Migrating from Paper to Interactive Paperless Work Instructions

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Abstract
One of the effects of the ever increasing mountain of regulatory requirements and the globalization of markets is the need to disseminate and collect information across the shop floor and the enterprise in either real or near real time. Companies are finding that a paper environment does not provide the nimbleness needed to execute today's adaptive business models which are required in a rapidly changing economy.

Fortunately, a variety of process and information technologies have emerged and intersected to provide economical solutions for today's process management and product traceability needs. Electronic process trees and instructions can be used as collaborative information portals providing a wide range of capabilities. By strategically applying measured amounts of technology to achieve the operational nimbleness needed, a company can stay relevant in what is becoming a rapid globalization of markets and regulations.

Changing Manufacturing Environment
In today's ever changing manufacturing environment it's important to be able to disseminate information to and from the manufacturing floor. Over the years paper work orders, work instructions, travelers and forms were some of the ways information moved across the shop floor and the enterprise. It's common place today, if not a necessity, to have a network of computers on the manufacturing floor. The cost of network and computer hardware has dramatically dropped in recent years. Advances in networkable data bases and information technologies coupled with reduced cost have opened the door for a wide range of economical, integrated, operational improvement solutions. These solutions can replace, work in tandem, integrate with or fill gaps in existing legacy systems.

Global regulatory requirements are growing at a rapid pace and are affecting all industries. Market fluctuations and global economies are forcing companies to find ways to expand and shrink work forces to compensate for the oscillation of business cycles. Applying the right operational tools can make a difference on the bottom line.

Paper Work Instructions
Typical work instructions were seen as a necessary evil which was needed to get through a regulatory audit. In a paper format, they would normally contain the minimum amount of information. The most common tool used to generate work instructions is some type of word processing, presentation or CAD software which could be cumbersome and time consuming to generate. Copies were printed and strategically positioned around the enterprise.

Document control of paper work instructions has always been a challenge. Getting a new or revised document through the necessary sign-off process could be a protracted cycle. The biggest challenge could come after document approval. Distributing the new documents and retrieving the old revisions was always a challenging task. There is always the question of work in process. Do you use the new or old revision? Do you have two revision levels on the floor at the same time? How do operators know which document to use? We have all been through an audit where the auditor finds the one old document on the manufacturing floor that was not retrieved.

The Next Level of Work Instructions
The next level of work instructions are when the document is turned into a pdf file or a read only document. This type of document still needs to go through the sign off process. It is normally put on a network directory that is maintained by the Documentation Control Department. There still is a reasonable amount of effort in maintaining these directories. The questions regarding work in-process still exist. This method can also run into trouble if more then one person is using the same document at the same time.

Both of the above methods are static and do not lend themselves to sharing basic content and formats across an environment where there are multiple individuals generating documents.

The New Generation of Interactive Work Instructions

Using Relational Data Bases, SQL Servers and the latest network technologies, work instructions become much more than work instructions: they become interactive collaborative tools that can provide economical solutions for improving operational efficiencies throughout the enterprise. This type of tool combines a dynamic blend of process management, work instruction and manufacturing execution software that allows for the dissemination and collection of Manufacturing and Business Intelligence (MI and BI). These tools are now being deployed, from the manufacturing floor to accounting, in a wide range of industries across the Globe.

Interactive Paperless Work Instructions can be applied anywhere a procedure needs to be followed.
Some examples are:
- **Accounting** - *Sarbanes-Oxley (Sarbox or SOX) compliance*
- **Assembly Procedures**
- **Equipment Preventative Maintenance**
- **Equipment and Tool Calibration**
- **Training -** *New or cross training of employees*
- **Tracking of Returned Materials**
- **Tracking Products** through the process
- **Shipping / Receiving**
- **Setup Procedures**

