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Strategies in Hand-Held LIMS
The growth of Pocket PCs in Information Management

Laboratory Information Management Systems (LIMS) are designed to organize the processing of samples through the laboratory and to provide a data repository for producing certificates of analyses and management reports. Over the years LIMS have expanded beyond the walls of the laboratory through interfaces to ERP, MRP, Process Control, Accounting, Logistics and Customer Support systems. This integration makes LIMS an essential tool for passing mission critical information to the organization to help make decisions that improve productivity, product quality, regulatory compliance and customer relations. Today's challenge is to find ways to improve the quality, processing and delivery of data even further.

Traditional LIMS run on PCs and provide the basic lab functions of sample login, sample receipt, work assignment, worksheet generation, results entry, data review, results and management reporting. The PC can be an impediment to productivity because they are located in stationary positions. Laptops with wireless network connections provide a portable option but they are relatively bulky, have a fairly short battery life and take a long time to boot. Laptops are also expensive and subject to damage when frequently transported so they're not really practical for continuous portable use.

A more convenient option for entering and accessing LIMS can be found among the handheld devices that are currently available. Handhelds are lightweight, low cost computers that can fit into a pocket and use a pen-like stylus as the primary input device (keyboards can be added as an optional device). The stylus interface uses both handwriting recognition software and on-screen electronic keyboard for data entry.

Devices that use the Palm™ operating system are currently the most popular on the market, but the operating system was designed specifically for use as a PDA and lacks the power, flexibility, interfaces and programming environment to provide the functions demanded by LIMS users.

A better choice is the Pocket PC™ operating system from Microsoft™. PocketPCs are more powerful and available from a number of well-known companies such as Hewlett Packard, Compaq, Symbol Technologies and Casio. These devices can be docked to a PC to transfer data to and from a PC, can be fitted with a wireless network card and/or a cellular connection for network access. Some Pocket PCs can be ordered in ruggedized, industrial versions and can be fitted with barcode readers and label printers to provide a complete road-ready device.

The Pocket PC provides two basic options for implementing portable LIMS applications. The applications can be either self-contained or interactive.

Self-Contained Environment

Self-contained environments have the software and data residing the Pocket PC. The data (such as sample information, worklists, results, etc.) are downloaded and uploaded between the LIMS and the Pocket PC while in a docking station. Downloaded data is generally used for sample login and results entry. After inputting data into the Pocket PC, the device can be docked and the data uploaded and synchronized with the LIMS data.

The main advantage of using a self-contained Pocket PC application is that it is not dependent on access to the network. All of the information is retained until it is uploaded and synchronized with the LIMS.

There are several disadvantages to using a self-contained application. The programs and data must reside on the Pocket PC. Although they are getting more powerful every day, there are application and size limitations on these devices. Downloaded data will not be up to date so it is possible for the application to reference information that is no longer valid. The synchronization of data is a complex process that can require a great deal of forethought and planning to avoid conflicts with existing data. If

the device runs out of memory, some applications must be removed to load the desired application and data. This can prove to be terribly inconvenient.

Interactive Application

Interactive applications require the Pocket PC to be connected to the network at all times. This can be accomplished using the IEEE 802.11 broadband wireless network connection that delivers an 11 Mb/sec transfer rate or a using a cellular telephone connection. The interactive applications can run directly on the Pocket PC or can run as active server pages on a web server and use the Pocket IE browser to present the data.

The advantages to using the browser-based architecture are many. Data is always current, so mistakes are virtually eliminated. Programming is simplified because there is no need for data synchronization.

Very little computing capacity required because absolutely no software or data needs to reside on the Pocket PC. Implementation cost is low because there is no software to install or maintain on the individual Pocket PCs.

The only disadvantage to this approach is the requirement for network availability because there are times and places where the network will not be available.

Sample Login

In many situations field personnel pull samples in an and-hoc fashion. Normally samplers fill out a form with sample descriptive information and, in some cases, results from field tests. The forms and samples are delivered to the laboratory where the data is entered into the LIMS. This is an error-prone process that has a time lag built into it and includes duplication of effort. The Pocket PC LIMS provides and excellent alternative as samples can be logged and results entered directly into the database as they

are taken. Duplication of effort is eliminated and the sample and its results are immediately available to all authorized users the moment they are entered.

