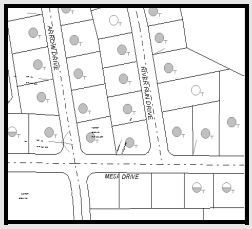
We call these applications “map-based”, implying highly usable field systems that include mapping as an element but don’t require users to be GIS experts or CAD operators. Instead, mapping fits seamlessly into the overall functionality of the application, providing field personnel with another tool to get their work done. In addition, applications-specific software offers users a language they are familiar with as well as standards that reflect their business practices.

Where Do the Maps Come From?

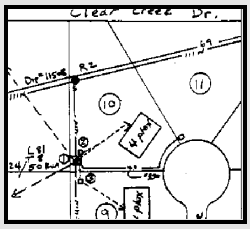
The answer to this question depends on the organization, the application, and the organization's current state of map "readiness". In general, the following categories cover the different possibilities.



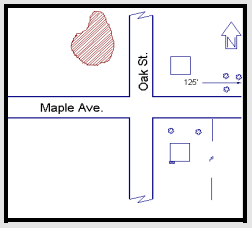
If you need standard maps, i.e. street maps or USGS topographic maps, this data is easy to acquire. It already exists in digital form (an example is the U.S. Census street maps, or Tiger Files) and can be easily loaded on a mobile computer.



If you have your own maps in digital form such as a corporate GIS or a CAD system you don't need to create a separate database for mobile applications. The existing maps can be downloaded onto a pen machine. Later, changes can be uploaded to a corporate database (with proper validation).



If you don't have maps in digital form, but do have good paper maps, you can scan these maps and use them as raster data. They serve as a backdrop or reference for objects or notes you add in the field.



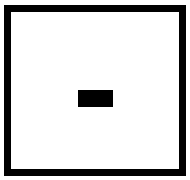
In some cases, you may not have any maps for a project area. Using MapFrame software, you can create maps and sketches on-site. In effect you can build your own map database for a special project.

The Art of True Mobility

As a class of hardware, pen computers offer the possibility of a completely new mode of human-computer interaction. Transfer pen and paper to an electronic medium and you have mobile pen computing.

The benefits of pen technology are not automatic, though. As with any technology, a number of design decisions ultimately determines the character and shape of the product. In the case of pen computing, software design decisions are critical for the emergence of a system that is truly mobile.

Pencentric vs. Pen-Aware



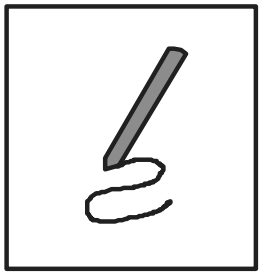
It would be a mistake to think that offering someone an electronic stylus automatically insures the success of a mobile computing system. Effectively automating field operations requires more than acquiring a pen machine that can be carried from place to place. Software designed for pen machines has to be evaluated in terms of how well it is adapted to the pen vs. the desktop. The first approach we call "pencentric". The second, we call "pen aware".

Pencentric describes the sum of the qualities that make pen applications useful and usable, and leverage the new platform. Pen-aware describes desktop applications that have been modified to accommodate pen input.

Pen-aware solutions use the pen to simulate a mouse with some form of gesture recognition substituted for a keyboard. All input is expected to ultimately end up as translated text form, as if it were typed in from a keyboard.

Unfortunately, pen aware solutions miss the point. Instead of using the pen as it was intended -- as a whole new way of communicating with computers -- it is utilized merely as an adjunct to the keyboard.

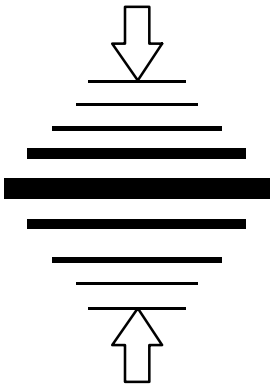
Pencentric solutions, on the other hand, take advantage of the essentially mobile nature of pen computing. The interface is intuitive and easy to use, mirroring the way people use maps



and paper forms in the field. Objects can be moved, copied, deleted, or changed with a single gesture.

Because mobile workers tend to have minimal computer experience, it's important to offer easy to recognize, learn, and remember symbols and gestures that represent or are synonymous with tactile motions currently used in note taking and/or form completion.

Compact Data Representation



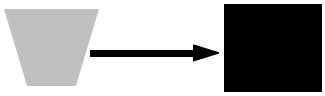
Though disk capacity continues to grow rapidly in pen computers, it is still below that of desktop machines. Not only is the process of miniaturization costly and time consuming, there is also the additional issue of designing for ruggedness in pen machines.

Unfortunately, complex field applications often require a large amount of mass storage for spatial data. How to resolve this seeming dilemma?

As discussed above, applications-specific solutions offer a partial answer, easing the problem of limited disk space by eliminating the excess baggage of a general purpose system. Storage constraints can also be minimized by using a combination of raster and vector methods along with compact data representation techniques. Using these techniques ensures that the data necessary for “real world” projects will fit in the storage capabilities of mobile machines.

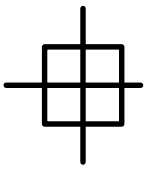
Compact data representation is also important because of the growing use of wireless data transfer. Minimizing file size reduces the cost of transmission and increases the probability of successful transfer.

Data Transfer



Problems of limited disk capacity can also be eased by minimizing the amount of data that has to be stored on a pen machine. One way to do this is by adding data communications capability (cellular, private radio, paging networks). In this way, users can extract parts of the central data base as needed.

Global Positioning System



Pen computers equipped with a GPS receiver let users determine their current location out in the field. However, the precision of the coordinates from GPS vary depending on equipment and techniques used. As a result, GPS is not the answer for every situation. GPS *is* a useful component in mobile applications that lack a good map base.

Conclusion

Mobile computing has evolved to the point where it can now support highly complex field applications. These applications streamline and improve existing operations and support innovative new activities made possible by the advent of mobile computing. Designed correctly, pen-based applications cut costs and result in immediate and appreciable performance gains.

These gains are not automatic, though. The most effective applications are those that take into account both the advantages and limitations of pen computing. These applications come in the form of industry-specific packages that offer users a language they are familiar with as well as standards reflecting their business practices.