There is a large spectrum of tools on the market. Many are just work instructions. Others were designed to perform an unrelated function but, with some work, can generate something that can be used as work instructions. A new generation of Process Management Work Instruction Software (PMWIS) tools provides a wide range of capabilities. This new generation of tools is designed to provide a company with the ability to improve productivity and to better react to business cycles. With this type of capability, *tribal knowledge can be easily turned into Intellectual Capital!*

Typical Capabilities
The following is a list of typical capabilities that are found in this new generation of tools:
- ✓ SQL/Relational Data Base backbone
- ✓ Central repository for all process related information
- ✓ Productivity measurement capability
- ✓ Closed-loop process control
- ✓ Historical knowledge database
- ✓ Paperless with auto formatable pdf outputs (see Figure 1)
- ✓ Can be used as a communication tool
- ✓ Ability to automate redundant or time consuming processes
- ✓ Ability to interact with MRP/ERP system
- ✓ Ability to interact with external programs and electronic forms
- ✓ Automatic revisioning (revision management)
- ✓ Electronic sign-off
- ✓ Multiple language support
- ✓ Integrated report generation (ability to use 3rd party reporting tools)
- ✓ Integrated Work Orders
- ✓ Modular for staged implementation and growth

Figure 1 – Outputs

There are two elements to a paperless system:
    Hardware
      ✓ Computer or thin client

✓ Monitor, keyboard and mouse
✓ Network hardware
Software
✓ Server Data Base Module
✓ Editing Modules
✓ Collaborative Viewer Modules
✓ Support Modules (for special functions)

Software Functions
When evaluating tools, a company should get as much functionality as possible. Experience has proven that once a company starts down the road to paperless instructions, an endless list of applications come to the surface. Selecting a tool that has the flexibly and functionality to deal with a broad range of tasks can have a continuing return in operational efficiency. The following gives some insight into the type of functionality that a company would expect in a Process Management Work Instruction tool.

- **Work Instruction Generation -**
Setting up product templates (work instruction step trees) can be made using intuitive icons and click and drag functions.
The edit and view screen is normally divided into two or three sections. In Figure 2, the work instruction tree is on the left side, the text instructions are on the top right side and pictures and links to supporting documentation is on the bottom right.
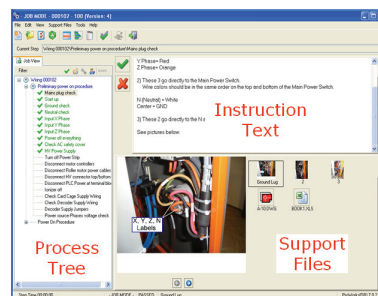

Figure 2 – Edit Screen Type 1

Figure 3 shows another typical edit/view screen. On the right top side is a canvas type field where pictures can be placed and sized. Text and symbols can then be overlaid using standard imbedded drawing tools.
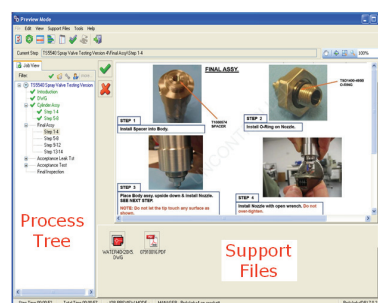

Figure 3 - Edit Screen Type 2

Typical edit functions should be available making the editing of work instructions as simple as possible for the person maintaining the work instructions. Editing should be as simple as Drag and Drop, and Copy and Paste. They should have access to previous revisions and should be able to review previous changes with descriptions and reasons for those changes.

- **Collaborative Information Portals -**
Information Portals (Viewers) should be able to interact with engineers, managers and supervisors with the click of an icon. Access to a Bill of Material (BOM) and Bill of Tools (BOT), drawings, videos and Work Orders should all be available with a click of the mouse. Language tabs allow the operator to view instructions and icons in their native language. Links can be set up to allow the operator to review CAD drawings, standards and electronic forms. Special fields should be easily set up to insert or capture serial numbers, test data or any other pertinent data. The capability and range of applications that an Interactive Collaborative Portal can be used for is light years ahead of a paper system. Processes and documentation can be implemented in real time. Data can be collected and analyzed in real or near real time.