Small printers can be attached to the Pocket PC to allow labels to be generated on the spot to ensure positive identification of samples. This eliminates the need to deliver paperwork with the sample.

Global Positioning Systems (GPS) can be added to the Pocket PC to provide the exact coordinates of the sampling point that can be very useful when sampling for environmental monitoring.

Sample Receipt

The Pocket PC LIMS can be used to record that received the sample(s) and when by retrieving a list of samples that are pending receipt and simply tapping the stylus on the samples that are received. Alternatively, some Pocket PCs can be equipped with a bar code reader to quickly 'swipe' the sample id that is on the sample's attached label.

Worklist Generation

Traditionally users print hard copies of worksheets that provide them with samples that require analyses. Some worklists present a listing of samples that require a single test; some require a listing of tests for a specific sample. However they are organized, hardcopy worksheets have 2 fundamental flaws; they don't reflect the current backlog because any samples that are received after the report has been printed will not be included on the list, and they don't allow direct entry into the database.

The Pocket PC LIMS solves both of these problems because the worklist presented is dynamic. That is, the listing reflects the current backlog at all times. In addition, the worklist can double as a results entry screen. Once the results are entered, the worklist automatically updates and removes that sample from the worklist.

Figure 2: Main Menu screen

Figure 3: Login screen with character recognition

Figure 4: Login screen with keyboard

Figure 5: Results entry by method – list of methods

Figure 6: Results entry by data – single data entry

Results Entry

The Pocket PC LIMS excels at result entry. It can provide an interactive worklist and results entry function, whereby the user can identify the sample that requires testing and enter the results using the stylus interface. The beauty of this approach is that it's just as easy as writing the results into a lab notebook or on a piece of paper, it is faster than many instrument interfaces, it automatically updates the database, it automatically executes calculations (if necessary) and it automatically compares the results with any testing limits to provide the user with instant feedback. The PocketLIMS is a great efficiency tool for the bench chemist and technicians.

Data Review

Laboratory managers are often the bottleneck in the processing of samples. Many times the organization's SOP requires data review by management before releasing the information and/or product represented by the samples being tested. Managers cannot always get to a PC to review the data; however, the Pocket PC LIMS can be used to access and review and release data while out of the laboratory.

Data Access

It can be very critical for people to obtain lab information without going to a PC. For example, an engineer or operator may need to view the data that represents the contents of a tank or a reactor while on the plant. A marketing representative may need to see the historical data of a product for a customer. Quick access to information can be the difference in producing a quality product, or shipping the correct product, making a sale, etc.

Limitations of the Pocket PC

Although there are many advantages of using a Pocket PC LIMS it cannot totally replace PC-based systems because there is a trade-off between portability (device size and weight) and functionality. Instead, they can be used to augment the traditional LIMS in those situations where it is practical.

The first limitation is the screen size and resolution available on the Pocket PCs. The device must fit into your hand, and the technical limitations of the screen restrict the display area to approximately $1/5^{th}$ to $1/10^{th}$ of that of a desktop PC. This means that the use should be limited to functions that don't require the user to see a lot of information.

The second limitation is the input device. Handwriting recognition has come a long way in the last few years, but some people will dismiss it as being 'too hard' or 'too different'. The change in user interface is similar to the DOS to Windows shift that took some users a while to embrace.

The third limitation is wireless coverage. Wireless networking is less expensive to implement than hard-wired networks because the cost and inconvenience of wiring is virtually eliminated. Having said that, implementing a wireless network will require some new thinking by management that may find the concept difficult to accept. Even when a wireless network is implemented, it can't be done all at once and there will be 'holes' in the wireless network where the Pocket PC will lose connection with the database.

The fourth limitation is cellular coverage. As anybody who has used a cellular phone will tell you, there are some places where there is no cellular service. This means that you may not always be able to use the Pocket PC with a cellular connection to your server.

Summary

Laboratory data is a valuable corporate asset that should be quick and easy to enter and retrieve by authorized users both inside and outside of the lab. Laboratory information is critical for improving the quality of products, increasing the efficiency of production, rapid development of new products and the support of existing customers. The ability to access information where needed in 'real time' will add enormously to the company's bottom line. The implementation of Pocket PC LIMS can add efficiency and cost-savings by reducing several error-prone steps while making data immediately available in a secure manner.

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