- **Traceability (Background Data Collection) -**

The software should keep track of all events, in the background, on each step within a work order (operator, time stamp, start, complete, pass, fail, etc ….) Pass and Fail condition should be recorded for each step, providing an audit trail for accountability. Data base punch list should provide a snapshot of process variables and events. Completion of key steps in a task can be monitored.   Because these tools are sequel server based, information and data can be mined with imbedded or standard 3rd party reporting tools.

- **Revision Management (Auto Revision Control) -**

Auto Revision Control can dramatically reduce the time it takes to manage work instructions. This function normally works in conjunction with background data collection.   The software records everything that is changed and organizes the information so it can be presented for sign-off. This type of system provides the capability to review revision history and the ability to drill down through the changes.   This function should also provide the ability to determine when and where a revision would be implemented.

- **Interact with External Applications/Equipment -**

The tool should make it easy to set up Data Collection Windows.   Interfaces should allow for customization to interact with external applications and / or machinery using such interfaces as File I/O and RS232. This type of capability can be used to eliminate time consuming and cumbersome tasks.

- **External Data Link (EDL) -**

External Data Link (EDL) should provide the ability to connect to other SQL Servers databases and automatically import existing data (BOMs - Work Orders) from ERP, MRP and PLM systems to avoid data duplication, ensuring data accuracy and reducing cost of maintenance.

- **Knowledge Data Base Capability -**

An example of a knowledge data base would be to capture Failure Symptoms (conditions of failure and frequency can be collected for all steps in the process that are not passed) and Corrective Actions (steps necessary to "fit" escape conditions). This information can be organized and offered to the next person executing the same process. Data can be mined for Continuous Improvement Initiatives. *Tribal Knowledge can be turned into Intellectual Capital!*

- **Configuration Options -**

Configuration Options should have the ability to display or hide groups of steps based on a product configuration. This gives users the ability to only maintain one work instruction set for multiple configurations.

- **Special Instructions -**

The tool should allow template authors to use Special Instruction icons to prompt job processors to define instructions in one step that will be available in another step later in the process. Special Instructions are useful for job-specific information that cannot be determined prior to the process. This feature should also allow EDL (External Data Link) and IDL (Internal Data Link) options. Links can be created in one step, and made available to steps further on in the process or on another process template.

- **Event Notification -**

There should be two types of e-mail notifications on critical events within the Process. **Notification of Step Status -** There may be individuals that should be notified of the status of certain steps within a process tree template. For example, it may be important that a manager be notified if a certain step is failed. Other individuals may need to know if and when a certain step is passed or waived. The template author should have the ability to define rules for any step. **Receive Notification of Assigned Step -** There may be steps in a template that have been assigned to a specific user. During assignment, the template author has the opportunity to specify that the assigned user be notified when the assigned step is about to be processed.

- **Expert / Novice Mode -**

As users become increasingly proficient at executing processes, they may find that they no longer need the detailed step by step instructions that Template Editors (Process Engineers) provide. In fact, the detailed descriptions intended for people who are less familiar with the process, will work to slow the process down.   A tool should accommodate the differences between more experienced users and less experienced users with a feature called Expert Mode. Expert Mode allows Template Editors to flag steps that more experienced users may skip. These steps are referred to as "Novice only" or "information only" steps and are denoted with a symbol on the process tree: Users can then be designated as "Experts" on

the different templates. When Users designated for a particular template reach a step that is marked "Novice Only," the tool automatically waives the step.

- **Work Orders -**

An integrated Work Order capability provides a capability to schedule work and track data though the build process. Coupled with Background and Process Data Collection, a high level of product process traceability is attached to a work order. A work instruction template is linked to the work order within the tool. This link can provide additional control over work instruction document revisioning with work in process (WIP).

- **Integrated Report Generation / Analyze the Process with Data Visualization -**

With data being captured in real time and being stored in a SQL data base, it's important to be able to mine and analyze this rich data. An easily configurable, integrated report generator or the ability to access the data with a 3rd party report generator is essential. This type capability allows a company to set a variety of standard preformatted reports for such things as: tracking product thought the process (see Figure 4), indentifying bottle necks, etc..

Figure 4 –Product Tracking

- **Multiple Language Support -**

It used to be that multiple language support was only important to multi national companies. Today, many facilities work in a bilingual environment. Regulatory audits are becoming more sensitive to this type of work environment. It is important for a tool be able to seamlessly toggle between and operate in two, three or more languages.   The individual operator should be able to select and work in their native language. Not only should the instruction text toggle from one language to another, the icons and software messages should also be in the user's native language. Typically, there are two types of offerings for a language capability. In the first type of offering, the tool comes programmed in one or more languages. The second type is that the tool has a built in capability that gives the end user the flexibility to setup as many new languages as required very quickly without need of a software engineer.

- **Replicate Processes Across Regions -**

There are times when companies need to share best practices or span production across job sites, divisions and locations. In many cases there is a need to utilize low cost regions for manufacturing, while maintaining tight controls over the production building process. The ability to bundle, water mark and encrypt work instructions and or work orders can be important to keep proprietary knowledge secure.

Benefits

The benefits of migrating from a paper system to an interactive collaborative system can vary depending on the tool that is used and how the tool is applied. In general, a company will see improvement in the following areas:

- **Higher Quality –**
  - ✓ The process is performed the same way every time.
  - ✓ The process is not people dependent.
  - ✓ All QA checks performed to the same standard.

- **Improved Efficiency –**
  - ✓ Fewer mistakes are made.
  - ✓ New users trained by software, not another user.
  - ✓ Lower skilled workers perform higher level tasks because the knowledge is in the software.

- **Increased Productivity –**
  - ✓ Issues solved quickly.
  - ✓ Repetitive functions can be automated.
  - ✓ Users are guided through entire process.

- **Process Portability –**
  - ✓ Entire process with support documentation can easily be exported to other facilities.

- **Reduction in Labor Costs** for work instruction development and deployments is common due to shorter development / format times, faster processing of change orders.

- **Reduction in Work Instruction Maintenance** with integration to ERP/MRP/PLM systems, leveraging existing master product / process data.

- **Operational Improvements** from documented standard work processes and manufacturing errors (Reduced Rework/Scrap).

- **Reduction in Training Time** for cross training and new employees.

Implementation

Process Management Work Instruction Software (PMWIS) tools should be able to be installed with the minimum amount of IT resources. A PMWIS vender should be able to support the installation remotely if necessary. Implementation can be accomplished incrementally, work cell by work cell. Most companies have a network infrastructure in place to support a PMWIS tool. If the hardware is not in place at a work station (computer or thin net client) the cost can run from $350 to $550 per station, depending on the configuration. Depending on the vender, a server license can cost from $5,000 to $10,000. An editing license can cost from $2,000 to $3,000 and viewing licenses can cost from $400 to $1,200. Well designed PMWIS tools have intuitive functions and require a minimum amount of training to use. PMWIS can be operational in a matter of weeks.

Conclusion

Major advances have been made in the PMWIS technology. This coupled with the fact that the cost of hardware has dramatically dropped in recent years, makes PMWIS technology now affordable for small companies and robust enough for multi divisional corporations. Migrating from paper work instructions to a paperless interactive tool can provide integrated functions which can improve operational efficiency and nimbleness. Functions such as Background Data Collection and Auto Revisioning can be useful tools for meeting regulatory requirements.

Migrating from Paper to Interactive Paperless Work Instructions

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An Increasing mountain of regulatory requirements and the globalization of markets is changing the Manufacturing Environment

Over the years paper

**work orders,
work instructions,
travelers
and forms**

**were some of the ways information moved
across the shop floor and the enterprise.**

A wide range of economical, integrated, operational improvement solutions are now available.

Solutions can replace,
work in tandem,
integrate with or
fill gaps in
existing legacy systems.

Expand and shrink work forces to compensate for the oscillation of business cycles.

Paper Work Instructions

The most common tool used to generate
work instructions is some type of
word processing,
presentation or
CAD software
which could be cumbersome and
time consuming to generate and maintain.

Paper Work Instructions

- **Document Control** (a challenge)
- **Sign-Off Process** (could be a protracted cycle)
- **Distributing the new documents**
- **Retrieving the old revisions**
- **Work in process**
  - Do you use the new or old revision?
  - Do you have two revision levels on the floor at the same time?
  - How do operators know which document to use?
  - Audits?

The Next Level of Work Instructions

- pdf file or a read only document (on network Directory)

  - Still is a reasonable amount of effort in maintaining these Documents

  - The questions regarding work in-process still exist.

The New Generation of Interactive Work Instructions

Work instructions become much more than work instructions: they become

Interactive Collaborative Tools

Combines a dynamic blend of

process management,

work instruction and

manufacturing execution software

Allows for the dissemination and collection

of

Manufacturing and Business Intelligence
(MI and BI)

Can be applied anywhere a procedure needs to be followed.

Some examples are:

- **Accounting** - *Sarbanes-Oxley (Sarbox or SOX) compliance*
- **Assembly Procedures**
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- **Training -** *New or cross training of employees*
- **Tracking Returned Material**
- **Tracking Products** through the process
- **Shipping / Receiving**
- **Setup Procedures**

Large **spectrum of tools on the market:**

- Just Work Instructions
- Designed to perform an unrelated function
- Process Management Work Instruction Software (PMWIS)

Typical Capabilities

- **SQL/Relational Data Base backbone**
- **Central repository for all process related information**
- **Productivity measurement capability**
- **Closed-loop process control**
- **Historical knowledge database**
- **Paperless with auto formatable pdf outputs**
- **Can be used as a Communication tool**
- **Ability to automate redundant or time consuming processes**
- **Ability to interact with MRP/ERP system**
- **Ability to interact with external programs and electronic forms**
- **Automatic revisioning** (revision management)
- **Electronic sign-off**
- **Multiple Language Support**
- **Integrated Report Generation** (ability to use 3rd party reporting tools)
- **Integrated Work Orders**
- **Modular for staged implementation and growth**

Process Management Server

Paperless Deployment

Paper Deployment

Instruction Terminals
Equipment Interface
Data Collection
Electronic Forms

Generate pdf Files
Print Work Instruction
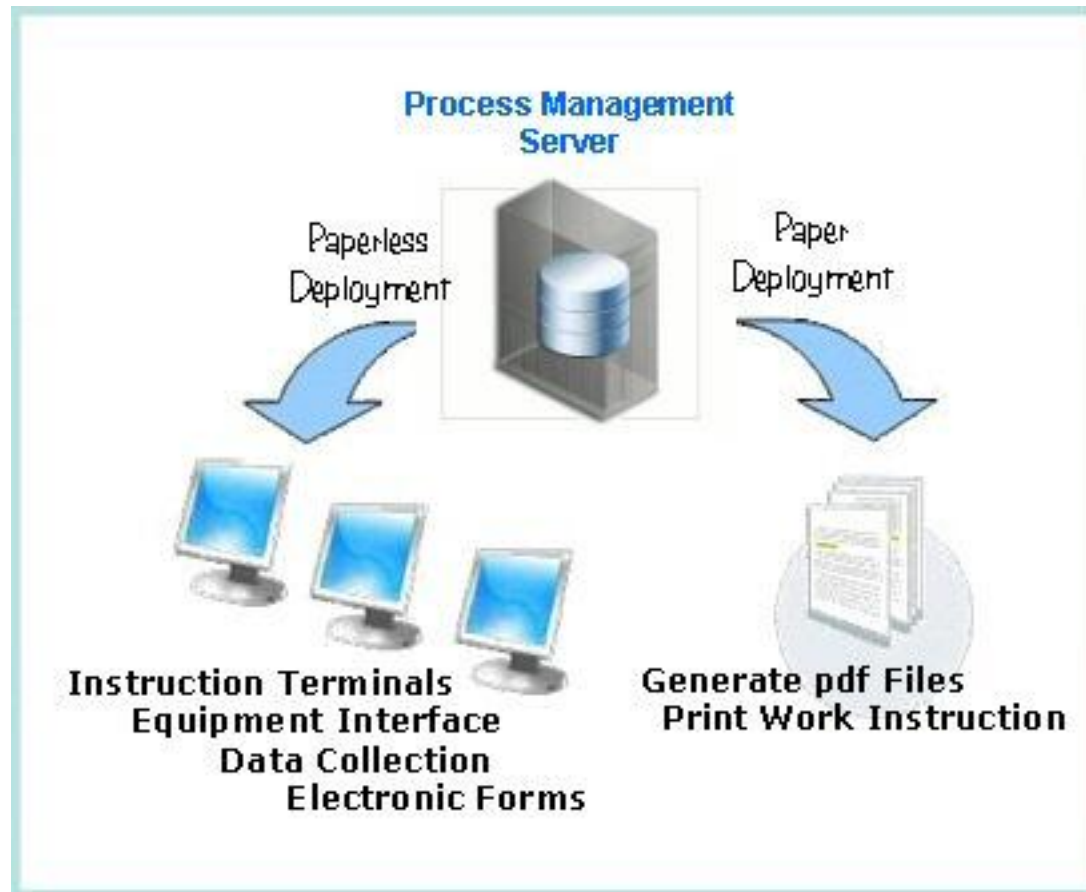
Hardware

➤ Computer or thin-net client
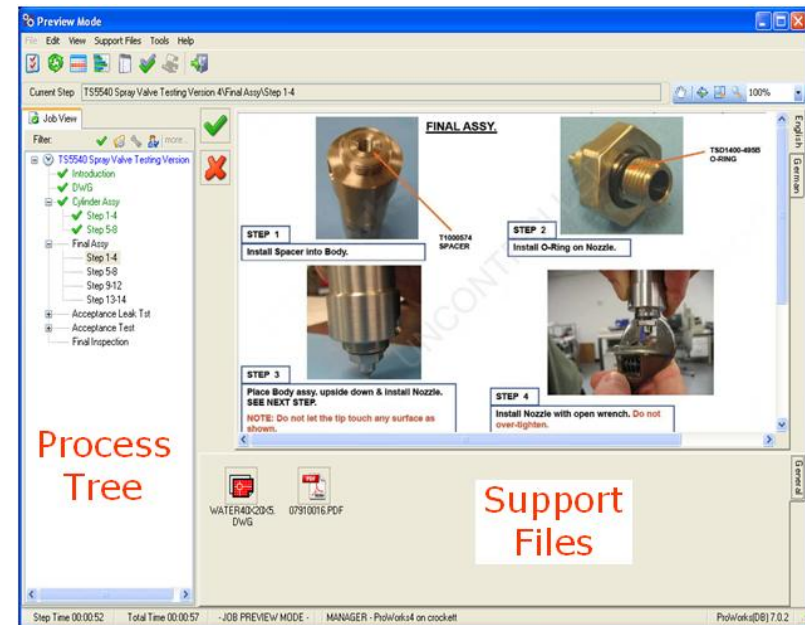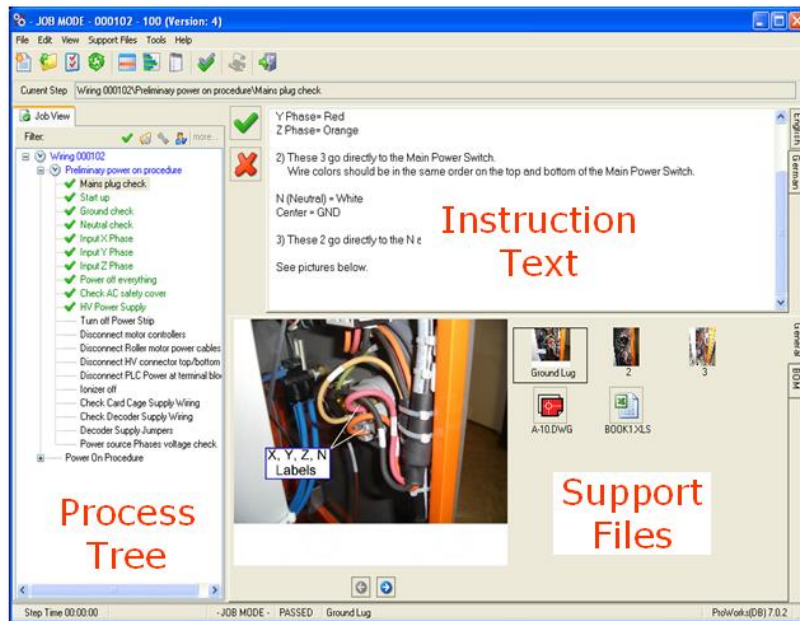➤ Monitor, keyboard and mouse
➤ Network hardware

Software

➤ Server Data Base Modular
➤ Editing Modules
➤ Collaborative Viewer Modules
➤ Support Modules (for special functions)

Software Functions

Selecting a tool that has the flexibility and functionality to deal with a broad range of tasks can have a continuing return in operational efficiency.

Typical Icon Functions

Click the "**New**" icon to create a new template.

Click the "**Open**" icon to open an existing template.

Use the "**Cut**", "**Copy**" and "**Paste**" icons to make edits to tasks and steps.

Use the "**Insert...**" buttons to quickly insert tasks/steps, pictures, support files and movies.

Use these icons to set the completion type for steps. The stop light icon indicates a PASS/FAIL step, and the checkmark icon indicates a COMPLETE step.

Use this icon to set a fixed sequence of tasks and steps.

Use the "**Edit...**" icons to define auto commands, user inputs, estimated time, options and trouble-shooting errors.

Use the "**Special Instructions**" icon to create special instructions for the user during job mode.

Use the "**View Edit History**" icon to view a list of edits made to the template.

Use the "**Approve Changes**" icon to submit edits for Manager approval (by a Power User); Manager may use the icon to approve and release the changes they have made to a template.
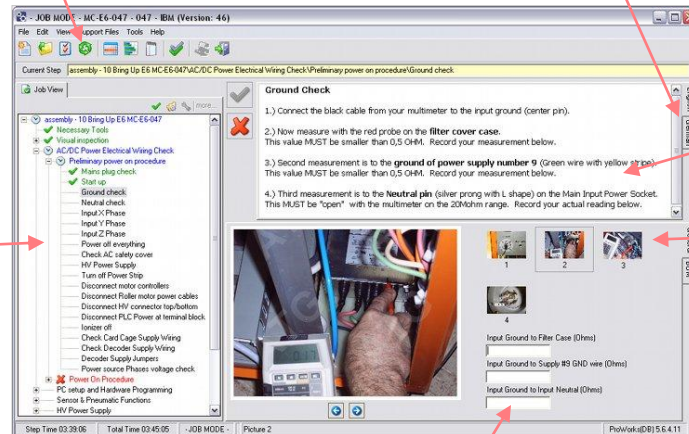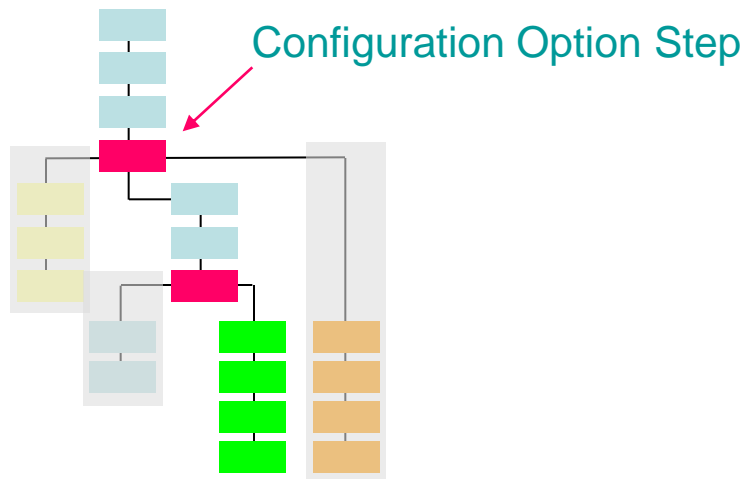
Software Functions

- **Interact with External Applications/Equipment**

- **External Data Link** (EDL)

- **Knowledge Data Base Capability**

- **Traceability** (Background Data Collection)

- **Revision Management** (Auto Revision Control)

- **Interact with External**

Software Functions

■ **Configuration Options** - have the ability to display or hide groups of steps based on the configurations. This gives users the ability to only maintain one work instruction set for multiple configurations.

Configuration Option Step
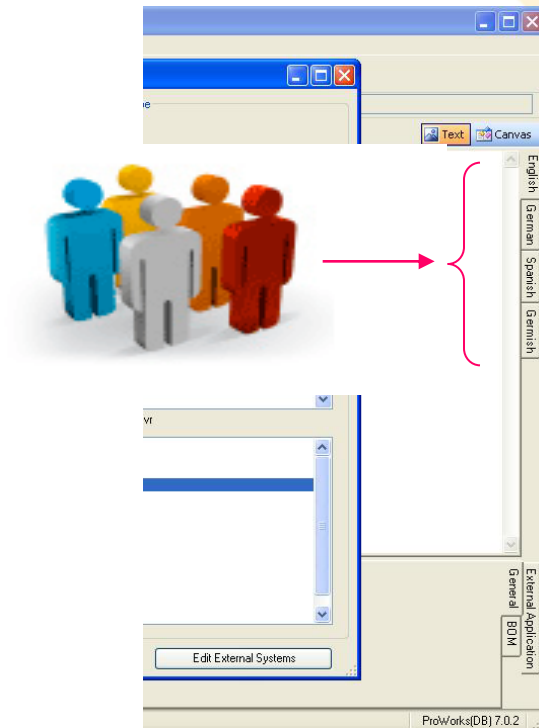
Software Functions

- **Special Instructions**

- **Event Notification**

- **Expert / Novice Mode**

- **Work Orders**

- **Integrated Report Generation**

**Analyze the Process
with Data Visualization**

Software Functions

Multiple Language Support

**Replicate Processes
Across Regions**

Benefits

- **Higher Quality**

- **Improved Efficiency**

- **Increased Productivity**

- **Process Portability**

- **Reduction Work Instruction Costs**

- **Reduction in Work Instruction Maintenance**

- **Operational Improvements**

- **Reduction in Training Time**

Implementation

- Minimum amount of IT resources

- Implementation can be accomplished incrementally

- Hardware Cost: $350 to $550 per station

- Server License: $5,000 to $10,000

- Editing licenses: $2,000 to $3,000

- Viewing Licenses: $400 to $1,200

- Training: Well designed PMWIS tools have intuitive functions and require a minimum amount of training to use

Pricing is depend on configuration and vender.

Conclusion

- PMWIS technology now affordable for small companies and robust enough for multi divisional corporations.

- Migrating from paper work instructions to a paperless interactive tool can provide integrated functions which can improve operational efficiency and nimbleness.

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